
STUDIES ON DIVERSITY AND ECOLOGY OF INVASIVE ALIEN FLORA IN MORADABAD DISTRICT

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ABSTRACT

A survey of invasive alien plant species in Moradabad was made and we found a total richness of 91 species belonging to 33 families. Dicots represented 81 species and monocots 10 species. About 46.15% of these alien species were introduced from tropical America followed Africa and South America. Maximum number of species (17) were from the family Asteraceae, followed by Amaranthaceae (9) and Euphorbiaceae (6) while grasses represented by 6 species. Herbs accounted for 58 species, undershrubs 5 species, shrubs 10 species, climbers 5 species, and Trees 5, whereas Grasses and Sedges represented 6 and 2 species respectively. The data revealed that both aquatic and terrestrial invasive plant species are becoming threat to the native flora as they reproduce rapidly and crowding out native species. Most of species are used for medicinal purpose in local area.

Keywords: Importance value index (IVI), invasive alien species (IAS), Uses, Moradabad.

1. INTRODUCTION

Plant invasions have been recognized as one of the most serious global processes impacting the structure, composition, and function of natural and semi-natural ecosystems. Invasive species are good at exploiting bare soil and empty niches. Invasive species are generally non-natives that infest natural ecosystems, including forest, rangelands, and pastures (Kommidi et al., 2021). Once the alien plants are established in the natural habitats, they adversely destroy the indigenous flora by competing with them for habitat and nutrients (Naidu et al., 2015). The invasion of alien species into various places is recognized as a major cause of loss of biodiversity, after habitat destruction (Reddy, 2008). These plant species that move from one geographical region to the other, establish and proliferate there and threaten native ecosystem, habitats and species are known as invasive alien plants (Hulme, 2009; Pysek et al. 2004). The invasive plants are also known as alien, exotic or introduced ones, which are new to a specific area, become dominant, replacing /substituting the native plant species.

Invasive Alien Plant Species (IAPS) exhibit greater abundance, density, or competitive dominance than species native to habitats (Sharma et al., 2005). Once established, early detection of spreading pattern and eradication of IAPS is more cost effective than long term control. Invasive plants species are the second most important threat to global biodiversity (Bhatt et al., 2011). India is likely to be prone to plant invasions due to several historical and geographical factors. Many natural and human created migration routes opened possibilities for invasion by alien species, and long-

lasting human influence, which diversified the already naturally heterogeneous landscape mosaic, created suitable habitats for alien species (Bogaert et al., 2014; Mehraj et al., 2018).

2. HISTORY OF INVASIVE ALIEN ANGIOSPERMS IN INDIA

The British brought *Lantana camara* L. to India in 1807 as an ornamental plant at the East India Botanical Gardens in Calcutta (now Kolkata). *Pontederia crassipes* Mart, (formerly known as *Eichhomia crassipes*) was brought to Bengal as an ornamental aquatic plant from South America during the British colonial era. Trees such as *Leucaena leucocephala* (Lam.) de Wit and *Prosopis juliflora* L. was introduced under various forestry programmes in 1877, from England to southern India as a substitute fuel wood tree (Maheshwari, 1963). *Ageratum conyzoides* L. has been found before 1882 in India which is evident from 'The British Flora of India' (Hooker, 1882). *Parthenium hysterophorus* L. was introduced accidentally from Tropical America and was first documented by R.S. Rao (1951) in Maharashtra (Fig.1). Pandey et al. (2009) reported that the seeds of *Ambrosia trifida*, *Cenchrus tribuloides*, *Cynoglossum officinale*, *Solanum carolinense* and *Viola arvensis* have entered in India along with wheat imported by government of India in 2006-07 from Europe, Russia, Australia and Canada.

3. DEFINITION OF INVASIVE ALIEN SPECIES

As per National Invasive Species Information Centre (NISIC) USA, Executive Order 13112 (Section 1. Definitions) an "*invasive species*" is a species that is: (1) non-native (or alien) to the ecosystem under consideration and, (2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

IUCN defines Invasive Alien Species as "*an alien species which becomes established in natural or semi-natural ecosystems or habitat, an agent of change, and threatens native biological diversity*".

