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Invasive Alien Plant Species Assessment in Urban Ecosystem: A Case Study from Andhra University, Visakhapatnam, India

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Abstract

This paper highlights the current status of invasive alien plant species in Andhra University Campus of Visakhapatnam district, India, with background information on habit, nativity, longevity, uses and mode of introduction. Data were collected through Phytosociological method. Altogether 21 species belonging to 15 families were documented. The highest Importance Value Index (IVI) was found for Antigonon leptopus. The data show that Wrightia tinctoria is the most frequently encroached tree species by A. leptopus. Species diversity of Invasive alien plants showed that this study area was highly disturbed. Fabaceae is the most dominant family with 3 species (14%) of contribution. About 62% of these alien species were introduced from Tropical America followed by Tropical South America (9%) and Tropical Africa (4%). Analysis of habit shows that herbs dominate (11 species) followed by shrubs (8) and climbers (2). A search in the literature indicated that several of these species have potential uses for different purposes. Similarly, only 5 Species (24%) seem to have been introduced deliberately and the rest of them unintentional through trade exchanges including grain import. However, quantitative impact of these species on the indigenous flora and invaded ecosystems is yet to be studied. There is an urgent need to develop regional data on Invasive Alien Species (IAS) diversity.

Keywords: Andhra university campus, importance value index (IVI), invasive alien species (IAS), Visakhapatnam.

Introduction

According to the Global Invasive Species Program (GISP), "Invasive alien species (IAS) are non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health. Invasive alien species (IAS) are one of the most significant drivers of environmental change worldwide".

Convention for Biological Diversity visualize "biological invasion of alien species as the second worst threat after habitat destruction" and article 8(h) of the Biodiversity Convention asks for measures "to prevent the introduction, control or even eradication of those alien species which threaten ecosystems, habitats or species". Introduction of these species may occur accidently or through their being imported for a limited purpose and subsequently escaping or deliberately on a large scale[1]. Invasive weeds have faster rates of growth and biomass production compared to native species, high competitive ability, high reproductive efficiency including production of a large number of seeds, efficient dispersal, vegetative reproduction, rapid establishment and other traits that help them adapt to new habitats[2,3]. Invasive exotic plants are implicated in the decline of threatened and endangered species, because they alter ecosystem processes, change vegetation structures and displace native species, often because they reach high densities and biomass[4]. Establishment of a database of naturalized species is the first step in the development of invasion biology, and will also serve as a stepping-stone for further detailed studies on the biology and impact of individual species[5]. Therefore, investigation of the spread of alien or exotic species has become an imperative issue in the Indian subcontinent and globally.

Material and Methods

Study Area: Visakhapatnam is a growing city in Andhra Pradesh on the East Coast of India and lies in the northern part of the coast of Coromandel. The Andhra University area under investigation lies between East longitude 83° 15' - 83° 22' and North latitude 17° 14' - 17° 46'and spreads in a sprawling campus of 422 acres. The natural vegetation consists predominantly of dry deciduous and deciduous scrub vegetation. The average temperature is high and uniform and mean annual temperature is approximately 25°C. About 70% of the annual rain is received during South-West monsoon season, average varying from 500-1000mm. Quartzites, quartz veins and red loamy soil are also found in various places of Andhra University. It is of red type and most of it is of least fertile variety.

Data Collection Methods: The study was carried out from December 2012 to April 2013. Data were collected through Phytosociological method. The sampling technique was random sampling. Randomly total of 30 plots were taken, 15 from each North and South campus of Andhra University. In each plot a quadrate of 20*20m was randomly selected. Within this

quadrate, 5*5m quadrates were allocated randomly in two corners for the assessment of shrubs. Likewise herbs regeneration was recorded from nested sampling of 1*1m quadrate within the 5*5m quadrate representing 0.01% intensity. Figure 1, shows the distribution of nested sampling within main quadrate. The detail procedures for making plots have been described by Chhetri (1996)[6].

