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# INVASIVE ALIEN SPECIES OF POTOHAR PLATEAU, NORTHERN PAKISTAN

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Abstract - The present research work is based on the identification of Invasive Alien Plant Species (IAPS) distributed in Potohar Plateau, which are threat to indigenous flora. To confirm the invasive and alien status of these species, we investigated the flora of Potohar plateau. The target population sampling method was used for the collection and listing of IAPS present in all districts of Potohar Region. Invasion status of IAPS was recorded from wastelands, roadsides, crop fields, banks of canals, mismanaged gardens and housing colonies. Our results revealed that *Broussonetia papyrifera* Vent., *Cannabis sativa* L., *Eucalyptus camaldulensis* Dehnh., *Lantana camara* L., and *Parthenium hysterophorus* L. are highly invasive species. Whereas seventeen IAPS were found in naturalized, ten recently escaped from controlled cultivation, three were newly introduced while fifteen grown casually in the study area. The common life form of IAPS was herbs and are used for medicinal and ornamental purposes. These species have invaded maximum area to obstruct the distribution of native flora including medicinal and economically important plants, which are now found in patches. We tend to use eradication methods to control further replacement of indigenous vegetation. This study suggests that the Government of Pakistan should take possible steps to prevent natural habitat of local flora and make separate zones for IAPS. The present study will help the researchers and policymakers to control invasion and alien species.

Keywords: alien plants; invasive flora; Northern Pakistan; Potohar plateau; Islamabad.

## Introduction

Potohar Plateau is situated northeast of Pakistan with an area of approximately 25,000 Square kilometers, topographically the area includes hilly and plain areas. The area is situated between attitude 32°5’34’’N and longitude 71°30′ 73”E. The lowest altitude from sea level is Jhelum plain 250 m (825 ft), and the crop production depends upon monsoon rains (Rashid & Rasul 2011; Figure 1). Potohar Plateau is a densely populated area with residents from different cultures, which makes the frequent introduction of exotic plants. The construction of houses, roads and industries are in processes limiting the range of natural vegetation through land use that lead to changes in soil composition. To increase greenery in the study area, foreign plants are being introduced intentionally for afforestation. The native flora of the Potohar region consists of dry deciduous scrubby vegetation and few tree species.

Out of about 6000 species of vascular plants in Pakistan, ~700 are listed as aliens species with 5-6 are considered strong invaders (Altaf & Zarif 2003). The route of invasion for plants is increasing due to trade and travel, or they may be introduced accidentally (Voller & McNay 2007). Alien and invasive flora of North America, Australia and Europe is well documented; (Dukes & Mooney 2004; Keller et al., 2011; Reichard &White 2001), however, such documentation is scanty for Asia (Wu et al., 2004). It is asserted to document the introductions of new species which can facilitate the botanist and policymakers to differentiate between invasive and local species. IAPS has some irreversible adverse effects on endemic biodiversity and the ecosystem. They compete with the native vegetation and result in the reduction of local vegetation (Latombe et al., 2016). The phenomenon of globalization is homogenizing the world’s flora and fauna (Mooney & Hobbs 2000).

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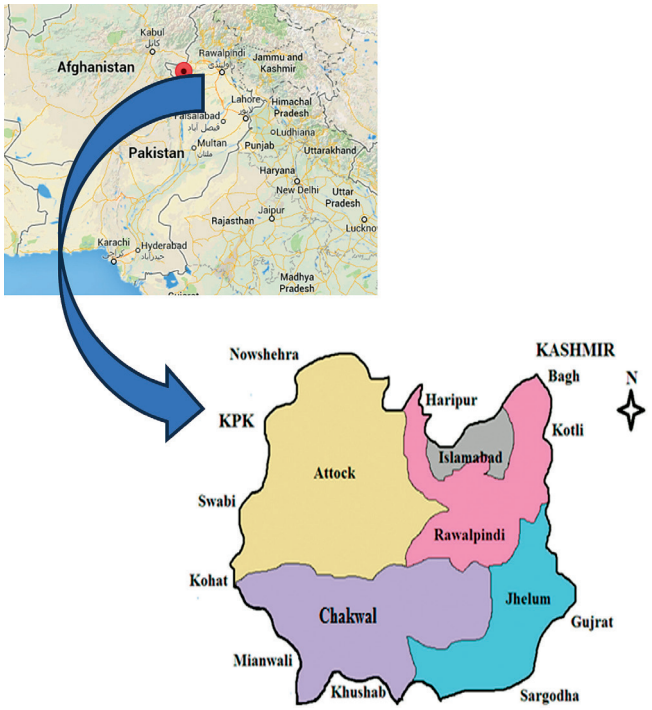


**Figure 1.** Map of Potohar Plateau (Northern Pakistan) and location of the studied areas.

So, it is an acceptable agreement that invasion by exotic species is one of the greatest threats to biodiversity and its conservation (Coblentz 1990). No considerable work has been published to list IAPS and their impact on biodiversity in Pakistan except enlisting the invasive weeds of southern districts of Khyber Pukhtoon Khawa-Pakistan (Khan et al., 2011). The objective of the present study is to identify and enlist the IAPS flora from Potohar Plateau region.

