



## A PRELIMINARY INVESTIGATION ON ALIEN AND NATIVE ELEMENTS IN THE FLORA OF PANTNAGAR, UTTARAKHAND, INDIA

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Globalization of earth's biota is continuously taking place and the process is accelerated by intentional or unintentional anthropogenic activities. In Pantnagar also natural Tarai vegetation is removed for agricultural activities which have resulted in accumulation of many alien elements in cultivation. It has also taken its toll by invasion of the area by 160 alien species outside cultivation. The indigenous flora is gradually being replaced by aliens, particularly invasive aliens. The study indicates that out of total 662 species of seed plants, 462 (69.78%) are aliens. Outside cultivation, a total of 360 species occur of which 160 species (44.45%) are aliens and 200 (55.55%) species are indigenous. American elements are dominant amongst alien species. This high proportion of aliens which includes 60 invasive alien species and 3 world's worst invasive alien species clearly depict the dismal position of natural vegetation. Results indicate that though the agriculture and associated urbanization may not lead directly to reduction in number of species but it certainly lead to reduction in indigenous flora which is out competed by more adaptive alien or invasive alien species in altered habitat.

**Keywords:** Alien plants, flora, indigenous plants, invasive aliens, Pantnagar

Flora of a country, state, district or national park is made up of two types of plants- 'natives' or indigenous plants and 'aliens' also known as exotic plants or introduced plants or non-native plants. None of the flora of the world is exclusively composed of native elements and the percentage of blended alien elements with it simply indicates the 'biological pollution', which may have catastrophic economic and ecological ramifications (McNeely 2001, Carey 2002, Pimental *et al.* 2005). Therefore, compilation of a regional flora, keeping in mind the alien and native elements, is of immediate relevance (Pysek *et al.* 2004), not only for simply analysing the floristic diversity but also for assessing the impact of human activities (intentional or unintentional) in deterioration of the native flora.

In the current scenario of globalization of earth's biota and changing environmental conditions, a close assessment on transfor-

mation of flora is essentially required for early detection and amelioration of detrimental changes which can otherwise severely impair the life-sustaining ecosystem goods and services, which in turn can adversely jeopardize the human welfare (Kaiser 1999). Biological invasion by aliens has been widely ranked as the first or second greatest threat to the global biodiversity (Stiling 2006, Drake *et al.* 1989) and alien species may even alter native habitats and soil properties or processes substantially (Lodge 1993, Van Dyke 2008, Raizada *et al.* 2008). The number of studies dealing with plant invasion is increasing rapidly and invasion ecology is one of the most rapidly developing branches of ecology (Williamson 1996). Plant invasion is a global problem and need global coordination for its effective monitoring and management (McNeely *et al.* 2001, Simberloff *et al.* 2005, Sharma *et al.* 2005). Moreover, in the scenario of climate change many of the aliens may

**Table:1** Families, genera and species of seed plant diversity of Pantnagar

| Groups       | Families   |            | Genera     |            | Species    |            |
|--------------|------------|------------|------------|------------|------------|------------|
|              | No.        | %          | No.        | %          | No.        | %          |
| Dicots       | 92         | 82.14      | 364        | 80.3       | 531        | 80.2       |
| Monocots     | 15         | 13.39      | 83         | 18.3       | 122        | 18.4       |
| Gymnosperms  | 5          | 4.46       | 6          | 1.32       | 9          | 1.35       |
| <b>Total</b> | <b>112</b> | <b>100</b> | <b>453</b> | <b>100</b> | <b>662</b> | <b>100</b> |

become favored aliens and will flourish at the expense of native vegetation (Moore 2004). However, there are a few studies conducted on this aspect from different regions of India, some of the important being Sharma and Pandey (1984), Pandey and Parmer (1994), Nagar *et al.* (2004), Pandey (2000), Khuroo *et al.* (2007) and Negi and Hajra (2007), Singh *et al.* (2010) etc.

