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Assessment of invasive plant species and its impact on soil quality near national highway in Dimoria tribal belt of Assam

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Abstract
The invasive species are one of the major threats to native plant diversity. Invasive plant species have dominated the fallow lands in Dimoria Tribal Belt of Assam state. The present paper gives an account of the phytosociology of the invasive species found growing on the fallow lands along the roadside of National Highway No. 37 and changes in its soil fertility status. Phytosociological parameters like density, abundance, and frequency of the species were collected by laying 3x3 m quadrates in the selected area. The soil quality indicators namely temperature, texture, bulk density, moisture content, $p^{H,}$ organic matter, nitrate, phosphorus, and potassium were investigated under the five invaded sites with nearby forest vegetation as control. A total of 6 invasive plant species belonging to 3 families were recorded during the study period. The study revealed low soil quality status under the invaded sites as compared with the control. It is, therefore, necessary to check the invasion of these species through various measures.

Keywords: physico-chemical properties, invasive species, soil quality, phytosociology

1. Introduction
"Invasive species is a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (National Invasive Species Council, USA). Invasive species live outside its native distributional range and are introduced through human activity, either deliberate or accidental to new geographical areas where they become established and then proliferate and spread.

Most of the world's invasive plant species found in India belong to Tropical and Central America (Lowe *et al.*, 2000). As per the "Novel Weapons Hypothesis" the success of invasive species depends on their novel biochemical weapons in the form of allelopathy or plant-soil microbe interactions (Callaway and Ridenour, 2004) [5].

Invasive alien plants have caused extensive economic and ecological damage throughout the world. Invasive species impact ecosystem services (Charles and Dukes, 2007) [6] and soil nutrient cycling processes (Ehrenfeld, 2003) [11]. Levine *et al.* (2003) [16] reviewed over 150 studies documenting the impact of exotic plants and it was found that roughly equal no. of studies examined effects on community structure (species diversity and composition) and effects on ecosystem process (nitrogen cycling, hydrology, etc). Invasive species alter the soil properties which in turn depend on the baseline conditions of the invaded area (Novoa *et al.*, 2014) [20].

Despite the importance of invasive species, their impacts on native biodiversity and rural livelihood are immense (Kunwar, 2003; Hejda *et al.*, 2009) [15].

The two main causes of species extinction are due to climate change and species invasion (Burgiel and Muir, 2010) [4]. Furthermore, climate change can exacerbate species invasion (Masters and Norgrove, 2010 [42]; The Ad Hoc Working Group on Invasive Species and Climate Change, 2014).

The alien flora of India accounts for 1599 species, belonging to 842 genera in 161 families and constituting 8.5% of the total vascular flora found in the country (Khurro *et al*., 2012). In India especially North-West Himalaya *Ageratum conyzoides* L., *Parthenium hysterophorus* L., *Lantana camara* L. and *Eupatorium adenophorum* Sp. (Syn. *Ageratina adenophora* (Spreng.) are the major invaders that cause huge loss to indigenous species diversity (Dogra *et al*., 2009) [10]. Likewise, invasive plant species like *Ageratum conyzoides* L, *Lantana camara* L, *Mikania micrantha* Kunth, *Parthenium hysterophorus* L. *Mimosa pudica* L. *Chromolaena odorata*, etc. also poses a major threat to indigenous biological diversity of Assam. The vegetation of Assam in known for its great diversity and endemism. Assam is one of the biodiversity richest zone of North-East India and accounts for nearly 50% of the total number of the plant species in India as a whole. Das and Duarah (2013) [9] recorded 18 invasive alien plants along road side areas of Jorhat, Assam belonging to 18 families. The present study is an attempt to assess the phyto-sociology of the invasive alien plant species and to assess their impact on soil quality in Dimoria Tribal Belt of Assam along the National Highway No. 37.

2. Materials and Methods
2.1 Study area
The Dimona Developmental Block lying between 26° N and 26°14/ N latitudes and 91°51/ E and 92°10'E longitude is situated in the South-Eastern part of the Kamrup Metro District of Assam and on the south bank of river Brahmaputra (figure-1). It is bounded by Meghalaya on the south, by Morigaon District on

North-East and by greater Guwahati City on the west up to Jorabat Amrigog.