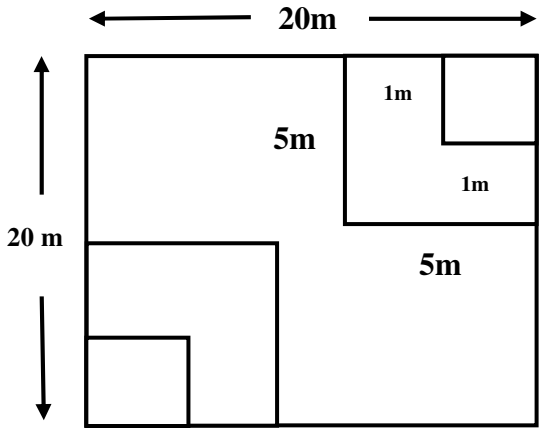


Figure-1
Layout of Quadrates

As part of this study, we focused on building a comprehensive list of alien species. All plant species within each quadrate were identified then counted and estimated their cover percentage. In case of perennial herbaceous climber like *Antigonum leptopus,* nesting sample of 1*1m quadrate were used. In this*, A. leptopus* shoot were considered as a ramet and was counted as an individual[7]. The collected specimens were identified with the aid of standard literature; Invasive Alien Flora of India[8] and Flora of Visakhapatnam[9] and visual inspection by taxonomists. Family classification follows APG III. 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 literature[10-14]. Plants were categorized by habit (herb, shrub, climber), by longevity (annual, biennial, perennial), and literature were reviewed for their potential uses.

Data Analysis: The quantitative characteristic as Importance Value Index (IVI) and the species diversity indices; Margalef's index of richness (SR), Shannon-Weiner's diversity index (H') and Simpson's index (D) were calculated according to Zobel et al. (1987)[15].

Results and Discussion

Phytosociological study of the Invasive Alien flora of Andhra University Campus reveals altogether of 21 species belonging to 15 families. According to Reddy, 2008, there are altogether 173 invasive alien plants which are permanently naturalized in India.

Quantitative structure of Invasive alien plant species: The study shows a massive number of IAS in Andhra University and *Antigonon leptopus* is the most threatening one with the highest Importance Value Index (table-1). This result is verified with some other studies, In Hawaii, *A. leptopus* is commonly cultivated and now sparingly naturalized in disturbed areas[16] making it more dominant. It is the vine nature of *Antigonon leptopus* that causes it to have highest coverage and affect the resource apportionment of other species present. The abundance of seedling and the high levels of recruitment observed in the study area also suggest that it will continue to be dominant in the areas where it is established.

Diversity of Dominance: The dominance diversity curve has been used to interpret the dominance of species in the community in relation to resource apportionment and niche space[17]. Figure 2; shows the dominant species as *Antigonon leptopus* with the IVI 73.257. The dominance diversity curve is very essential to demonstrate resource apportionment and niche space among species over the span of time.

Encroachment of Antigonon on Tree species: Regarding, the invasion ability of *A. leptopus* on tree species, *Wrightia tinctoria is* the tree most severely encroached by *Antigonon leptopus* with 18% of this tree being invaded over the study area. This is very important to document because knowing this will help us preserve that particular tree species along with other animal species dependent on it directly or indirectly. For instance, *Trewia nudifora*, commonly known as Rhino apple tree is being greatly invaded by *Mikania micrantha* in protected area of Nepal[18]. The Indian Rhino (*Rhinoceros unicornis*) which feed on these *Trewia nudifora* fruit is being greatly affected by such invasion. Therefore, this kind of assessment is more important for ecologically diverse area (figure-3).

Diversity Index: The values of Shannon-Wiener index, Simpson's Diversity Index and Species Richness of Invasive alien plant species in Andhra University were 2.306, 0.864 and 3 respectively. These as a whole were showing high evenness of individual type with greater richness and less abundance of particular species. This suggests us that this particular urban ecosystem was highly disturbed providing suitable habitat for variety of alien species and reducing diversity of native one.

Exotic invasion is often associated with declines in local plant diversity[19]. To verify this quantitively in Andhra University Campus, further study on correlation between native species richness and abundance of alien flora should be carried out.