## Materials and Methods

In this study we conducted 30 systematics surveys to identify and record the invasive status of alien plants (Feb 2018 – Jan 2019) in different habitats (terrestrial/aquatic) of different districts: Attock (6 sampling areas in each Tehsil that is Attock, Fateh Jang, Hasaan Abdal, Hazro, Jand and Pindigheb) Chakwal (3 sampling areas Chakwal, Kallar kahar and Talagung), Jhelum (4 sampling areas in each tehsil including Jhelum city, Pind dadan khan, Dina and Sohawa) Rawalpindi (7 sampling areas in Rawalpindi City, Gujar khan, Kallar syedan, Kahuta, Kotli sattian, Murre and Taxilla) and 8 field trips in Islamabad (Capital) main city and villages. For each sampling areas, field experimental campaigns were arranged to collect, identify and note down the invasive status of each IAPS on different habitats as wastelands, roadsides, crop fields, banks of canals, mismanaged gardens and around housing colonies. Using herbarium specimen of Herbarium of Pakistan, Quaid-i-Azam University, Islamabad (ISL), a list of IAPS has been drawn up and then in each study area only IAPS species were collected and identified. The frequency of plant species was calculated by using the Target population method (Coulloudon et al., 1999). 5 replicates were used from each sampling area and Invasion status is assigned according to Colautti & MacIsaac 2004. Finally, 3 specimens were collected for each plant species, dried, identified and were deposited in the National Herbarium of Pakistan, Quaid-i-Azam University, Islamabad, from understudy localities as shown in Appendix.

## Results

For each study areas, most of the present IAPS were collected on wastelands, roadsides, crop fields, canal banks, unattended farms and gardens. *Asclepias curassavica* L., *Bougainvillea glabra* Chois., and *Phoenix dactylifera* L. were found in cultivated conditions; the first two species are ornamental while the third one grown for afforestation as well as famous for its edible fruit. *Cestrum nocturnum* L., *Duranta repens* L., *Hibiscus rosa-sinensis* L., *Lagerstroemia indica* L., *Mirabilis jalapa* L., *Nerium oleander* L., *Ocimum americanum* L., *Quisqualis indica* L., *Tecoma stans* (L.) Juss. ex Kunth and *Thevetia peruviana* (Pers.) K. Schum. were used to grown as ornamental plants but recently they have colonized natural habitats. Currently they were found on wastelands, along roadsides, or in unattended gardens. All of them possess strong invasive potential so eradication measures should be used to stop them from becoming naturalized. *Achyranthes aspera* L., *Amaranthus viridis* L., *Anagllis arvensis* L., *Chenopodium ambrosioides* L., *Commelina benghalensis* L., *Digera muricata* (L.) Mart., *Datura inoxia* Mill., *Gomphrena serrata* C. Martius, *Jacaranda mimosifolia* D.Don, *Jasminum mesnyi* Hance., *Jatropha integerrima* Jack., *Ligustrum lucidum* Ait. f., *Melia azedarach* L., *Sonchus oleraceus* L. and *Stellaria media* (L.) Merr. were commonly found on various sites of the study area, as single plant or in form of groves. These species have invaded all parts of the Potohar Plateau. *Ageratum conyzoides* L., *Alternanthera pungens* Kunth., *Calotropis procera* (Aiton.) R. Br., *Cassia occidentalis* L., *Conyza bonariensis* (L.) Cronquist, *Conyza canadensis* (L.) Cronquist, *Cynodon dactylon* (L.) Pers., *Eleusine indica* (L.) Gaertn., *Hamelia patens* Jacq., *Malvastrum coromandelianum* (L.) Garcke, *Martynia annua* L., *Oxalis*

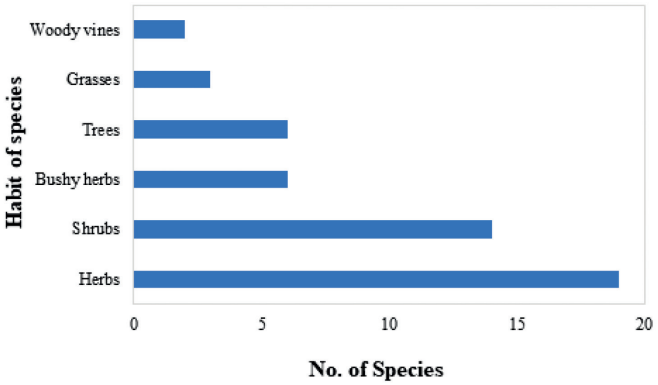


**Figure 2.** Major habits of studied Invasive Alien Plant Species (IAPS).

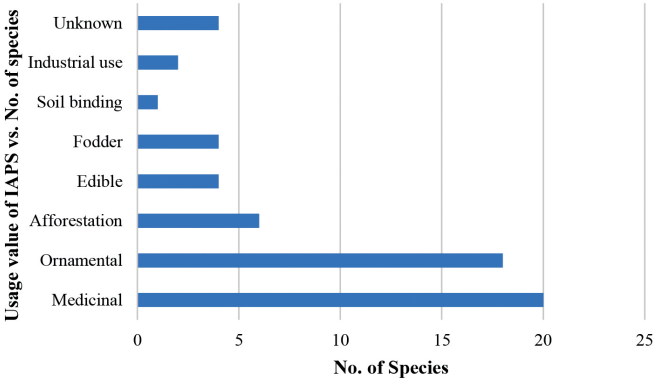


**Figure 3.** Major reasons for the introduction of IAPS in study areas.

*corniculata* L., *Riccinus communis* L., *Sorghum halepense* (L.) Pers., *Tribulus terrestris* L., *Verbena officinalis* L. and *Xanthium strumarium* L. are frequently ubiquitous in study area. It is difficult to eradicate IAPS having strong invasive potential. *Broussonetia papyrifera* Vent., *Cannabis sativa* L., *Eucalyptus camaldulensis* Dehnh., *Lantana camara* L. and *Parthenium hysterophorus* L. were not only found frequently but they have dominated the local flora in several manners. The most common growth habit of IAPS in the Potohar Plateau was herb that represent the 38% of total sampled species, then the shrubs represented the 28%, bushy herbs and trees 12%, grasses 6% and vines are only 4% (Figure 2).