Pantnagar is an agriculture dominated area in Tarai tract of Uttarakhand. Tarai tract is a meeting ground of two distinct phytogeographical regions of India i.e. Indo-gangetic plains with intense agriculture, urbanization and industrialization, and the Himalaya which is a global mega hot-spot of biodiversity. Being a transition zone between these two heterogeneous domains, fertile soil with abundance of moisture has sustained rich floristic diversity in the past. But currently due to rapid urbanization, industrialization and ever-spreading intensive agriculture the native vegetation is restricted to protected areas only. In Pantnagar also most of the land is utilized for

agricultural production, house construction and industries. Natural forest does not exist in the area and only a few remnants of native trees observed as isolated individuals along roads, footpaths or at the boundaries of agricultural fields. Thus this area provides a classic environment to study the impact of changed land use in the form of agriculture, urbanization and industrialization vis-à-vis floristic composition and diversity, close observation of which has been presented herewith.

## MATERIAL AND METHODS

The study area is campus of G.B. Pant University of Agriculture and Technology Pantnagar having a perimeter of 28.52 Km. and 10,000 acres of land area, mainly occupied by agricultural fields. Since the inception, the University has been a nucleus of agricultural research in India and credited as harbinger of “Green Revolution” in India (Annon. 2003, 2006). Pantnagar is situated in Tarai tract near the outer hills of Kumaon Himalaya in Udham Singh Nagar district of Uttarakhand state.

**Table: 2** Alien elements and habits in naturally occurring (wild) plants of Pantnagar

| Origin       | No of      |              | Trees     |              | Shrubs    |              | Climbers  |              | Herbs      |              | Aquatic  |              |
|--------------|------------|--------------|-----------|--------------|-----------|--------------|-----------|--------------|------------|--------------|----------|--------------|
|              | spp.       | %            | spp.      | %            | spp.      | %            | spp.      | %            | spp.       | %            | herb, %  |              |
| American     | 74         | 20.55        | 1         | 2.00         | 5         | 15.62        | 6         | 28.57        | 61         | 24.20        | 1        | 20.00        |
| European     | 26         | 7.22         | -         | -            | -         | -            | -         | -            | 26         | 10.31        | -        | -            |
| African      | 22         | 6.11         | 3         | 6.00         | 3         | 9.38         | 1         | 4.76         | 15         | 5.96         | -        | -            |
| Wides        | 22         | 6.11         | 1         | 2.00         | -         | -            | 1         | 4.76         | 20         | 7.94         | -        | -            |
| Asian        | 15         | 4.17         | 1         | 2.00         | -         | -            | -         | -            | 14         | 5.55         | -        | -            |
| Australian   | 1          | 0.28         | -         | -            | -         | -            | -         | -            | 1          | 0.39         | -        | -            |
| Indigenous   | 200        | 55.55        | 44        | 88.00        | 24        | 75.00        | 13        | 61.90        | 115        | 45.63        | 4        | 80.00        |
| <b>Total</b> | <b>360</b> | <b>100.0</b> | <b>50</b> | <b>100.0</b> | <b>32</b> | <b>100.0</b> | <b>21</b> | <b>100.0</b> | <b>252</b> | <b>100.0</b> | <b>5</b> | <b>100.0</b> |