According to **Wildlife Protection Act, 1972** (amended in 2022), in India, Invasive Alien Species are defined as "*non-native species posing a threat to wildlife or habitats*".

The definitions adopted by Decision VI/23 of the Conference of the Parties to the Convention on Biological Diversity at its sixth meeting, The Hague, 7–19 April 2002 (**CBD 2002**) are as follows: "*invasive alien species means an alien species whose introduction and/or spread threaten biological diversity*".

According to **Wittenberg et al. (2005)** Alien species- "*a species introduced outside its natural distribution*".

Invasive alien species (IAS): "*an alien species which threatens ecosystems, habitats and species*". These are addressed under Article 8(h) of the CBD.

4. STATUS OF INVASIVE ALIEN SPECIES IN INDIA

The first detailed study regarding invasive alien species in India was conducted by Reddy et al. (2008) and reported terrestrial herbaceous weeds (e.g. *Ageratum conyzoides* and *Parthenium hysterophorus*), shrubs (e.g. *Lantana camara* and *Chromolaena odorata*) trees (e.g. *Prosopis juliflora* and *Leucaena leucocephala*), vines (e.g. *Mikania micrantha*) and aquatic plants (e.g.

Pontederia crassipes (formerly known as *Eichhornia*) have created havoc in a number of habitats in India. After that Sankaran et al. (2009) listed *Chromolaena odorata*, *Lantana camara*, *Mikania micrantha* and *Mimosa diplotricha* as the major invasive alien plants in India. Reshi and Khuroo (2012) reported the occurrence of 1,599 alien plant species belonging to 841 genera in 161 families in India, and the alien flora thus represents 8.5 % of the total Indian vascular flora. There are several other reports available that provide information on the invasive flora of a particular region/area of India (Khanna, 2009; Joshi and Rawat, 2011; Chandra Sekar, 2012; Lal et al., 2012; Moktan & Das, 2013; Surendra et al., 2013; Srivastava et al., 2014; Kumar & Bihari, 2015; Wagh and Jain, 2015; Sekar et al., 2015; Beena et al., 2016; Naithani et al., 2017; Sheikh and Dixit, 2017; Inderjit et al., 2018; Panda et al., 2018; Mallick et al., 2019; Nayak et al., 2019; Khuroo et al., 2021; Wani et al., 2022).

5. STUDY AREA (MORADABAD)

Moradabad is a district of state of Uttar Pradesh which lies under the Gangetic plain region at latitude 28.51N and longitude 78.48E and covers an area of 3493 sq.km. Moradabad is also known as 'Pital Nagari' as it is famous for Brassware Industries and is named after the son 'Murad' of Shahjahan. There are four tehsils Bilari, Kanth, Moradabad, Thakurdwara and eight blocks namely, Moradabad, Mundapandey, Bhagatpur Tanda, Bilari, Kundarki, Chajlet, Thakurdwara and Dilari in Moradabad District (Fig.1). During summers the temperature is usually from 44.2 °C to 30 °C and during winters it ranges from 25 °C to 3.2 °C. Vegetation is highly dependent on rainfall, which is, in most cases, seasonal and erratic. The average rainfall varies between 800 to 900 mm. The relative humidity is up to 90% in monsoon season and in drier part of the year it decreases to less than 20%.