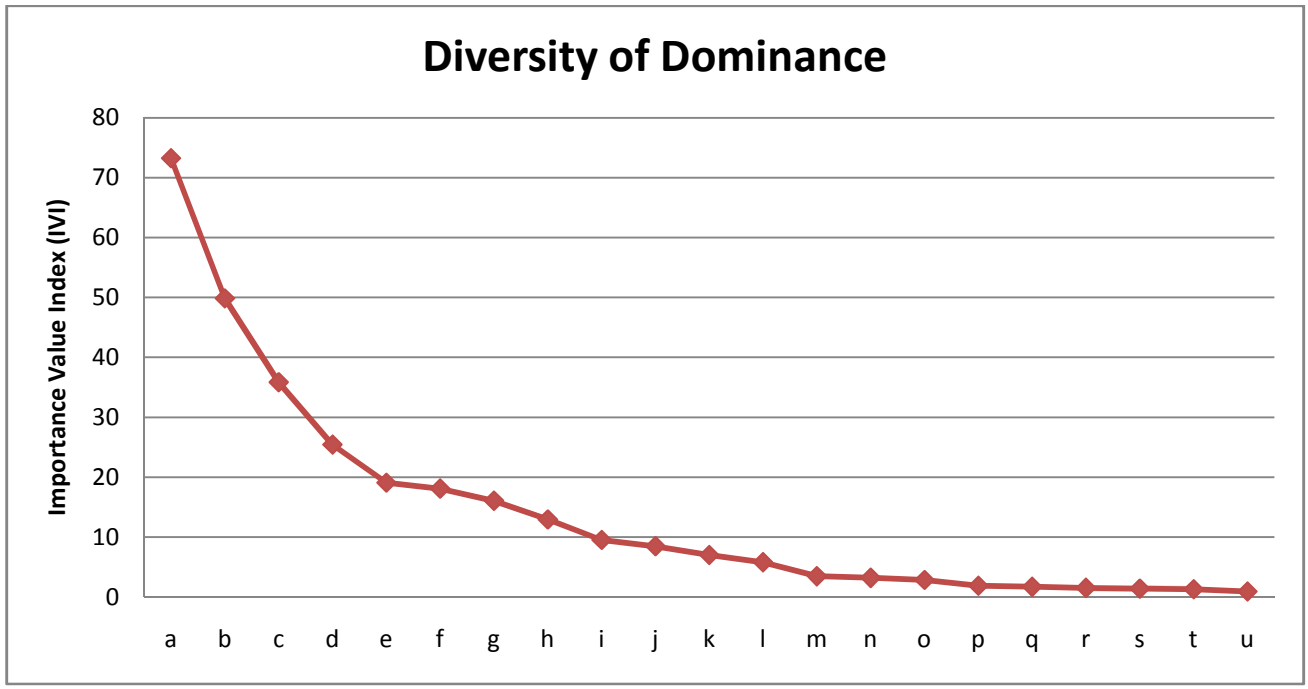
Enumerations of alien species are shown along with habit, nativity, longevity, potential uses and mode of introduction (table-2).

Taxonomic distribution of Alien flora: In the alien flora of the Andhra University Campus, Fabaceae is the most dominant family with 3 species. Similar results were reported from invasive alien flora of Gadag district, Karnataka, where Fabaceae was also found to dominate and it was stated that the dominance of Fabaceae may be due to the nitrogen-fixing bacteria often associated with these taxa, allowing these species to improve the soil fertility[20] (figure-4).

Table-1
Quantitative structure of Invasive alien plant species in Andhra University

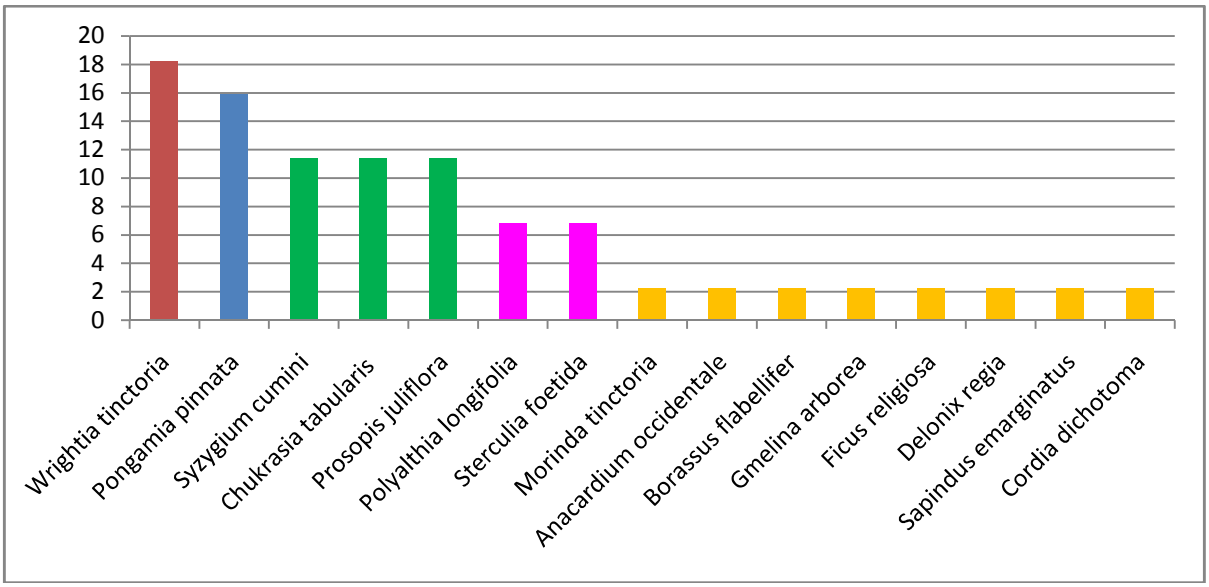
S.N.	Name of Species	Common name	RD	RF	RC	IVI*
1	*Antigonon leptopus*	Mexican creeper	38.688	13.38	21.189	73.257
2	*Sida acuta*	Wire weed	22.311	11.972	15.587	49.87
3	*Cassia occidentalis*	Coffee senna	1.633	16.901	17.34	35.874
4	*Chromolaena odorata*	Siam weed	0.76	11.972	12.713	25.445