Most of the IAPS were introduced in Potohar Plateau for their medicinal value or increasing the variety of ornamental species in gardens (Figure 3). Tree species were imported for increasing greenery and plantation along the roadside by the government. Some IAPS were important as edible and other were used as fodder for domestic animals. Very few species were brought for industrial uses; *R. communis* was introduced for obtaining oil from seeds and fiber from its stem while *C. sativa* was brought for obtaining fiber from the stem. *P. hysterophorus* was brought in the late 20th century for its cultivation along riversides to bind soil with its deeply penetrating roots. Maximum IAPS were brought from South America and African regions (Figure 4). Many IAPS are native to China and European countries. On the other hand, the actual period and route for the introduction of many IAPS cannot be traced.

The maximum number of IAPS has been naturalized in the study area that was 17 species while 15 species were transient/casual in invasion status (Figure 5). Recently 10 species have been escaped from controlled cultivation and have invaded nearby lands. Three species have not yet invaded any area but were in controlled condition while five IAPS were highly invasive; because they are causing an allopathic problem for other plants and animals, causing economic loss, and ecological imbalance.

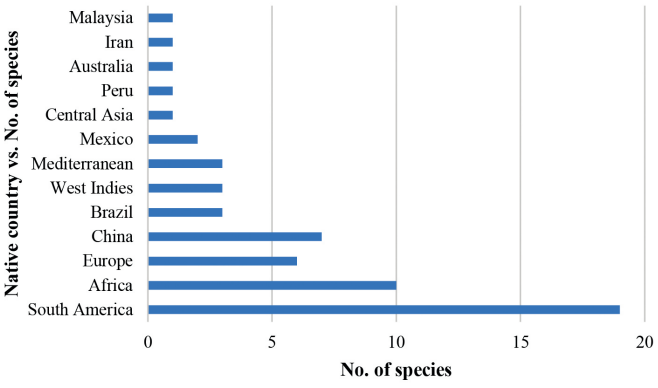


**Figure 4.** Nativity/Origin of IAPS from study areas.

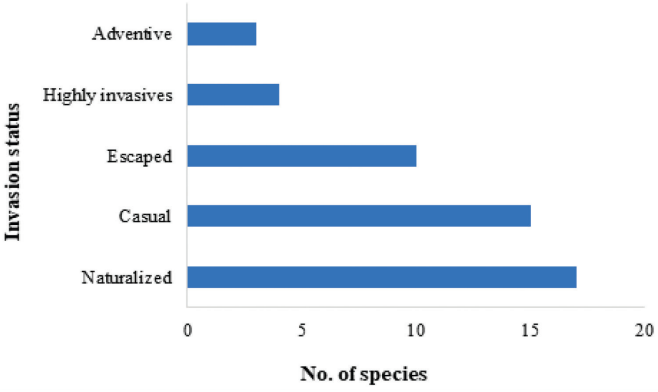


**Figure 5.** Invasion status of IAPS in the study areas.

## Discussion

We documented the Alien and Invasive Flora of Potohar Plateau (Northern Pakistan) for the first time and discussed all recorded species based on their life forms like herbs, shrubs and trees.

**Herbs**

IAPS are the driver of biodiversity change (Latombe et al., 2016). *A. aspera* is a weed of maize fields, it is introduced species in Pakistan, and its pollens cause allergy (Marwat et al., 2010; Lewis et al., 1983). *A. conyzoides* is an allelopathic weed, found in form of colonies and invaded the grasslands, forests, crops and pastures throughout India (Kohli et al., 2006). *A. conyzoides* have been reported as an allelopathic weed (Kong et al., 1999). According to a study in India, plant diversity was reduced by 32% in the area invaded by *A. conyzoides* (Dogra et al., 2009). Marwat et al. (2010) reported that *A. pungens* is a common weed of wasteland throughout the tropical regions, which can be controlled mechanically. *A. viridus* and *C. ambrosioides* are weeds of cornfields or vegetables in warmer regions of the world but are frequent in temperate regions as well. Moreover, birds and wind are major reasons for their dispersal whereas the crop rotation can control these noxious weeds (Marwat et al., 2010). *A. curassuvica* is an aquatic species (Reddy et al., 2008) and in Pakistan, it is grown as an ornamental plant under controlled conditions. *Conyza bonariensis* and *C. canadensis* grow wildly on roadsides and water channels. They have invaded pastures and its control seems to be difficult because a single plant produces 226,000 seeds per plant (*C. bonariensis*), 200.000 seeds per plant (*C. canadensis*) (Kempen and Graf 1981; Weaver, 2001). In Khyber Pakhtunkhwa (KP) *C. bonariensis* is a major weed of sugarcane crop and increasing its invasiveness because of fast spreading in the area (Khan et al., 2011). In Pakistan *Commelina benghalensis* is found as a weed in maize fields (Marwat et al., 2010) according to our observation in the field the plants grow and spread in dim light through root detachment as well as through seed growth. *Commelina benghalensis* invades areas with moist soil including roadsides, grasslands and other disturbed areas. It is especially problematic in pastures and crop fields where it forms dense, pure stands that can smother other plants such as low-growing crops (Force, 2005). In KP *D. muricata* is increasing its behavior as a weed (Khan et al., 2011). *D. muricata* is also know naturalized in Tiawan as in invasive species (Wang and Chen, 2013). *M. coromendelianum* is an introduced species in Pakistan that grows on wasted lands and behaves as weed (Marwat et al., 2010). *M. coromendelianum* and *T. terrestris* were brought in Pakistan for their medicinal value but now its invasiveness is increasing (Khan et al., 2011). *G. serrata* and *M. coromendelianum* have replaced local vegetation and covered land completely competing with the natural native grass. *G. serrate* is also invasive and naturlaized in India, the species can be found growing on lawns, roadsides, cultivated land, orchards sandy open areas, woodlands, hammocks and in gardens, from sea level to 2400 m (Mas, 2013). *M. cormandelianum,* like other invasive weeds, is often abused for causing detrimental changes in native vegetation in the entire range of its occurrences (Saxena, 2020). *T. terrestris* grows rapidly along roads and waste places; its seed bank remains in the soil for its successful spread; it punctures bicycle tires and injures feet (Donaldson 2011) with its seeds having three hard and long spines. *T. terresteris* an aggressive and hardy invasive species, widely known as a noxious weed, because of its small woody fruit – the bur – having long sharp and strong spines which easily penetrate surfaces, such as the bare feet or thin shoes of crop workers and other pedestrians, the rubber of bicycle tires, and the mouths and skin of grazing animals (Hashim 2014).