The area falls under a sub-tropical monsoon climate. The average annual temperature is 27^0C and the average annual rainfall is about 200 cm. Semi-evergreen and mixed deciduous with the presence of occasional sub-tropical broad-leafed forest types are found in the area. The vegetation types bear a similarity to the vegetation of the foothills of Meghalaya. *Dipterocarpus macrocarpus, Shorea robusta, Cassia fistula, Gmelina arborea, Acacia catechu, Areca catechu, Tectona grandis, Dalbergia sisso* are the important tree species of the area. Tall grass species belonging to the genera *Saccharum species. Phragmitis species. Arundo species. And Erinthus sp*ecies and a large number of herbaceous plants found in cultivated fields, roadsides, and wasteland forms the ground layer of vegetation.

2.2 Selection of sampling station

The invasion of alien plant species was studied through a random observation method in selected five plots near National Highway No. 37 from Khetri Tiniali, Dimoria Block, Assam during February 2015. The corresponding part of a forest with no invasive plant species was chosen as a control to see its effect on soil fertility (figure-2).

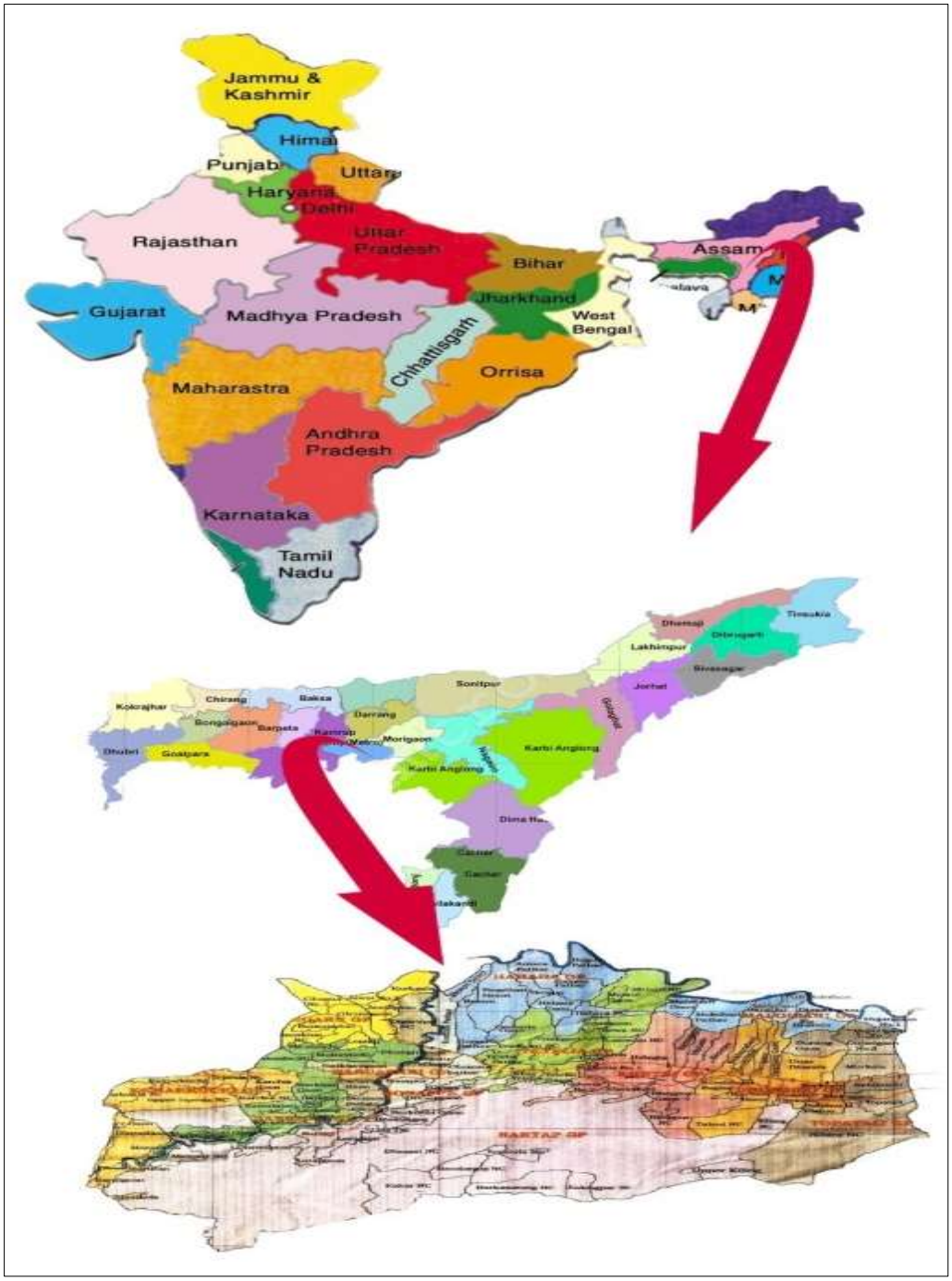

Fig 1: Location of Dimoria Tribal Development Block

Fig 2: Location map of soil sampling site under invasive plant species and control

2.3 Sample plots for invasive species

The organization and structure of plant diversity determine the distribution pattern of individuals among the species in a particular habitat, which can be studied by phytosociology. In this regard, phytosociological analysis is important for understanding the functioning of any community (Warger & Morrel, 1976) [23]. Phytosociological studies were carried out to cover all invasive species near the highway. Data on various phytosociological parameters like density, abundance, and frequency of the species were collected by laying 3x3 m quadrates in the selected areas. Phytosociological parameters indicated below were analyzed by the following methods and formulas (Curtis 1959, Misra 1968) [19].