5	*Mimosa pudica*	Sensitive plant	8.426	6.338	4.335	19.099
6	*Calotropis gigantea*	Giant milkweed	0.337	11.268	6.503	18.108
7	*Cleome viscosa*	Dog mustard	9.3375	2.113	4.627	16.0775
8	*Dinebra retroflexa*	Viper grass	8.07	2.817	2.07	12.957
9	*Lantana camara*	Lantana	0.195	4.225	5.114	9.534
10	*Hyptis suaveolens*	Wild spikenard	0.399	4.93	3.166	8.495
11	*Parthenium hysterophorus*	Whitetop weed	2.611	2.817	1.607	7.035
12	*Croton bonplandianum*	Ban tulsi	1.661	2.817	1.34	5.818
13	*Datura metel*	Datura	0.033	2.817	0.633	3.483
14	*Alternanthera tenella*	Joyweed	1.78	0.704	0.731	3.215
15	*Argemone mexicana*	Mexican prickly poppy	1.424	0.704	0.731	2.859
16	*Passiflora foetida*	Stinking passion flower	0.593	0.704	0.609	1.906
17	*Cassia alata*	Ringworm cassia	0.043	0.704	0.974	1.721
18	*Cuscuta reflexa*	Sky creeper	0.593	0.704	0.244	1.541
19	*Chloris barbata*	Swollen finger grass	0.593	0.704	0.122	1.419
20	*Gomphrena serrata*	Prostrate Globe Amaranth	0.356	0.704	0.244	1.304
21	*Solanum viarum*	Tropical Soda Apple	0.119	0.704	0.122	0.945