**Shrubs**

*Duranta repens* is used as a hedge outside houses and lawns by gardeners. It grows very fast and if not removed properly it produces many fruit with seeds. Small shrubs can be chopped off and the root balls can be pulled out to control their spread. Gardeners must not let this hidden invasive species escape. *Lantana camara* is considered by IUCN as one of the world 100 most invasive species (Day et al., 2003), and among the world's 10 worst weeds (Sharma et al., 2007). *L. camara* spread successfully and speedily due to the following reasons; large number of fruit per plant and its ability to grow under a wide range of climatic conditions (Dobhal et al., 2010; Day et al., 2003), allelochemicals are present in all parts of this shrub which reduce the germination and growth of other surrounding species (Ambika et al., 2003). It possesses spines and poisonous compound like triterpenes which deter the local herbivores (Sharma et al., 2007). Local vegetation *Dodonea viscosa* Jacq., *Calotropis procera* Aiton., *Carissa opaca* and *Olea ferruginea* Royle. are in close competition with *L. camara* but due to the excessive spread of this noxious weed; these native shrubs have a patchy distribution now. In the study area, thickets of this plant-like *L. camara* can be seen along roadsides and wastelands.

**Trees**

*E. camaldulensis, B. papyrifera, J. mimosifolia* and *T. peruviana* were introduced in Pakistan in mid of 20th century (Zahid & Ahmad 2002) for afforestation, but now they are showing invasive behavior in the study area. *Eucalyptus* species though a potential industrial crop is not recommended as an intercrop in agroforestry (Bansal 1988) because Calder & Dye (2001) have proved via an experiment that *E. camaldulensis* uses twice of groundwater as compared to native trees and have deeper roots. *B. papyrifera* has replaced native flora massively, it causes severe pollen allergy in inhabitants of Islamabad during the spring season. The World Conservation union lists paper mulberry as one of the six worst plant invaders in Pakistan (IUCN Website). Since 2010, efforts have been started to mechanically cut down male trees

but this species showed rapid growth from the underground roots *J. mimosifolia* and *T. peruviana* have invaded wastelands but are not found to cause any severe damage to the economy or human beings even if this species has high invasion potential producing numerous seeds. *T. peruviana* is avoided from being grazed due to poisonous leaves (Mandal 2012). *M. azedarach* and *P. dactylifera* are old introductions, brought for their medicinal value and edible fruit respectively. However, they have not shown their invasive nature yet and are mostly found in cultivated form.

**Bushy herbs**

C*annabis sativa* is used by some local people as a sedative by making an infusion or by smoking dried leaves. It is common in northern Punjab and KP, invading wasted areas and roadsides (Qaiser, 1973). According to Marwat et al. (2010) it is an ancient introduce species, which was brought for fibers or its use as a narcotic, and later, it escaped from cultivated areas and became wild. Now it has invaded enough land that its control is inevitable but difficult due to its exponential growth during monsoon season. *D. inoxia* and *X. strumarium* are medicinal plants; both are found commonly in form of colonies or single plant on wastelands. They cannot be grazed by animals because *D. inoxia* is poisonous, while both of them possess spiny fruits, which deter grazers, so they are spreading their range of distribution speedily. *M. annua* was cultivated for its colorful flowers but this plant gets naturalized here. In Pakistan *P. hysterophorus* was introduced in the 1980s (Rashid et al., 2014) for binding of soil at river banks success of *P. hysterophorus* lies in its strong competitiveness for soil moisture and nutrients (Wiesner et al., 2007), its twin sprouting seasons, its ability to tolerate harsh climates (Fatimah & Ahmad 2009) and as a prolific seed producer (Joshi 1991). The study on allelochemical constituents released from *P. hysterophorus* revealed that sesquiterpene lactones (parthenin) and phenolics (Swaminathan et al., 1990) affect other plants growth (Batish et al., 2002). It is proved that *P. hysterophorus* is the cause of allergy; prolonged skin contact can result in allergenic eczematous dermatitis, while inhalation of pollen can cause allergenic rhinitis which can lead to bronchitis and asthma (Tower & Rao 1992). A survey by Shabbir & Javaid (2010) revealed that *P. hysterophorus* is becoming a dominant weed with the highest values of relative density and frequency as well as affecting Maize growth. It has replaced the indigenous flora including useful medicinal herbs. It is an aggressive weed and is a huge threat to the environment and biodiversity (Pandey et al., 1993). Its pollens inhibit fruit set in crops such as tomato, brinjal, beans and capsicum, and reduces grain filling in cereals (e.g. Maize, Sorghum) (Towers & Rao 1992).