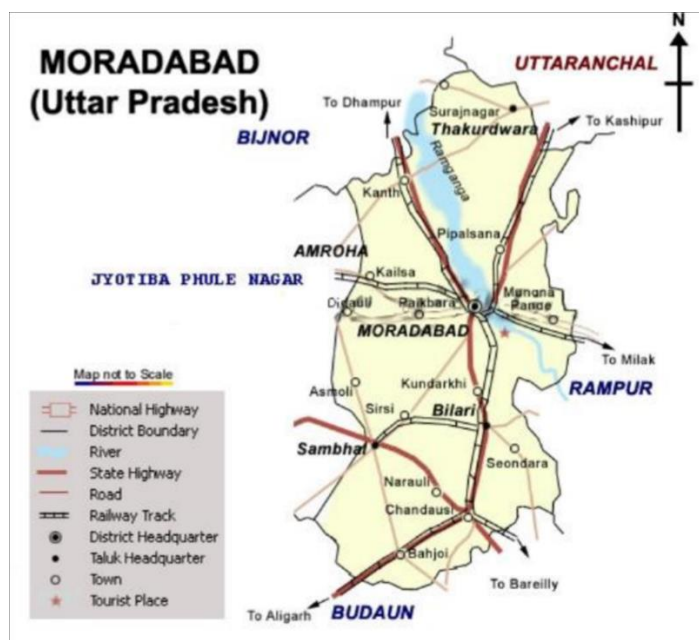


Fig.1. Location map of study area

6. METHODOLOGY

Intensive field studies were carried out in a planned manner repeatedly in different seasons in 2024 in order to get maximum representation of invasive alien species. The collected specimens were identified with the aid of standard literature; Invasive Alien Flora of India (Mallick et al., 2019) and Invasive Alien Angiosperms of Uttar Pradesh (Khanna, 2009). The native ranges of the species were recorded from internet resources (e.g., <http://www.hear.org/pier/> and <http://www.invasivespeciesinfo.gov/plants/main.html>) and published literatures. Plants were categorized by habit (herb, shrub, climber), by longevity (annual, biennial, perennial), and literature were reviewed for their potential uses. Frequencies and distribution of each identified IAPS for separate habitat type were counted in quadrates of 1 m² (size 1 m×1 m) and 4 m² (size 2 m×2 m) that were placed at an interval of 30 m for herbs and shrub species, respectively. Randomly total of 140 quadrates were taken, Relative Density (RD in %) and Relative Frequency (RF in %), and Relative Abundance (RA in %) were calculated to calculate IVI for each species using the following formulae:

$$\text{Relative Frequency (RF, \%)} = \frac{\text{Frequency of individual species}}{\text{Sum of the frequencies for all species}} \times 100$$

$$\text{Relative Density (RD, \%)} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100$$

$$\text{Relative Abundance (RA, \%)} = \frac{\text{Abundance of individual species}}{\text{Total abundance of all species}} \times 100$$

$$\text{Importance value index (IVI)} = \text{RF} + \text{RD} + \text{RA}$$

7. RESULTS

Phytosociological study of the Invasive alien flora in Moradabad reveals altogether of 91 species belonging to 33 families (Table- 1& Fig.2). Species diversity of Invasive alien plants showed that the study area was highly disturbed. The highest Importance Value Index (IVI) was found for *Parthenium hysterophorus* L. followed by *Ageratum conyzoides* L. (73.24) and aquatic herb, *Pontederia crassipes* Mart. showed maximum IVI (62.26) as compared to others. *Cynodon dactylon* (L.) Pers. has been found in almost all quadrats (Table-2). Family Asteraceaceae is the most dominant family with 17 species (13.18%) of contribution followed by Amaranthaceae (9.89%) and Euphorbiaceae and Poaceae (6.59%) each (Fig-3). About 46.15% of these alien species were introduced from Tropical America followed by Africa (13.18%) and Tropical South America (9.89%). Analysis of habit shows that herbs dominate with 58 species followed by shrubs with 10 and grass with 6 species (Table-2 & Fig-4). Various uses of Invasive alien species by local people of Moradabad have been mentioned in Fig-5.



Fig.1. Parthenium hysterophorus 2. Ageratum conyzoides 3. Lantana camera
4. Gompherna celosioides 5. Argemone mexicana 6. Ipomoea carnea
7. Conyza canadensis 8. Saccharum spontaneum 9. Croton bonplandianum