RF- Relative Frequency, RD- Relative Density, RC- Relative Coverage, IVI- Importance Value Index, *Values are presented in the decreasing order of Importance Value Index (IVI)



a- Antigonon leptopus, b- Sida acuta, c- Cassia occidentalis, d- Chromolaena odorata, e- Mimosa pudica, f- Calotropis gigantea, g- Cleome viscosa, h- Dinebra retroflexa, i- Lantana camara, j- Hyptis suaveolens, k- Parthenium hysterophorus, l- Croton bonplandianum, m- Datura metel, n- Alternanthera tenella, o- Argemone mexicana, p- Passiflora foetida, q- Cassia alata, r- Cuscuta reflexa, s- Chloris barbata, t- Gomphrena serrata and u- Solanum viarum.

Figure-2
Diversity of Dominance for alien plant species



**Trees totally covered were only considered.*

Figure-3
Encroachment of Antigonon on Tree species of the Andhra University

Table-2
List of Invasive Alien Plant Species of Andhra University, Their Source Region and Potential Uses

Family	Species	Longevity	Nativity	Habit	Potential uses	Mode of Introduction
Amaranthaceae	*Alternanthera tenella*	P	TA	H	V	UI
	Gomphrena serrata	A	TA	H	M	UI
Apocynaceae	*Calotropis gigantea*	P	AF	S	M	UI
Asteraceae	*Chromolaena odorata*	P	TA	S	BF	O
	Parthenium hysterophorus	A	TNA	H	M	CA
Cleomaceae	*Cleome 82viscosa*	A	TA	H	M	UI
Cuscutaceae	*Cuscuta reflexa*	A	M	H	NK	UI
Euphorbiaceae	*Croton bonplandianum*	A	TS	H	CH	UI
Fabaceae	*Cassia alata*	P	WI	S	O	O
	Cassia occidentalis	A	TSA	S	M	CA
	Mimosa pudica	P	TA	H	O	AP
Lamiaceae	*Hyptis suaveolens*	A	TA	S	FO	UI
Malvaceae	*Sida acuta*	A	TA	H	M	UI
Papaveraceae	*Argemone mexicana*	A	TCSA	H	M	UI
Passifloraceae	*Passiflora foetida*	A	TSA	C	EF	UI
Poaceae	*Chloris barbata*	A	TA	H	FO	UI
	Dinebra retroflexa	A	TA	H	FO	UI
Polygonaceae	*Antigonon leptopus*	P	TA	C	O	O
Solanaceae	*Datura metel*	P	TA	S	M	UI
	Solanum viarum	P	TA	S	M	CA
Verbenaceae	*Lantana camara*	P	TA	S	W	O

Longevity – A = Annual; B = Biennial; P = Perennial; Nativity - TA = Tropical America; TSA = Tropical South America; AF = Tropical Africa; WI = West Indies; M = Mediterranean; TS = Temperate South America; TNA = Tropical North America and TCSA = Tropical Central and South America. Habit - H = Herb; C = Climber; S = Shrub; Potential Uses – M = Medical; O = Ornamental; FO = Fodder; CH = Bioactive Chemical; EF = Edible Fruit; V = Vegetable; W = Wood; BF = Bio-fuel and NK = Unknown. Mode of Introduction – O = Ornamental; UI = Unintentional; CA = Contamination of Agri. Import and AP = Agri. Purpose.