**Grasses**

Among many invading grasses *C. dactylon* and *E. indica* and *S. halepense* are found wildly and are grazed by animals. *S. halepense* is an old introduction in Pakistan and found in sugarcane, maize, and wheat crop fields (Marwat et al., 2010). A report is presented by Riar et al., (2011) that *S. halepense* is a problematic weed in the USA and it is becoming resistant to Glysophate (herbicide).

## Conclusions

In this study, we enlisted and identified the invasive and alien species from the Potohar regions. The invasive alien plant species problem is getting worse and the environmental, economic, social risk, and negative impact on the natural flora and fauna are increasing day by day. These invasive alien species should not be ignored by the government and environmental interest groups. These invasive plant species are present in a specific region and countrywide, causing problems that required national and local solutions. Some, of the studied species, are naturalized and overtake the native flora. Additionally, some of the invasive species cause an allelopathic effect on other plant groups and suppress the growth of the native natural flora of the region. Therefore, national and regional policymakers are advised to take bold steps to encounter the spread of invasive species, to prevent local ecological imbalance in Pakistan flora.

## References

Altaf H., Zarif M., 2003. Invasive alien tree species: A threat to biodiversity. Pakistan Journal of Forestry 53, 127-141.

Ambika S.R., Poornima S., Palaniraj R., Sati S.C., Narwal S.S., 2003. Allelopathic plants. 10. *Lantana camara* L. Allelopathy Journal 12(2), 147-162.

Bansal G.L., 1988. Allelopathic effect of aqueous extracts of stem and leaves of three tree species on the germination of some crops and weeds. Trends in Tree Sciences 10, 119-123.

Batish D.R., Singh H.P., Kohli R.K., Saxena D.B., Kaur S., 2002. Allelopathic effects of parthenin against *Avena fatua* and *Bidens pilosa*. Environmental and Experimental Botany 47, 149-155.

Calder I., Dye P., 2001. Hydrological impacts of invasive alien plants. Land Use & Water Resources Research 1, 1-12.

Colautti R.I., MacIsaac H.J., 2004. A neutral terminology to define 'invasive' Species. Diversity and Distribution 10, 135-141.

Coblentz B.E., 1990. Exotic Organisms: A Dilemma for Conservation Biology. Conservation Biology 4(3), 261-265.

Coulloudon B., Podborny P., Eshelman K., Rasmussen A., Gianola J., Robles B., Habich N., Shaver P., Hughes L., Spehar J., Johnson C., Willoughby J., Pellant M., 1999. Sampling Vegetation Attributes. Edited, designed, and produced by the Bureau of Land Management's National Applied Resource Sciences Center.

Day M.D., Wiley C.J., Playford J., Zalucki M.P., 2003. Lantana: Current Management, Status and Future Prospects. Australian Centre for International Agricultural Research, Canberra. ACIAR Monographs 102, 1-128.

Dobhal P.K., Kohli R.K., Batish D.R., 2010. Evaluation of the impact of *Lantana camara* L. invasion, on four major woody shrubs, along Nayar river of Pauri Garhwal, in Uttarakhand Himalaya. International Journal of Agricultural and Biological 2(7), 155-161.

Dogra S.K., Kohli R.K., Sood S.K., Dobhal P.K., 2009. Impact of Ageratum conyzoides L. on the diversity and composition of vegetation in the Shivalik hills of Himachal Pradesh (Northwestern Himalaya), India. International Journal of Biodiversity and Conservation 1(4), 135-145.

Donaldson S., 2011. Identification and Management of Puncturevine (*Tribulus terrestris* L.). Fact Sheet FS-03-34. University of Nevada Cooperative Extension.

Dukes J.S., Mooney H.A., 2004. Disruption of ecosystem processes in western North America by invasive species. Revista chilena de historia natural 77, 411-437.

Fatimah H., Ahmad T., 2009. Phenology of *Parthenium hysterophorus* – a key factor for the success of its invasion. Advances in Environmental Biology 3(2), 150-156.

Georgia Invasive Species Task Force. 2005. Invasive Weeds in Georgia.

Hashim, S., Bakht, T., Marwat, K. B., & Jan, A. (2014). Medicinal properties, phytochemistry and pharmacology of *Tribulus terrestris* L.(Zygophyllaceae). Pakistan Journal of Botany 46(1), 399-404.

IUCN Pakistan Website, http://www.iucn.org/asia/pakistan/countries/pakistan.

Joshi S., 1991. Interference effects of *Cassia uinflora* Mill. on *Parthenium hysterophorus* L. Plant and Soil 132, 213-218.

Khan I., Marwat K.B., Khan I.A., Ali H., Dawar K., Khan H., 2011. Invasive weeds of Southern districts of KPK- Pakistan. Pakistan Journal of Weed Science Research 17(2), 161-174.

Keller R.P., Geist J., Jeschke J.M., Kühn I., 2011. Invasive species in Europe: ecology, status, and policy. Environmental Sciences Europe 23, 1-17.

Kempen H.M., Graf. J. 1981. Weed seed production. Proceedings of the Western Society of Weed Science 34, 78-81.

Kohli R.K., Batish D.R., Singh H.P., Dogra K.S., 2006. Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Lantana camara* L.) in India. Biological Invasions 8(7), 1501-1510.

Kong C.H., Hu F., Xu T., Lu Y.H., 1999. Allelopathic potential and chemical constituents from volatiles of *Ageratum conyzoides* L. Journal of Chemical Ecology 25, 2347-2356.

Latombe G., Pyšek P., Jeschke J.M., Blackburn T.M., Bacher S., Capinha C., Costello M.J., Fernández M., Gregory R.D., Hobern D., et al., 2016. A vision for global monitoring of biological invasions. Biological Conservation (213), 295-308.