Table. 1. Invasive Alien Flora of Moradabad district

S. No	Species	Family	Life Form	Habit	Uses	Nativity
1.	<i>Abelmoschus esculentus</i> Moench.	Malvaceae	Sh	P	F, M	As
2.	<i>Acacia farnesiana</i> (L.) Willd	Mimosaceae	T	P	Av	TSA
3.	<i>Acanthospermum hispidum</i> DC.	Asteraceae	H	A	M	Br
4.	<i>Aerva javanica</i> (Burm.f.) Juss. ex Schult.	Amaranthaceae	H	P	M	TA
5.	<i>Achyranthes aspera</i> L.	Amaranthaceae	H	A	M	AF
6.	<i>Ageratum conyzoides</i> L.	Asteraceae	H	A	M	TA
7.	<i>Ageratum houstonianum</i> Mill. Gard.	Asteraceae	H	A	M, O	TA
8.	<i>Alternanthera philoxeroides</i> (Mart.) Gri.	Amaranthaceae	H	P	M, Veg	TA
9.	<i>Alternanthera pungens</i> Kunth.	Amaranthaceae	H	P	F, M	TA
10.	<i>Alternanthera tenella</i> Colla, Mem. Acad.	Amaranthaceae	H	A/P	M	TA
11.	<i>Alternanthera sessilis</i> (L.) R.Br. ex DC.	Amaranthaceae	H	P	M	TA
12.	<i>Alstonia scholaris</i> (L.) R.Br.	Apocynaceae	T	P	Av, Fu	AF
13.	<i>Amaranthus spinosus</i> L.	Amaranthaceae	H	P	F, M	TA
14.	<i>Anagallis arvensis</i> L.	Primulaceae	H	A	M	Eu
15.	<i>Antigonon leptopus</i> Hook. & Arn.	Polygonaceae	Cl	P	O	TA
16.	<i>Argemone mexicana</i> L.	Papaveraceae	H	A	M	TSA
17.	<i>Bidens pilosa</i> L.	Asteraceae	H	A	F, M	TA
18.	<i>Blainvillea acmella</i> (L.) Philipson	Asteraceae	H	A	M, P	TA

19.	<i>Blumea lacera</i> (Burm.f.) DC.	Asteraceae	H	A	M	TA
20.	<i>Calotropis gigantea</i> (L.) R.Br.	Asclepiadaceae	Sh	P	Av, M	AF
21.	<i>Calotropis procera</i> (Ait) R.Br.	Asclepiadaceae	Us	P	M	AF
22.	<i>Cannabis sativa</i> L.	Cannabinaceae	Us	P	F, M	As
23.	<i>Catharanthus pusillus</i> (Murray) G.Don	Apocynaceae	H	A	M	TA
24.	<i>Catharanthus roseus</i> (L.) G.Don	Apocynaceae	Us	P	O, M	WI
25.	<i>Cardamine trichocarpa</i> Hochst. ex A. Rich.	Brassicaceae	H	A	F, Fo	TA
26.	<i>Celosia argentea</i> L.	Amaranthaceae	H	A	M	AF
27.	<i>Cenchrus purpureus</i> (Schumach.) Morrone	Poaceae	G	P	Fo, T	TA
28.	<i>Chamaesyce hirta</i> (L.) Millsp.	Euphorbiaceae	H	A	M	TA
29.	<i>Chenopodium album</i> L.	Chenopodiaceae	H	A	M, Veg	Eu
30.	<i>Chloris barbata</i> Sw.	Poaceae	G	P	Fo, Fu	TA
31.	<i>Chrozophora rotleri</i> (Geig) Spreng.	Euphorbiaceae	H	A	NK	AF
32.	<i>Cleome gynandra</i> L.	Cleomaceae	H	A	M	TA
33.	<i>Cleome viscosa</i> L.	Cleomaceae	H	A	Veg, M	TA
34.	<i>Conyza canadensis</i> (L.) Cronq.	Asteraceae	H	A	M	SA
35.	<i>Corchorus tridens</i> L.	Tiliaceae	H	A	Veg, M	AF, Aus
36.	<i>Croton bonplandianus</i> Boil.	Euphorbiaceae	H	P	M	SA
37.	<i>Cuscuta campestris</i> Yunck.	Cuscutaceae	Cl	P	M	NA
38.	<i>Cuscuta reflexa</i> Roxb.	Cuscutaceae	Cl	P	M	MR
39.	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	H	P	Fo, M	TA
40.	<i>Cyperus difformis</i> L.	Cyperaceae	Sg	A	M	TA
41.	<i>Cyperus iria</i> L.	Cyperaceae	Sg	A	M	TA