**Table - 3** Invasive Alien Species in the Flora of Pantnagar

| Sl. No | Name of Species                               | Family          | Nativity | Growth Form | Cultivated or Wild    |
|--------|---|-----------------|----------|-------------|-----------------------|
| 1.     | <i>Ageratum conyzoides</i> L.                 | Asteraceae      | American | Herb        | Wild                  |
| 2.     | <i>Antigonon leptopus</i> Hook.& Arn.         | Polygonaceae    | American | Climber     | Cultivated ornamental |
| 3.     | <i>Argemone mexicana</i> L.                   | Papaveraceae    | American | Herb        | Wild                  |
| 4.     | <i>Asclepias curassavica</i> L.               | Asclepiadaceae  | American | Herb        | Cultivated medicinal  |
| 5.     | <i>Asphodelus tenuifolius</i> Cav.            | Liliaceae       | American | Herb        | Wild                  |
| 6.     | <i>Bidens pilosa</i> L.                       | Asteraceae      | American | Herb        | Wild                  |
| 7.     | <i>Blainvillea acmella</i> (L.f.) Philipson   | Asteraceae      | American | Herb        | Wild                  |
| 8.     | <i>Calotropis gigantea</i> (L.) W.T.Aiton     | Asclepiadaceae  | American | Shrub       | Wild                  |
| 9.     | <i>C. procera</i> (Ait.) W.T.Aiton            | Asclepiadaceae  | American | Shrub       | Wild                  |
| 10.    | <i>Cassia alata</i> L.                        | Caesalpiniaceae | American | Shrub       | Cultivated Ornamental |
| 11.    | <i>Cassia occidentalis</i> L.                 | Caesalpiniaceae | American | Herb        | Wild                  |
| 12.    | <i>Cassia tora</i> L.                         | Caesalpiniaceae | American | Herb        | Wild                  |
| 13.    | <i>Celosia argentea</i> L.                    | Amaranthaceae   | American | Herb        | Wild                  |
| 14.    | <i>Euphorbia hirta</i> L.                     | Euphorbiaceae   | American | Herb        | Wild                  |
| 15.    | <i>Euphorbia indica</i> Lam.                  | Euphorbiaceae   | American | Herb        | Wild                  |
| 16.    | <i>Cleome viscosa</i> L.                      | Capparaceae     | American | Herb        | Wild                  |
| 17.    | <i>Corchorus aestuans</i> L.                  | Tiliaceae       | American | Herb        | Wild                  |
| 18.    | <i>Croton bonplandianum</i> Baill.            | Euphorbiaceae   | American | Herb        | Wild                  |
| 19.    | <i>Cuscuta reflexa</i> Roxb.                  | Cuscutaceae     | European | Herb.climb. | Wild                  |
| 20.    | <i>Cyperus difformis</i> L.                   | Cyperaceae      | American | Herb        | Wild                  |
| 21.    | <i>C. iria</i> L.                             | Cyperaceae      | American | Herb        | Wild                  |
| 22.    | <i>Datura metel</i> L.                        | Solanaceae      | American | Shrub       | Wild                  |
| 23.    | <i>Echinochloa colona</i> (L.) Link           | Poaceae         | American | Herb        | Wild                  |
| 24.    | <i>E. crusgalli</i> (L.) P.Beaur.             | Poaceae         | American | Herb        | Wild                  |
| 25.    | <i>Eclipta prostrata</i> (L.) L.              | Asteraceae      | American | Herb        | Wild                  |
| 26.    | <i>Eichhornia crassipes</i> (Mart.) Solm.     | Pontederiaceae  | American | Aq.Herb     | Wild                  |
| 27.    | <i>Emilia sonchifolia</i> (L.) DC.            | Asteraceae      | American | Herb        | Wild                  |
| 28.    | <i>Evolvulus nummularius</i> (L.) L.          | Convolvulaceae  | American | Herb        | Wild                  |
| 29.    | <i>Hyptis suaveolens</i> (L.) Poit.           | Lamiaceae       | American | Herb        | Wild                  |
| 30.    | <i>Imperata cylindrica</i> (L.) Raeusch.      | Poaceae         | American | Herb        | Wild                  |
| 31.    | <i>Ipomoea carnea</i> Jacquin                 | Convolvulaceae  | American | Shrub       | Wild                  |
| 32.    | <i>I. eriocarpa</i> R.Br.                     | Convolvulaceae  | African  | Herb        | Wild                  |
| 33.    | <i>I. pes-tigridis</i> L.                     | Convolvulaceae  | African  | Herb.climb. | Wild                  |
| 34.    | <i>I. quamoclit</i> L.                        | Convolvulaceae  | American | Herb.climb. | Wild                  |
| 35.    | <i>Lagascea mollis</i> Cav.                   | Asteraceae      | American | Herb        | Wild                  |
| 36.    | <i>Lantana camara</i> L.                      | Verbanaceae     | American | Shrub       | Wild                  |
| 37.    | <i>Malvastrum coromandelianum</i> (L.) Garcke | Malvaceae       | American | Herb        | Wild                  |
| 38.    | <i>Martynia annua</i> L.                      | Martyniaceae    | American | Herb        | Wild                  |
| 39.    | <i>Melilotus alba</i> Medik.ex Desr.          | Fabaceae        | European | Herb        | Wild                  |
| 40.    | <i>Melochia corchorifolia</i> L.              | Sterculiaceae   | American | Herb        | Wild                  |
| 41.    | <i>Mimosa pudica</i> L.                       | Mimosaceae      | American | Herb        | Wild                  |
| 42.    | <i>Mirabilis jalapa</i> L.                    | Nyctaginaceae   | American | Herb        | Wild                  |
| 43.    | <i>Nicotiana glauca</i> Viv.                  | Solanaceae      | American | Herb        | Wild                  |
| 44.    | <i>Ocimum americanum</i> L.                   | Lamiaceae       | American | Herb        | Cultivated medicinal  |
| 45.    | <i>Oxalis corniculata</i> L.                  | Oxalidaceae     | American | Herb        | Wild                  |
| 46.    | <i>Parthenium hysterophorus</i> L.            | Asteraceae      | European | Herb        | Wild                  |
| 47.    | <i>Passiflora foetida</i> L.                  | Passifloraceae  | American | Herb.climb. | Wild                  |
| 48.    | <i>Peperomia pellucida</i> (L.) Kunth         | Piperaceae      | American | Herb        | Wild                  |