Contribution of Different Geographical Regions: Contribution of different geographical regions in terms of nativity is shown in figure 5. The contribution of tropical America is (62%) noteworthy. The Tropical America contributed 74% of the noxious invasive plants in India[14]. The American continent contributed majority of the noxious invasive plants in Uttar Pradesh10 and also in China[21].

Habit-wise Distribution: The herbs constitute 52% (11 species), shrubs 38% (8 species) and climber 10% (2 species). The habit-wise distribution of alien invasive shown was preponderance of herbs. Habit-wise analysis shows herbaceous species share 151 species of Invasive alien species in India[14]. The herbs having greater vegetative and tolerance to harsh conditions could results in the preponderance of herbs[2] in the allies flora.

Potential Uses of Alien flora: A search in the literature indicated that several of these species have potential uses for different purposes. This can be important for management of these alien floras in sustainable way. Further, local consultation with respect to traditional uses of these alien floras can add important information on this aspect (figure-6).

Possible mode of Introduction of Alien flora: Based on literature, Only 5 Species (24%) seems to have been introduced deliberately and the rest of them unintentionally through trade exchanges including grain import. Many of these species are known invasive elsewhere also. About 80% of species are included in the Global Compendium of Weeds[21] (figure-7).

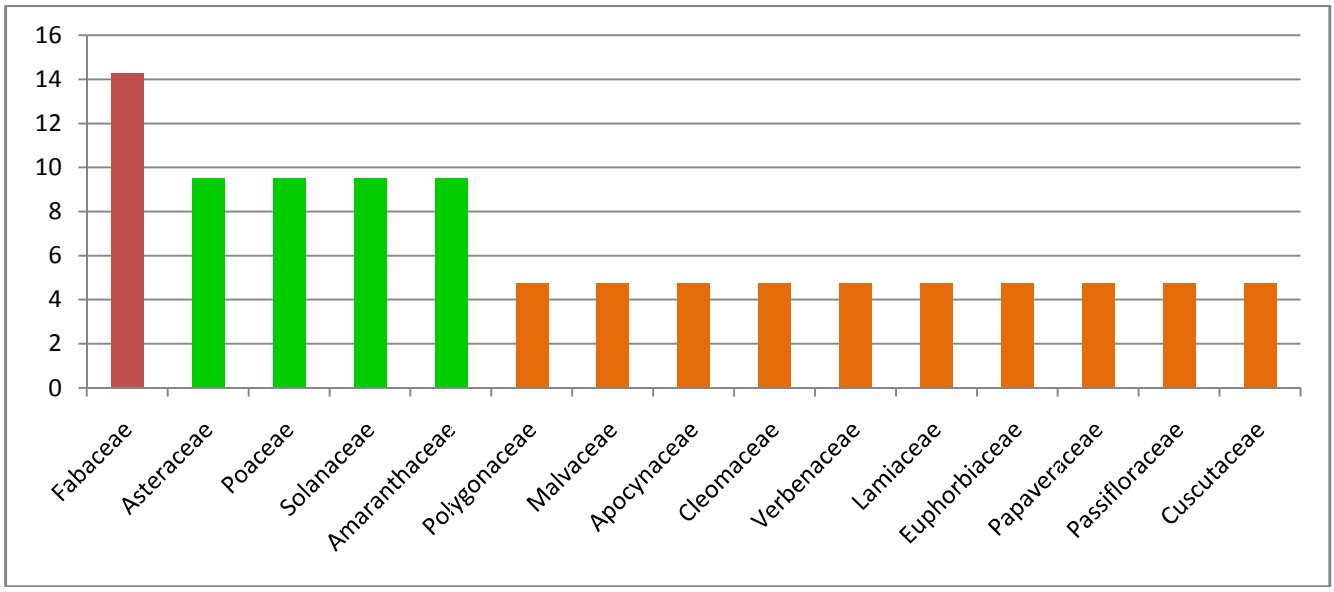


Figure-4
Taxonomic distribution of Alien flora of Andhra University

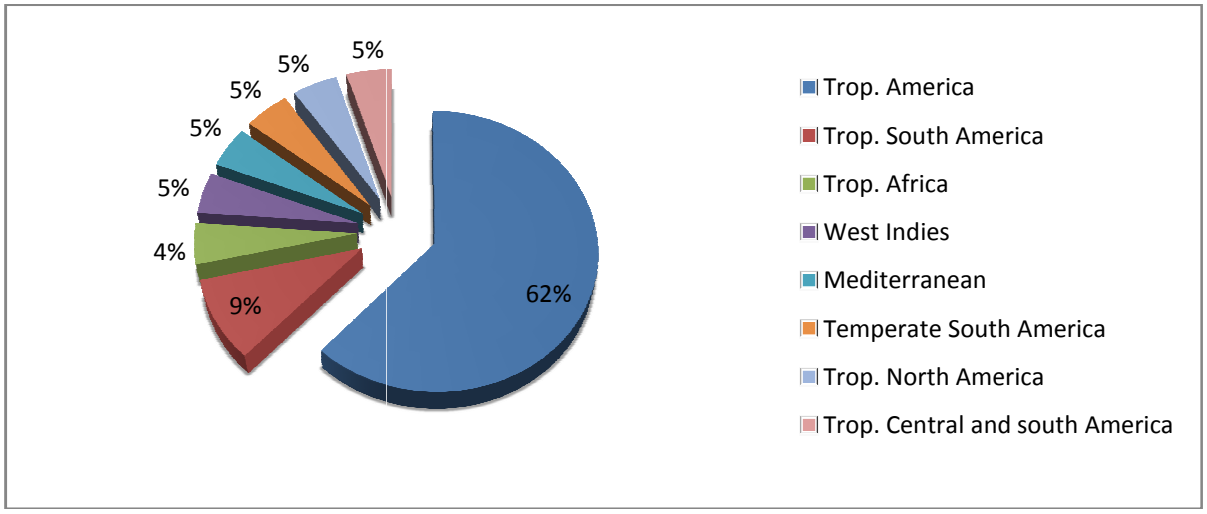


Figure-5
Contribution of Different Geographical Regions to the Invasive Flora of Andhra University