42.	<i>Datura innoxia</i> Mill.	Solanaceae	Sh	P	M	TA& M
43.	<i>Digera muricata</i> (L.) Mart.	Amaranthaceae	H	A	Fo, M	NA
44.	<i>Echinochloa colona</i> (L.) Link	Poaceae	G	A	Fo	TSA
45.	<i>Echinochloa crus-galli</i> Beauv	Poaceae	G	A	Fo	TSA
46.	<i>Echinops echinatus</i> Roxb.	Asteraceae	H	A	M	As
47.	<i>Eclipta prostrata</i> (L.) Mant.	Asteraceae	H	P	M	TA
48.	<i>Emilia sonchifolia</i> (L.) Dc.	Asteraceae	H	A	M	AF
49.	<i>Euphorbia cyathophora</i> Murray	Euphorbiaceae	Us	A	O, M	TA
50.	<i>Euphorbia thymifolia</i> L.	Euphorbiaceae	H	A	M	TA
51.	<i>Ficus benjamina</i> L.	Moraceae	T	P	Av	As, Aus
52.	<i>Galinosoga parviflora</i> Cav.	Asteraceae	H	A	M	TA
53.	<i>Gomphrena celosioides</i> Mart.	Amaranthaceae	H	P	M	TA
54.	<i>Gnaphalium polycaulon</i> Pers.	Asteraceae	H	A	M	TA
55.	<i>Grangea maderaspatana</i> (L.) Poir.	Asteraceae	H	A	M	TSA
56.	<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	Sh	P	O, M	TA
57.	<i>Ipomoea pes-tigridis</i> L.	Convolvulaceae	Cl	A	M	AF
58.	<i>Lantana camara</i> L.	Verbenaceae	Sh	P	O, Fu	TA
59.	<i>Melilotus alba</i> Medik. ex Desr.	Papilionaceae	H	A	M	Eu
60.	<i>Mikania micrantha</i> Kunth	Asteraceae	CL	P	M	TA
61.	<i>Mimosa pudica</i> L.	Mimosaceae	H	A/P	O, M	Br
62.	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	H	A	O, M	P
63.	<i>Nymphaea mexicana</i> Zucc.	Nymphaeaceae	H	A	O, M	M
64.	<i>Parthenium hysterophorus</i> L.	Asteraceae	H	A	M, T	TNA
65.	<i>Peristrophe paniculata</i> (Forssk.) Brum.	Acanthaceae	H	A	M,	TA
66.	<i>Phyllanthus niruri</i> L.	Euphorbiaceae	H	A	M	AF

67.	<i>Pontederia crassipes</i> Mart.	Pontederiaceae	H	P	O	TA
68.	<i>Portulaca oleracea</i> L.	Portulacaceae	H	A	M, Veg.	TCA
69.	<i>Prosopis juliflora</i> (Sw.) DC.	Mimosaceae	T	P	Fu, F, M	M
70.	<i>Ricinus communis</i> L.	Euphorbiaceae	Sh	P	Av, M	AF
71.	<i>Ruellia tuberosa</i> L.	Acanthaceae.	H	A	O, M	TA
72.	<i>Saccharum spontaneum</i> L.	Poaceae	G	A	Fu, Fo T	A
73.	<i>Senna alata</i> (L.) Roxb.	Caesalpiniaceae	Sh	P	Av	M
74.	<i>Senna obtusifolia</i> (L.) Irwin & Barn.	Caesalpiniaceae	Us	P	M, F	TA
75.	<i>Senna occidentalis</i> (L.) Link.	Caesalpiniaceae	Sh	A	M	SA
76.	<i>Senna tora</i> L.	Caesalpiniaceae	H	A/P	F, M, P	TSA
77.	<i>Sesbania bispinosa</i> (Jacq.) W.Wight	Papilionaceae	Sh	A/P	M, Fo, F	TA
78.	<i>Sida acuta</i> Burm.f.	Malvaceae	H	A	M	TA
79.	<i>Solanum americanum</i> Miller,	Solanaceae	H	A	M	TA
80.	<i>Solanum torvum</i> Sw.	Solanaceae	Sh	P	M	WI
81.	<i>Sonchus asper</i> (L.) Hill.	Asteraceae	H	A	M, Veg	MR
82.	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	H	A	M	WI
83.	<i>Tribulus terrestris</i> L.	Zygophyllaceae	H	A	M	TA
84.	<i>Tridax procumbens</i> L.	Asteraceae	H	P	M	TCA
85.	<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	H	A	M	TA
86.	<i>Typha angustifolia</i> L.	Typhaceae	H	P	T, Fu, Fo	TA