|     |   |                   |          |       |      |
|-----|---|-------------------|----------|-------|------|
| 49. | <i>Prosopis juliflora</i> (Sw.) DC      | Mimosaceae        | American | Shrub | Wild |
| 50. | <i>Saccharum spontaneum</i> L.          | Poaceae           | Asia     | Herb  | Wild |
| 51. | <i>Scoparia dulcis</i> L.               | Scrophularia ceae | American | Herb  | Wild |
| 52. | <i>Sesbania bispinosa</i> (Jacq.) Wight | Fabaceae          | American | Shrub | Wild |
| 53. | <i>Sida acuta</i> Burm.f.               | Malvaceae         | American | Herb  | Wild |
| 54. | <i>Sonchus asper</i> (L.) Hill          | Asteraceae        | European | Herb  | Wild |
| 55. | <i>Sonchus oleraceus</i> L.             | Asteraceae        | European | Herb  | Wild |
| 56. | <i>Tribulus terrestris</i> L.           | Zygophyllaceae    | American | Herb  | Wild |
| 57. | <i>Tridax procumbens</i> L.             | Asteraceae        | American | Herb  | Wild |
| 58. | <i>Triumfetta rhomboidea</i> Jacq.      | Tiliaceae         | American | Herb  | Wild |
| 59. | <i>Urena lobata</i> L.                  | Malvaceae         | African  | Herb  | Wild |
| 60. | <i>Xanthium indicum</i> Koenig          | Asteraceae        | American | Herb  | Wild |

Geographically, the land area covered by University lies in between the latitudes N 28°59'36"- 29°2'34" and longitude E 79°28'33"- 79°31'12" with an altitude range of 213m-238m above sea level (approx.; based on Google Earth, 2010). The exposure of slope is towards Southwest direction. Phytogeographically it falls in the Gangetic plains (Rao1994, Roy1996) but lies very close to Himalayan hot spot of biodiversity. The soil is quite rich in nutrients and soil pH is around 6.85.

The climate of Pantnagar is distinctly subtropical in nature and rainfall is much influenced by monsoon with nearly 90% precipitation occurring during June-September. Originally, Tarai region harbours sub-montane seasonal broadleaf forests (Singh

and Singh 1992), however, in Pantnagar area natural stands of forests are absent and major part of the area is under cultivation. This clearing of forests led to the absence of native trees, shrubs and predominantly occupied by weeds and grasses in the flora. Obviously the flora of the area is quite different from natural Tarai vegetation.