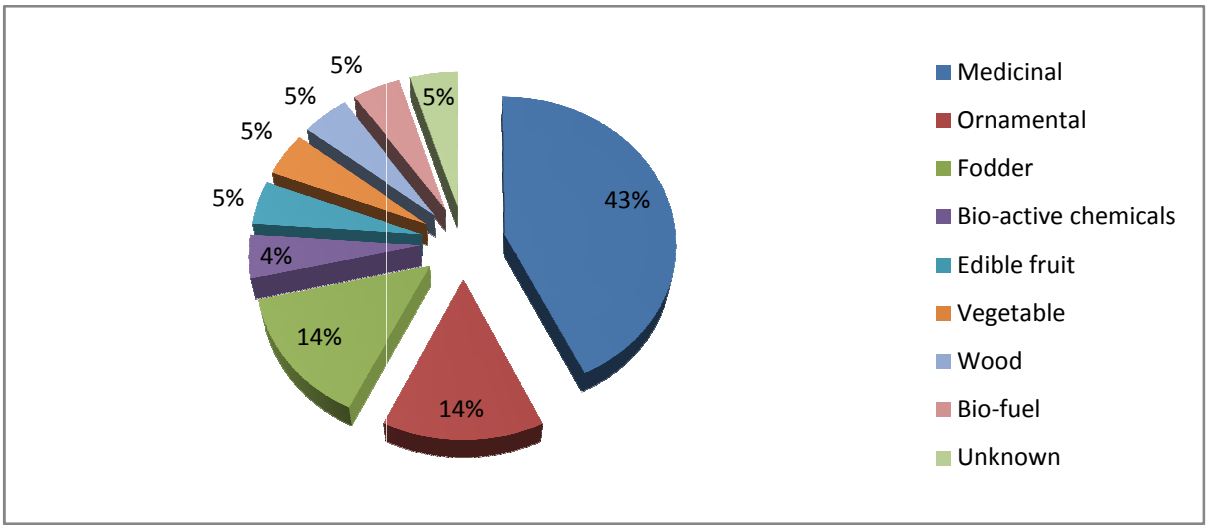


Figure-6
Potential Uses of Alien flora of Andhra University

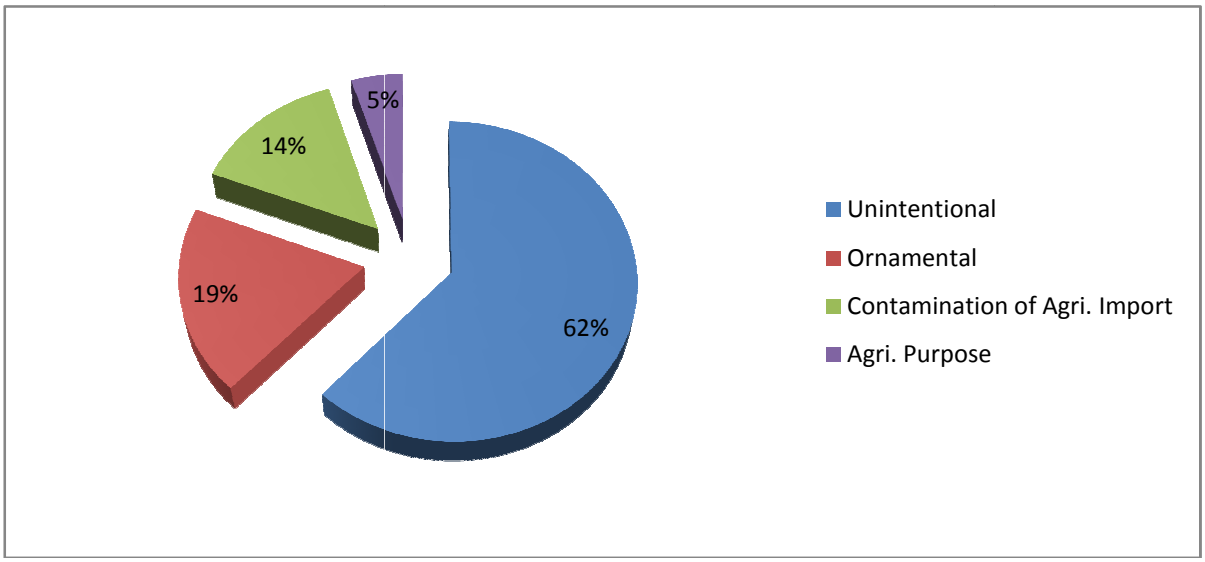


Figure-7
Possible mode of Introduction of Alien flora of Andhra University Campus

Based on field observation along with literature review indicated that the most noxious invasive plant species in the Andhra University Campus are *Antigonon leptopus*, *Lantana camara*, *Chromolaena odorata, Hyptis suaveolens, Cassia occidentalis, Calotropis gigantea* and *Parthenium hysterophorus* which are considered very harmful because of their prolific seed production and ability to spread fast[22]. They have allelopathic effect on other plants thus giving a strong competition to native flora and crops and are also a health hazard to humans and domestic animals. *Antigonon leptopus* damages or kills other plants by cutting out the light and smothering them. In this respect it is especially damaging in young plantations and nurseries. It also competes for water and nutrients.

However, quantitative impact of these species on the indigenous flora and invaded ecosystems is yet to be studies. Studies are also needed to understand their introduction pathway and status as to whether they have been just recently introduced or are now firmly established and also to quantify the severity of invasion in different habitats.

There are four main strategies to control or eradicate invasive species; manual, mechanical, chemical and biological[23]. Often, the success of biological control programs is not clear-cut because complete control is only achieved in some years and or at same localities[24]. Evidently, there is a need for concerted research on suitable and environmental- friendly control measures. CAB International on behalf of Global Invasive

Species Program (GISP) proposes three major management options – prevention, early detection and eradiction[25,26].

Conclusion

Many alien species are introduced deliberately for intended purposes. Nevertheless, a lot of risk is associated with the introduction of new species. Introduction of *Lantana camara*, *Chromolaena odorata, Antigonon leptopus* etc. have now become problematic due to their invasion on natural areas and urban ecosystem such as Andhra University Campus. Even biological control should be undertaken only after critical evaluation of the risks involved. Majority of IAS in India are of neo-tropical origin (South America). This is similar to Andhra University Campus having 62% contribution as majority and has been introduced in India by numerous pathways. The knowledge base on IAS control options is limited. This has resulted into numerous problems experienced only after alien species invasion, which do not seem to have easy solution.

Therefore, there is a need of better planning for early detection and reporting of infestation of spread of new and naturalised weeds by creation of plant detection network in each State by establishing communication links between taxonomists, ecologists and land managers to monitor and control invasive alien species.