87.	<i>Urena lobata</i> L.	Malvaceae	Sh	P	O, M,Fu	TA
88.	<i>Vernonia cinerea</i> L.	Asteraceae	H	A	M	TSA
89.	<i>Veronica anagallis-aquatica</i> L.	Scrophulariaceae	H	A/P	M	AF, Eu
90.	<i>Xanthium strumarium</i> L.	Asteraceae	H	A	M, Fu	TA
91.	<i>Youngia japonica</i> (L.) DC.	Asteraceae	H	A	M, F	TSA

Nativity: AF=Africa, Aus=Australia, As= Asia, Br=Brazil, Eu= Europe, TA= Tropical America, TSA= Trop. South America, Er=Eurasia, M=Mexico, MR=Mediterranean region, P=Peru, WI=West Indies

Uses: Av=avenue, Fo= fodder, Fu=fuel, F=food, M= medicinal, O=ornamental, Veg= vegetable, P=pesticide, T= thatching

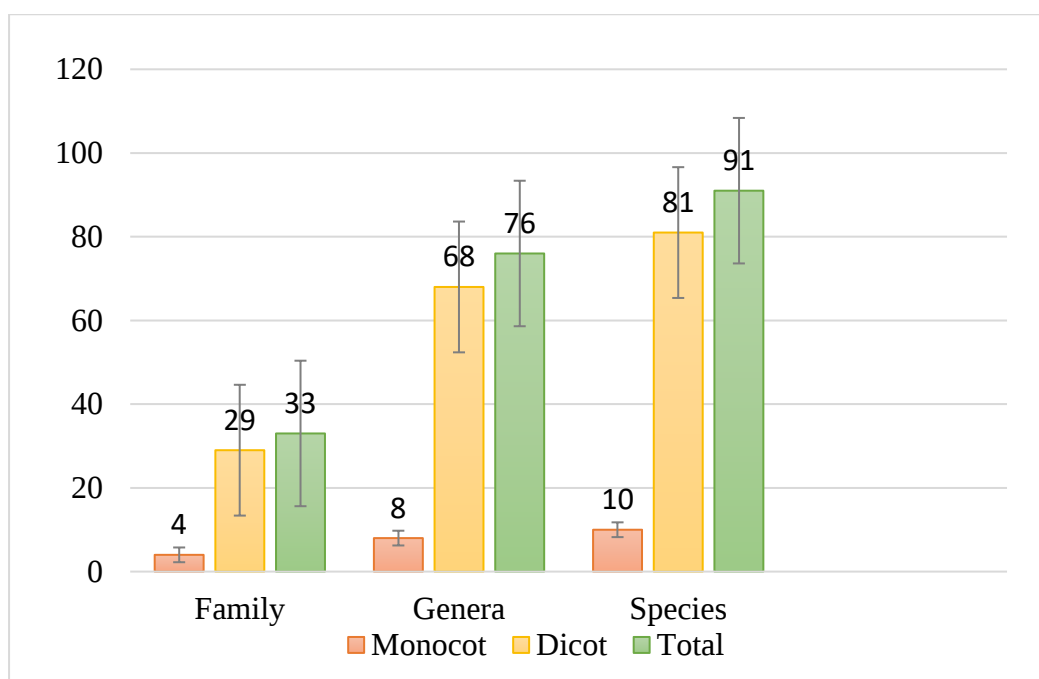


Fig.2 - Families, Genera and Species of Invasive Alien flora in Moradabad

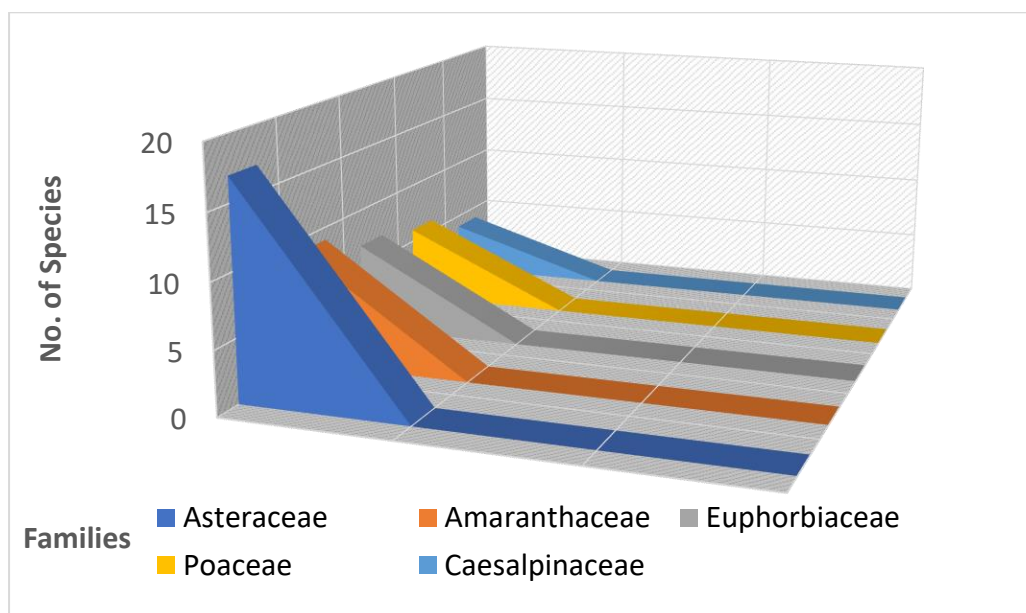


Fig.3. Top five Families of invasive alien plants in Moradabad

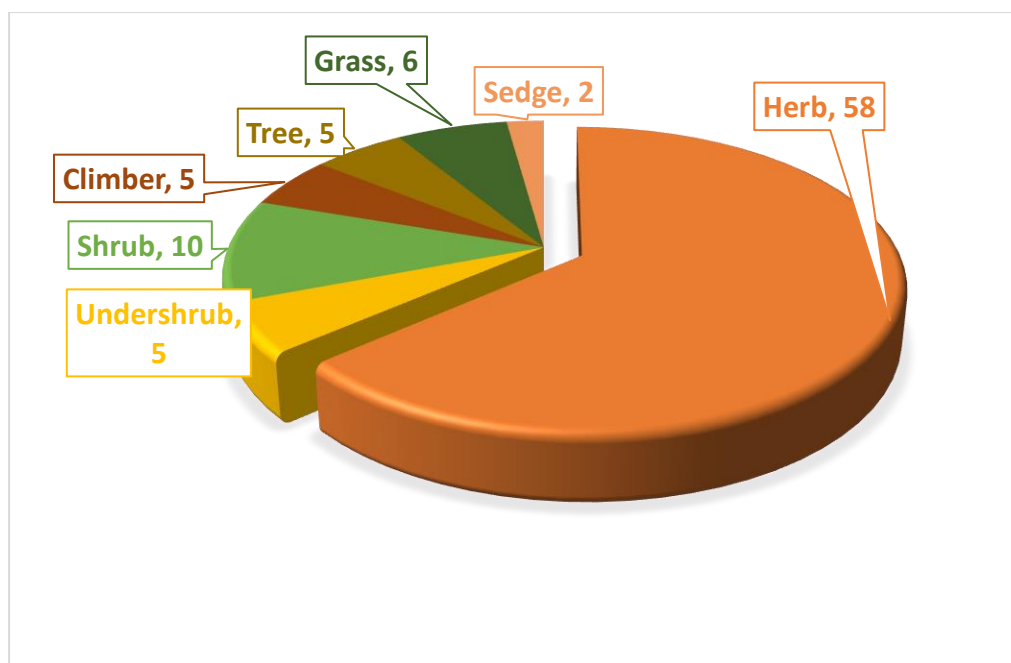


Fig.4. – Life Form of Invasive alien flora in Moradabad