A complete flora of Pantnagar is not available but preliminary information is published by Rao *et al.* (2003), therefore, to analyze up-to-date information on floristic diversity, field trips were regularly made in different parts of study area and specimens were collected to represent all available species in the year 2008-2009. Identification of collected specimens was done with the help of

**Table-4** Alien elements in the Flora of Pantnagar, India and other regions of India

| Total flora   |                   |                  |                  | Aliens     |                    | Invasive aliens |              |
|---|-------------------|------------------|------------------|------------|--------------------|-----------------|--------------|
| Study area and Reference                                  | Spp.              | Gen.             | Fam.             | Spp.       | %                  | Spp             | %            |
| Delhi (Maheshwari,1963)                                   | 531               | 326              | 92               | -          | 27                 | -               | -            |
| India (Nayar,1977, Reddy <i>et al.</i> 2008)              | 16809             |                  |                  | -          | 18                 | 173             | 0.99         |
| Allahabad (Sharma and Pandey,1984)                        | -                 | -                | -                | 458        | 38                 | -               |              |
| Rajasthan (Pandey and Parmer,1994)                        | -                 | -                | -                | 206        | 11                 | -               |              |
| Barda Hills, Gujrat (Nagar <i>et al.</i> 2004)            | -                 | -                | -                | 154        | 15                 | -               |              |
| Kashmir (Khuroo <i>et al.</i> 2006)                       | -                 | -                | -                | 571        | 29                 | 93              | 4.72         |
| Doon Valley, Uttarakhand (Negi and Hajra 2007, Babu 1977) | 1230 <sup>#</sup> | 624 <sup>#</sup> | 115 <sup>#</sup> | 436        | 19.43 <sup>#</sup> | -               |              |
| Uttarakhand (Uniyal <i>et al.</i> 2007)                   | 4700              | 1503             | 213              | -          | -                  | 129             | 2.74         |
| Uttar Pradesh (Singh <i>et al.</i> 2010)                  | -                 | -                | -                | -          | -                  | 152             | -            |
| <b>Pantnagar (present study)</b>                          | <b>360</b>        | <b>259</b>       | <b>76</b>        | <b>160</b> | <b>44.45</b>       | <b>60</b>       | <b>19.42</b> |

relevant regional floras like Babu (1977), Duthie (1903-1929), Gaur (1999), Maheshwari (1963), Osmaston (1927), Raizada (1976), Flora of India vols 1-5, 12, 13 (Sharma *et al.* 1993, Sharma and Balakrishnan 1993, Sharma and Sanjappa 1993, Hajra *et al.* 1997, Singh *et al.* 2000, Hajra *et al.* 1995a & b), other relevant literature, monographs, revisions, fascicles etc., whereas, ornamentals and exotics were identified with the help of Bailey (1949), Graf (1973, 1992). Identity of doubtful specimens was confirmed by matching them with authentic specimens at Herbarium of Botanical Survey of India, Dehradun (BSD) and Herbarium of Forest Research Institute, Dehradun (DD). Identified plant specimens were processed into herbarium specimens and were submitted to herbarium of Department of Biological Sciences, CBSH, G.B.Pant University of Agriculture and Technology Pantnagar (GBPUAT). Nomenclature of the taxa is adopted as per Uniyal *et al.* (2007), some recent publications and International Plant Name Index ([www.ipni.org](http://www.ipni.org)).

The origin and invasive nature of the plants were determined according to Babu (1977), Bailey (1949), Duthie (1903-1929), Gaur (1999), Graf (1992), Khuroo *et al.* (2006), Negi and Hajra (2007), Rao (1994), Reddy (2008), Sharma and Pandey (1984), and the information available at National Biodiversity Authority website ([www.nbaindia.org](http://www.nbaindia.org)) etc. Nativity of some of the species which are not mentioned in these floras/literature was determined by using the literature available on internet.

## RESULTS AND DISCUSSION

Analysis of the flora indicates that as many as 662 species within 453 genera and 112 families grow in Pantnagar. Out of these 662 species, 531 species in 364 genera and 92 families belong to dicots, 122 species in 83 genera and 15 families belong to monocots and

9 species in 6 genera and 5 families belong to gymnosperms. Dicots are represented by 80.21%, followed with monocots 18.43%, and gymnosperms 1.36% (Table-1). All the collected species were also analyzed for their nativity using authentic literature. Results indicate that only 200 species are indigenous elements, while 462 species are alien elements. These alien species are represented by 148 species of American elements, 58 species of African elements, 50 species of European elements, 11 species of Australian elements, 44 species of 'Wides' (native to more than one continent) and 151 species of Asian elements.