Lewis W.H., Vinay P., Zenger V.E., 1983. Airborne and Allergenic Pollen of North America. London: Johns Hopkins University Press, Baltimore.

Mandal L., 2012. Yellow Oleander-*Thevetia peruviana*-Poisoning. Postgraduate Medical Journal of National Academy of Medicine Sciences 12(2), 52-55.

Marwat K.B., Hashim S., Ali H., 2010. Weed management: A case study from North-west of Pakistan. Pakistan Journal of Botany 42, 341-353.

Más E.G., Lugo-Torres M.D., 2013. Universidad de Puerto Rico, University of Puerto Rico, Recinto Universitario de Mayagüez/Mayagüez Campus. USDA Servicio de Conservación de Recursos Naturales. Natural Resources Conservation Service. pp. 395. Área del Caribe/Caribbean.

Milton S.J., 2004. Grasses as invasive alien plants in South Africa. South African Journal of Science 100, 69-75.

Mishra A.K., Mir S.A., Sharma M.P., Singh H., 2014. Alien Plant species in Dehli Flora. International Journal of Geology, Earth & Environmental Sciences 5 (2), 128-140.

Mooney H.A., Hobbs R.J., 2000. Invasive species in a changing world: The interaction between global change and invasives. Invasive Alien Species (Eds by H.A. Mooney, R.N. Mack, J.A. McNeely, L.E. Neville, P.J. Schei and J.K. Wagge), pp. 310-331. Island Press, Covelo & London, Washington.

Negi P.S., Hajra P.K., 2007. Alien flora of Doon Valley, Northwest Himalaya. Current Science 92(7), 10.

Pandey D.K., Kauraw L.P., Bhan W.M., 1993. Inhibitory effect of Parthenium (*Parthenium hysterophorus*) residue on

growth of water hyacanth (*Eichhornia crassipes* Mart Solms. II): Effect of leaf residue. Journal of Chemical Ecology 19, 2651-2662.

Qaiser M., 1973. Cannabaceae, in Flora of West Pakistan (Eds by E. Nasin and S.I. Ali) pp. 1-5. Department of Botany, University of Karachi, Karachi, Pakistan.

Rashid K., Rasul G., 2011. Rainfall Variability and Maize Production over the Potohar Plateau of Pakistan. Pakistan Journal of Meteorology 8(15), 63-74.

Rashid M., Abbas S.H., Rehman A., 2014. The impact of highly alien invasive plants in Pakistan and their impact on the ecosystem: a review. Innovare Journal of Agricultural Science 2(1), 1-4.

Reddy C.S., 2008. Catalogue of invasive alien flora of India. Life Science Journal 5(2), 84-89.

Reichard S.H., White P., 2001. Horticulture as a Pathway of Invasive Plant Introductions in the United States Most invasive plants have been introduced for horticultural use by nurseries, botanical gardens, and individuals. BioScience 51, 103-113.

Riar D.S., Norsworthy J.K., Johnson D.B., Scott R.C., Bagavathiannan M., 2011. Glyphosate Resistance in a Johnsongrass (*Sorghum halepense*) Biotype from Arkansas. Weed Science 59(3), 299-304.

Saxena S., Rawat D.S., Rao P.B., 2020. *Malvastrum coromandelianum* (L.) Garcke: An Invasive Weed with Multiple Ethnopharmacological Properties. International Journal of Pharmacognosy and Phytochemical Research 12(1), 16-22.

Shabbir A., Javaid A., 2010. Phytosocoilogical survey and allelopathic effects of *Parthenium* weed in comparison to other weeds in Pakistan. Indian Journal of Agricultural Research 44(2), 119-124.

Sharma G.P., Raghubanshi A.S., 2007. Effect of *Lantana camara* L. cover on local depletion of tree population of the Vindhiyan tropical dry deciduous forest of India. Applied Ecolgy and Environmental Research 5(1), 109-121.

Shinwari M.I., 2008. The study of advanced taxonomic and conservation techniques applying on plant species with toxic or other biologically functional ingredients implied to market as well as environment. Post-Doctoral Research-Study Final Technical Report.

Singh T.B., Das A.K., Singh P.K., 2015. Study of Alien and Invasive Flora of Valley District of Manipur and Their Control. International Journal for Innovative Research in Science & Technology 1(12), 616-626.

Swaminathan C., Vinaya R.S., Suresh K.K., 1990. Allelopathic effects of *Parthenium hysterophorus* L. on germination and seedling growth of a few multi-purpose trees and arable crops. International Tree Crops Journal, 6, 2-3.

Towers G.H.N., Rao P.V.S., 1992. Impact of the pan-tropical weed, *Parthenium hysterophorus* L. on human affairs. *In*: Richardson, R.G. (Eds) Proceedings of the 1st International Weed Control Congress, Melbourne, Australia. pp. 134-138. Weed Science Society of Victoria. Melbourne

Voller J., McNay R.S., 2007. Problem Analysis: Effects of Invasive Species on Species at Risk in British Columbia. Report for FORREX.

Wagh V.V., Jain A.K., 2015. Invasive alien flora of Jhabua district, Madhya Pradesh, India. International Journal of Biodiversity and Conservation 7(4), 227-237.

Wang C.M., Chen C.H. 2013. *Digera muricata* (L.) Mart. (Amaranthaceae), a newly naturalized genus and species in Taiwan. Taiwania 58(3), 194-198.

Weaver Susan E. 2001. "The biology of Canadian weeds. 115. *Conyza canadensis*." Canadian Journal of Plant Science 81(4), 867-875.

Weber E., Sun S.G., Li B., 2008. Invasive alien plants in China: diversity and ecological insights. Biological Invasions 10, 1411-1429.