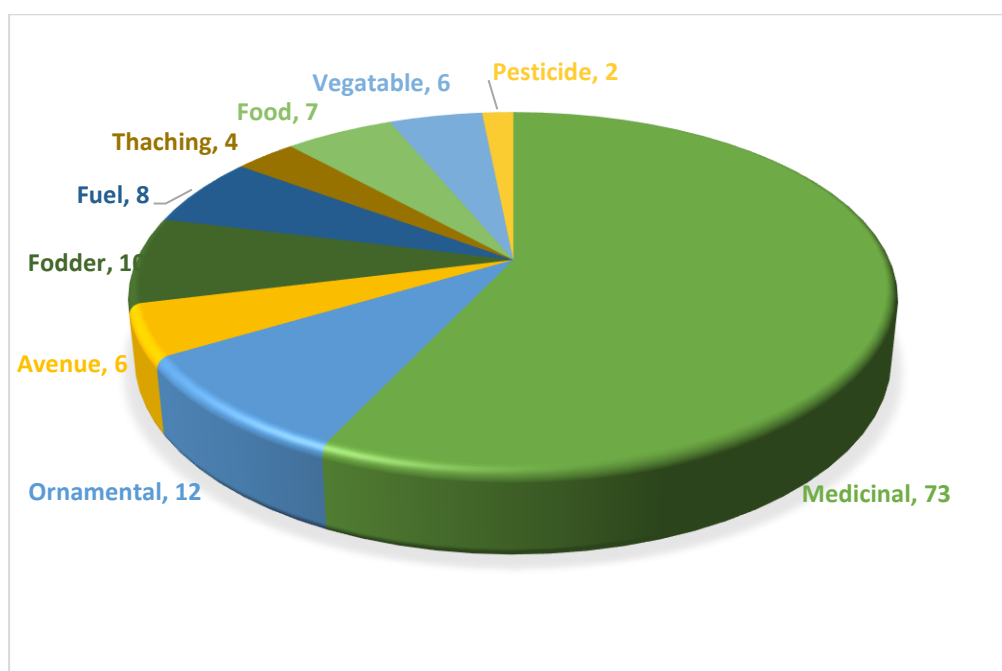


Fig.5.-Various uses of Invasive alien flora in Moradabad

Table. 2. Ecology of top fifteen invasive alien species in Moradabad

S.N.	Species	RD	RF	RA	IVI
1.	<i>Parthenium hysterophorus</i> L.	40.38	26.13	30.38	96.89
2.	<i>Ageratum conyzoides</i> L.	38.68	13.38	21.18	73.24
3.	<i>Cynodon dactylon</i> (L.) Pers.	34.98	16.90	19.98	71.86
4.	<i>Pontederia crassipes</i> Mart.	24.06	16.38	21.82	62.26
5.	<i>Antigonon leptopus</i> Hook. & Arn.	21.56	18.18	21.56	61.30
6.	<i>Tridax procumbens</i> L.	20.38	16.13	20.38	56.88
7.	<i>Lantana camara</i> L.	22.31	11.97	15.58	49.86
8.	<i>Amaranthus spinosus</i> L.	13.98	19.35	13.58	46.91
9.	<i>Cenchrus purpureus</i> (Sch.) Mor.	10.70	2.58	10.70	42.98
10.	<i>Mikania micrantha</i> Kunth	14.28	12.90	14.98	42.11
11.	<i>Senna tora</i> L	14.37	9.09	14.37	37.83
12.	<i>Ruellia tuberosa</i> L.	13.78	9.79	13.14	36.72
13.	<i>Ricinus communis</i> L.	11.92	9.65	12.10	33.67
14.	<i>Alstonia scholaris</i> (L.) R.Br.	12.29	9.68	9.79	31.76
15.	<i>Prosopis juliflora</i> (Sw.) DC.	8.54	9.22	8.29	26.05

8. CONCLUSION

Biological invasions are one of the most important ecological disturbances that threaten native biodiversity. It is noteworthy that such aliens have not only disturbed the environment and ecosystems but have also threatened the indigenous flora of the state as a number of plants are getting rare. There is every possibility that if the invasion of aliens will continue to operate unchecked in the study area, some species may get extinct, and the germplasm of economic plants may become rare or even vanish. Thus, it may be concluded that strict measures both at the governmental and non-governmental levels should be taken up to face the problem of invasive aliens in the study area.

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