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References

1. Levine S.A., Analysis of risk for invasions and control program, *Biological Invasion: A Global Perspective, SCOPE 37* (eds Drake J. A. et al.,), John Wiley, Chichester, UK, 425-435 **(1989)**

2. Sharma G. P., Singh J. S. and Raghubanshi A. S., Plant invasions: emerging trends and future implications, *Curr Sci,* **(88),** 726–734 **(2005)**

3. Simberloff D., Parker I. M. and Windle P. M., Introduced species policy, management and future research needs, *Frontiers of Ecological Environment***, (3)**, 12–20 **(2005)**

4. Denslow J. S., Managing dominance of invasive plants in wild lands, *Curr Sci,* **93(11)**, 1579–1586 **(2007)**

5. Wu S.H., Hsieh C.F. and Rejmanek M., Catalogue of the naturalized flora of Taiwan, *Taiwania*, **49(1)**, 16 – 31 **(2004)**

6. Chhetri N., Design of the forest flora research plots for the project of "Reciprocal relationship between population and environment". Population and Ecology Research Laboratory, Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal **(1996)**

7. Macanawai A.R., Day M.D., Diete T. T. and Adkins S.W., Frequency and density of Mikania micrantha and other weeds in taro and banana systems in eastern Viti Levu, Fiji, Seventeenth Australasian Weeds Conference **(2008)**

8. Reddy C.S., Bagyannarayana G., Reddy K.N. and Raju V.S., Invasive Alien Flora of India.pdf. **(2008)**

9. Kumari G. R., Rao P. S. N. and Subbarao G. V., Flora of Visakhapatnam District, Andhra Pradesh. **Vol. 1**. Botanical Survey of India **(2002)**

10. Seetharam Y. N., Kotresha V.S. and Uplaonkar S. B., Flora of Gulbarga District, Registrar, Gulbarga University, Gulbarga **(2000)**

11. Singh K. P., Shukla A. N. and Singh J. S., State-level inventory of invasive alien plants, their source regions and use potential, *Curr Sci,* **99(1)**, 107–114 **(2010)**

12. Wu S. H., Chaw S. M. and Rejmanek M., Naturalized Fabaceae (Leguminosae) species in Taiwan: the first time approximation, *Botanical Bulletin of Academia Sinica,* **(44)**, 59–66 **(2003)**

13. Paul T. K., The earliest record of *Parthenium hysterophorus* L. (Asteraceae) in India, *Curr Sci,* **98(10)**, 1272 **(2010)**

14. Reddy C.S., Catalogue of Invasive alien flora of India, *Life Science Journal,* **5(2)**, 85-87 **(2008)**

15. Zobel D.B., Yadav U.K., Jha P.K. and Behan M.J., A practical manual for ecology, Rani Printing Press, Kathmandu, Nepal **(1987)**

16. Wagner, Warren L., Herbst, Derral R. and Sohmer S. H., Manual of the flowering plants of Hawaii. Revised edition. Bernice P. Bishop Museum special publication, University of Hawaii Press/Bishop Museum Press, Honolulu **(1999)**

17. Whittakker R.H., Communities and ecosystem. Mc Milan Publishing Company, NewYork **(1975)**

18. Tiwari S., Adhikari B., Siwakoti M. and Subedi K., An Inventory and Assessment of Invasive Alien Plant Species of Nepal, IUCN- The World Conservation Union, Nepal **(2005)**

19. Richardson D.M., Macdonald I. A. W. and Forsyth G.G., Reductions in plant species richness under stands of alien trees and shrubs in the Fynbos biome*, South African forestry Journal,* **(149)**, 1-8 **(1989)**

20. Saldanha C. J., Flora of Karnataka. **Vol. 2**. Oxford & IBH Publishing. Co. Pvt. Ltd., New Delhi, **(1986)**

21. Randall R. P., A Global Compendium of Weeds. R. G. and F. J. Richardson, Melbourne **(2002)**

22. Rajiv P., Narendhran S., Subhash K. M., Sankar A., Rajeshwari S. and Rajendhra V., *Parthenium hysterophorus* L. Compost: Assessment of its Physical properties and Allelopathic effect on Germination and Growth of *Arachis hypogeal* L., *Int. Res. J. Env. Sci.,* **2(2)**, 1-5 **(2013)**

23. Khuroo A. A., Rashid I. and Reshi Z., The alien flora of Kashmir Himalaya, *Biol Invasions*, **(9)**, 269–292 **(2007)**

24. Hobbs R. J. and Humphries S. E., An integrated approach to the ecology and management of plant invasions, *Conservation Biology, (***9**), 761–770 **(1995)**

25. Syrett P., Briese D. T. and Hoffmann J. H., Success in biological control of terrestrial weeds, *Measures of Success in Biological Control*, (Eds S.D. Wratten and G. Gurr), Kluwer, Amsterdam, 189–230 **(2000)**

26. Wittenberg R. and Cock M. J. W., (Eds.) Invasive Alien Species: A Toolkit of Best Prevention and Management Practices, CABI Publication, UK **(2001)**