Wiesner M., Taye T., Hoffmann A., Wilfried P., Buettner C., Mewis I., Ulrichs C., 2007. Impact of the Pan-Tropical weed *Parthenium hysterophorus* L. on human health in Ethiopia. "Utilisation of diversity in land use systems: Sustainable and organic approaches to meet human needs", Tropentag, October 9-11, Witzenhausen.

Wu S.H., Hsieh C.F., Chaw S.M., Rejmánek M., 2004. Plant invasions in Taiwan: insights from the flora of casual and naturalized alien species. Diversity & Distribution 10, 349-362.

Zahid D.M., Ahmad R., 2002. Effect of age of Farm-grown Eucalyptus on seasoning quality of wood and its utilization in Pakistan. International Journal of Agriculture and Biology 4, 315-317.

## Appendix

List of the Invasive Alien Plant species (IAPS) present in the Potohar Plateau.

| Botanical Name | Family Name | Accession Number | Common Name | Life form | Origin in World | Reference for Origin | Invaded Habitats | Invasion Status | Reason for Introduction |
|---|---|---|---|---|---|---|---|---|---|
| *Achyranthes aspera* L. | Amaranthaceae | 114459 | Puth Kanda | Herb | South East Africa | Singh et al., (2015) | WL, RS, CF | III | Med |
| *Ageratum conyzoides* L. | Asteraceae | 66405 | Jangli gobhi | Herb | South America | Singh et al., (2015) | WL, RS, CF, CB | IV | Med |
| *Alternanthera pungens* Kunth. | Amaranthaceae | 11493 | Ghuroo Saag | Herb | South America | Mishra et al., (2014) | WL, RS | IV | Med |
| *Amaranthus viridis* L. | Amaranthaceae | 11439 | Jungli Chulai | Herb | South America | Weber et al., (2008) | WL, RS | III | Edi |
| *Anagllis arvensis L.* | Primulaceae | 98351 | Phooli | Herb | Europe | Wagh and Jain (2015) | G, WL | III | Med |
| *Asclepias curassavica* L. | Asclepiadaceae | 71787 | None | Herb | South America | Weber et al., (2008) | G | I | Orn |
| *Bougainvillea glabra* Chois. | Nyctaginaceae | 88341 | Boganvilla Bail | Woody vine | Brazil | Negi and Hajra (2007) | G | I | Orn |
| *Broussonetia papyrifera* Vent. | Moraceae | 114569 | Jangli Shahtoot | Tree | China | Negi and Hajra (2007) | RS, WL | V | Aff |
| *Calotropis procera* (Aiton.) R. Br. | Asclepiadaceae | 43669 | Akk | Shrub | South Africa | Wagh and Jain (2015) | WL, G | IV | Med |
| *Cannabis sativa* L. | Cannabaceae | 65904 | Bhang | Bushy Herb | Central Africa | Mishra et al., (2014) | WL, RS | V | Ind, Med |
| *Cassia occidentalis* L. | Fabaceae | 87320 | Kasumba | Shrub | South America | Singh et al., (2015) | WL, G | IV | Med |
| *Cestrum nocturnum* L. | Solanaceae | 98329 | Raat ki raani | Shrub | West Indies | Negi and Hajra (2007) | G, RS | II | Orn |
| *Chenopodium ambrosioides* L. | Chenopodiaceae | 129045 | Mushki Baathu | Herb | South America | Shinwari (2008) | WL, RS, CF | III | Edi |
| *Conyza bonariensis* (L.) Cronquist | Asteraceae | 68425 | Loosan Buti | Herb | South America | Weber et al., (2008) | WL, RS, CB | IV | Uk |
| *Conyza canadensis* (L.) Cronquist | Asteraceae | 67932 | Loosan Jhaari | Herb | Europe/South America | Shinwari (2008) | WL, RS, CB | IV | Uk |
| *Commelina benghalensis* L. | Commelinaceae | 76263 | Neela Phool | Herb | Africa | Singh et al., (2015) | WL, CB | III | Uk |
| *Consolida ambigua* (L.) Ball & Heywood | Ranunculaceae | 126793 | Asbarg | Herb | Mediterranean | Negi and Hajra (2007) | WL, RS, G | IV | Orn |
| *Cynodon dactylon* (L.) Pers. | Poaceae | 149031 | Khabbal | Grass | Africa | Singh et al., (2015) | WL, RS | III | Med |
| *Digera muricata* (L.) Mart. | Asteraceae | 65853 | Tar rara/ Tandla | Herb | North America | Mishra et al., (2014) | WL, RS, G | III | Med |
| *Datura inoxia* Mill. | Solanaceae | 590371 | Dhatura | Bushy Herb | South America | Mishra et al., (2014) | G, WL | II | Orn |
| *Duranta repens* L. | Verbenaceae | 142856 | Peeli Baar | Shrub | Mexico | Negi and Hajra (2007) | WL, RS, G | IV | Fod |
| *Eleusine indica* (L.) Gaertn. | Poaceae | 149453 | Madhana ghaas | Grass | South Africa | Milton (2004) | RS, WL | V | Med, Aff |
| *Eucalyptus camaldulensis* Dehnh. | Myrtaceae | 69262 | Sufaida | Tree | Australia | Singh et al., (2015) | RS | III | Fod |
| *Gomphrena serrata* C. Martius | Amaranthaceae | 11893 | Chhota Murgha | Herb | South America | Mishra et al., (2014) | RS, WL | IV | Orn |
| *Hamelia patens* Jacq. | Nyctaginaceae | 79205 | Laal jharri | Shrub | Brazil | Negi and Hajra (2007) | RS, G | II | Orn |
| *Hibiscus rosa- sinensis* L. | Malvaceae | 86341 | Baadshah Pasand | Shrub | China | Negi and Hajra (2007) | RS, G | III | Orn, Aff |