A major part of this floristic diversity (45.62%) is contributed by 302 species of taxa cultivated for various purposes (crops, ornamentals, germplasm collections etc.) in cultivated land, parks or along roads. Remaining 360 species (54.38%) occur as wild plants growing as indigenous taxa, naturalized taxa or weed. However, the cultivated species can not be considered permanent denizens of the area; moreover, there is no record of such species as naturalized in the area. The species occurring outside cultivation (wild plants/perennial flora) are represented by 259 genera under 76 families of angiosperms. The indigenous elements in this permanent flora are represented by 200 species (55.55%) in 169 genera of 60 families. Alien elements numbering 160, (44.45%) are represented by 120 genera and 43 families. Among the aliens, American elements are most abundant and represented by 74 species, followed by 26 European species, 22 African species, 22 Wides, 15 Asian elements (originating outside Indian subcontinent) and 1 Australian species. The Asteraceae have highest number of alien elements (15spp.) followed by the Fabaceae (14spp.), Amaranthaceae (12spp.), Euphorbiaceae (10spp.) and Solanaceae (10spp.).

In the perennial flora of Pantnagar, trees



are represented by only 50 species of which 44 are indigenous, and 6 are naturalized aliens. Similarly 32 species of shrubs are composed of 24 indigenous and 8 alien species, while 21 species of climbers are represented by 13 indigenous and 8 alien species. Out of 252 species of herbs, 115 species are indigenous beside 137 species of alien elements (Table-2).

Among the alien elements, there are many species which are invasive in nature. Invasive alien species are that subset of alien species whose establishment and spread threatens ecosystem, habitats, or species with economic or environmental significance (Mc Neely 2001). Information on invasive alien plants in India is published (Reddy 2008, Reddy *et al.* 2008) and has also been available at the official website of National Biodiversity Authority of India. Perusal of these sources indicates that invasive aliens are represented by 56 species in 47 genera of 28 families in naturally occurring flora of Pantnagar. Members of the Asteraceae dominate with 11 of invasive alien species, followed by Convolvulaceae (5 spp.), Poaceae (4 spp.), Malvaceae, Euphorbiaceae (3 spp. each), Asclepiadaceae, Caesalpiniaceae, Tiliaceae, Cyperaceae, Solanaceae, Fabaceae, Mimosaceae (2 spp. each). Remaining of the 16 families are represented by one species each. The Asteraceae is also known to dominate alien floras of China, India, Uttar Pradesh and Kashmir (Huang *et al.* 2009, Rao and Murugan 2006, Singh *et al.* 2010, Khuroo *et al.* 2007). The dominance of Asteraceae may be attributed to its prolific seed production and efficient seed dispersal mechanism. Among the invasive aliens, American elements are highly dominant with 47 species constituting 83.92% of total invasive flora. Remaining 9 species are represented by 5 European species (8.92%) 3 species of African elements (5.36%) and 1 Asian species (1.79%). Interestingly, most of these invasive aliens are herbs, aquatic herbs or

herbaceous climbers (49 species) whereas shrubs are represented by only 7 species. None of the invasive alien tree species has been recorded. In addition to these 56 species, additional 4 species of invasive aliens also exist in flora of Pantnagar as plants cultivated for ornamentals or medicinal value (Table-3).

The overall picture of this floristic diversity indicates that natural vegetation has been severely affected by agriculture and associated activities. Consequently a few indigenous elements exist in Pantnagar, notably without any natural stand of characteristic Tarai forest. In fact trees are represented by 131 species of which only 44 species (33.58%) are of indigenous elements, growing isolated along roadsides or at the periphery of study area. Thus the major part of tree diversity (66.42%) is represented by planted or cultivated exotic species.

In absence of natural tree dominated vegetation herbs are abundant in the area and represented by 388 species, of which only 115 species (29.64%) are indigenous elements. Despite of suitable climatic conditions the absence of natural stands of vegetation has forced disappearance of a predominantly tropical family Orchidaceae, while adjacent two protected areas Rajaji Sanctuary and Corbett National Park with similar geographical and climatic regimes have considerable number of ground and epiphytic orchids as enumerated by Uniyal and Rao (1993) and Pant (1986).

If 302 cultivated taxa are excluded, the flora of Pantnagar have 160 alien species (44.45%) which is highest as compared to India, Allahabad, Badra Hills Gujrat, Delhi or Kashmir Himalaya (Table-4). This higher percentage owes to complete absence of natural forest vegetation, smaller geographical area and intensive agriculture in most of the area. American elements constitute the major part of alien flora (46.26%) which is

intermediate between 55% for India (Nayar 1977) and 18% for Kashmir flora (Khuroo *et al.*2007). In subtropical climate American elements are found most abundant as recorded by Singh *et al.*(2010) in Uttar Pradesh. The subtropical climate of Pantnagar seems favorable for American elements. Herbs show maximum number and percentage of aliens being 54.36% as compared to 25% in shrubs, 38.09% in climbers and only 12% in trees which is obvious considering prolific production of propagules, easier establishment of seedlings, short life cycle and easier dispersal of seeds in herbs. A similar dominance of herbaceous habit was also recorded by Huang *et al.*(2009) in China and Singh *et al.*(2010) in UP. However, the most deteriorating feature of the flora is high percentage of invasive alien species, which constitute 15.56% of all naturally occurring taxa (360 spp.) and 35% of total alien flora when compared to 0.99% invasive aliens in India and 4.72% in Kashmir (Khuroo *et al.*2007). Not only the percentage but their abundance is alarming and suggest that change in land use pattern from natural forests to intensive agriculture in Tarai can lead to accumulation of invasive alien plants, which are considered as first or second largest threat to native biodiversity, and greatly responsible to jeopardize the human welfare in any area (Kaiser 1999, Stiling 2006, Drake *et al.*1989).

It is well known that a habitat characterized by disturbances is more prone to invasion than an undisturbed habitat. Disturbance may free resources, open up space and change the physical environment; thereby it can create opportunities for non indigenous species to invade system (Hobbs and Huenneke 1992). This fact becomes evident in Pantnagar where natural Tarai forest and wetland are converted to agricultural land leading to change in native environmental conditions and thus making the area more prone to invasion by

aliens. In such case poor adaptability of indigenous species to altered conditions could increase population of aliens which are good 'ecological match' for the changed environment and may eventually out compete native species (Singh *et al.*2006, Van Dyke 2008).

The invasive alien species present in the area, *Imperata cylindrica* (Poaceae), *Eichhornia crassipes* (Pontederiaceae), *Lantana camara* (Verbenaceae) are among the 100 worst invasive alien species on earth, as identified by Invasive Species Specialist Group of IUCN ([www.issg.org](http://www.issg.org)). These three species with *Alternanthera* spp., *Gomphrena celosioides* (Amaranthaceae), *Ageratum conyzoides*, *Parthenium hysterophorus* (Asteraceae), *Cyperus* spp. (Cyperaceae), *Malvastrum coromandelianum*, *Sida acuta* (Malvaceae), *Echinochloa crusgalli* (Poaceae) are noxious weeds, posing threats to agriculture and human welfare.

## CONCLUSION

Conclusively it is stated that the destruction of natural forests for agriculture and urbanization in Pantnagar has adversely affected the native flora, as demonstrated by presence of relatively low number of indigenous species. Though the total number of plant species in the flora is quite high (i.e. 662), however, majority of them are either cultivated or naturalized alien elements. The survival of cultivated taxa (particularly food crops, vegetables, ornamentals, medicinal plants etc) is always cultivation dependent, therefore, can not be considered permanent denizens of the area. The higher number of naturalized alien species particularly 60 invasive alien species, indicate that in time and space, they found ample habitats to colonize themselves even within the short agriculture and urbanization history of 5 to 6 decades in Pantnagar. It also indicates their aggressive colonization and invasion capabilities in a disturbed habitat. As

obvious, these species are considerable threat to remaining indigenous flora including to the nearby surrounding places. The study also indicate that the agriculture and urbanization as seen in Pantnagar may not lead directly to drastic reduction in number of species in totality but it forces the removal of indigenous flora and causes an increase in number of unwanted aliens or invasive alien species.

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