| Botanical Name | Family Name | Accession Number | Common Name | Life form | Origin in World | Reference for Origin | Invaded Habitats | Invasion Status | Reason for Introduction |
|---|---|---|---|---|---|---|---|---|---|
| *Jacaranda mimosifolia* D.Don | Bignoniaceae | 33691 | Neelum Jacaranda | Tree | Brazil | Negi and Hajra (2007) | WL, RS, G | III | Orn |
| *Jasminum mesnyi* Hance. | Oleaceae | 134796 | Peeli Chambeli | Shrub | China | Negi and Hajra (2007) | WL, RS, G | III | Orn |
| *Jatropha integerrima* Jack. | Euphorbiaceae | 86319 | Jatrofa | Shrub | China | Negi and Hajra (2007) | G | II | Orn |
| *Lagerstroemia indica* L. | Lythraceae | 13689 | Haar singhaar | Shrub | China | Negi and Hajra (2007) | WL, RS, G | V | Orn |
| *Lantana camara* L. | Verbenaceae | 13775 | Phoolbakri | Shrub | South America | Weber et al., (2008) | G, WL, RS | III | Orn, Med |
| *Ligustrum lucidum* Ait. f. | Oleaceae | 235760 | Dum Dum Baar | Shrub | China | Negi and Hajra (2007) | WL, RS, G | IV | Med |
| *Malvastrum coromandelianum* (L.) Garcke | Malvaceae | 37585 | Kraanti | Herb | South America | Mishra et al., (2014) | WL, RS | IV | Med |
| *Martynia annua* L. | Martyniaceae | 36558 | Bicchwa | Bushy Herb | South America | Mishra et al., (2014) | G, WL, RS | III | Med |
| *Melia azedarach* L. | Meliaceae | 263859 | Dharaik | Tree | Iran | Negi and Hajra (2007) | WL, RS, G | II | Orn |
| *Mirabilis jalapa* L. | Nyctaginaceae | 237584 | Gul-e-Abbasi | Bushy Herb | Peru | Shinwari (2008) | WL, RS, G | II | Orn |
| *Nerium oleander* L. | Apocynaceae | 39576 | Kanair | Shrub | China | Shinwari (2008) | G, RS | II | Med |
| *Ocimum americanum* L. | Lamiaceae | 13904 | Tulsi/ Niaz-bo | Herb | South America | Wagh and Jain (2015) | WL, RS, G | IV | Edi |
| *Oxalis corniculata* L. | Oxalidaceae | 98753 | Khatti Buti | Herb | Europe | Mishra et al., (2014) | WL, G | V | SB |
| *Parthenium hysterophorus* L. | Asteraceae | 65285 | Gajar Ghaas | Bushy Herb | North/South America | Mishra et al., (2014) | WL, RS, CB, G | I | Edi, Aff |
| *Phoenix dactylifera* L. | Arecaceae | 67329 | Khajoor | Tree | North Africa | Negi and Hajra (2007) | G | II | Orn |
| *Quisqualis indica* L. | Combretaceae | 234784 | Jhumka Bail | Woody vine | Malaysia | Negi and Hajra (2007) | WL, RS, G | IV | Med, Ind |
| *Riccinus communis* L. | Euphorbiaceae | 137883 | Arand | Shrub | Africa | Wagh and Jain (2015) | WL, RS, G | IV | Fod |
| *Sorghum halepense* (L.) Pers. | Poaceae | 34128 | Baru | Grass | Mediterranean | Milton (2004) | WL, RS, CB, G | III | Med |
| *Sonchus oleraceus* L. | Asteraceae | 66835 | Jangli Soraj Mukhi | Herb | Mediterranean | Mishra et al., (2014) | WL, RS, CB, G | III | Uk |
| *Stellaria media* (L.) Merr. | Caryophyllaceae | 78384 | Gandal | Herb | Europe | Singh et al., (2015) | WL, G | II | Orn |
| *Tecoma stans* (L.) Juss. ex Kunth | Bignoniaceae | 24876 | Tekoma | Shrub | South America | Negi and Hajra (2007) | WL, RS, G | II | Orn, Aff |
| *Thevetia peruviana* (Pers.) K. Schum. | Apocynaceae | 27858 | China Kanair | Tree | South America | Negi and Hajra (2007) | WL, RS, G | IV | Med |
| *Tribulus terrestris* L. | Zygophyllaceae | 73589 | Bhakra/ Ghokru | Herb | South America | Mishra et al., (2014) | WL, RS, G | IV | Fod |
| *Verbena officinalis* L. | Verbenaceae | 37859 | Sagoon | Herb | North Africa | Singh et al., (2015) | WL, RS, G | IV | Med |
| *Xanthium strumarium* L. | Asteraceae | 66492 | Cheeru | Bushy Herb | Europe | Mishra et al., (2014) | WL, RS | IV | Med |

**Invaded Habitats:** WL: Wastelands, RS: Roadsides, CF: Crop fields, CB: Canal banks, G: Gardens.

**Invasion Status:** I: Adventives/Temporary, II: Escaped from cultivated lands, III: Casual/Transient/Waif, IV: Naturalized/Spreading/Established/ Colonizing, V: Invasive/Noxious/Nuisance/pest/weed (Colautti and MacIsaac 2004).

**Reason for Introduction:** Med: For medicinal uses, Edi: Being edible, Ind: For industrial use, Aff: For afforestation, SB: For soil binding near water canals, Orn: As ornamental plant, Fod: As fodder for domestic animals, Uk: Unknown.