2.4 Soil test

Soil samples were collected randomly from the top 0-15cm of the soil surface from each plot. Each sample was a composite of four sub-samples covering an area of $3m^2$. Samples were air-dried, passed through a 1 mm sieve, and analyzed for physicochemical parameters which are given in Table 1.

Table 1: Soil properties understudy with their methods of measurement

Soil properties	Methods
Bulk density	Core sampling method (Blake and Hartge, 1986)
Texture	Feel method
Temperature	Soil thermometer
Moisture content	Gravimetric method
pH	Potentiometrically in 1:2.5 (v/v) soil suspension in water by Digital pH meter (Systronics)
Organic matter	Titrimetric method (Walkley and Black, 1934) % SOM=organic carbon x 1.724(Allison, L.E., 1965)
Nitrate nitrogen	Spectrophotometric method (ELICO,SL-159)
Available phosphorus	Spectrophotometric method(ELICO,SL-159)
Available potassium	Flame photometer method (ELICO,CL 22D)

3. Results and Discussions

The phytosociology of the invasive species in the study area is Given in the table below**.**

Table 2: Phyto-sociological studies of invasive plant species near National Highway No. 37 in Dimoria Tribal Belt of Assam.

SI No.	Species Name	Family	Density(m^2)	Abundance (m^2)	Frequency (%)
1.	*Chromolaena Odorata* L.	Asteraceae	93.4	93.4	100
2.	*Lantana camara* L.	Verbanaceae	2.6	4.3	60
3.	*Mikania micrantha* Kunth	Asteraceae	4	4	100
4.	*Mimosa pudica* L.	Fabaceae	2.8	4.6	60
5.	*Ageratum conyzoides* L.	Asteraceae	1.2	2	60
6.	*Parthenium hysterophorus* L.	Asteraceae	0.8	2	40

A total of 6 invasive plant species belonging to 3 families were recorded during the study period (Table 2). Asteraceae (*Chromolaena odorata*, *Mikania micrantha*, *Parthenium hysterophorus and Ageratum conyzoides*) was dominant family followed by Verbanaceae (*Lantana camara*) and Fabaceae (*Mimosa pudica*) in terms of species.

C. odorata has the highest density (93.4), abundance (93.4), and frequency (100%), followed by *M. micrantha*. *M. pudica, L.*

camara and A. conyzoides were co- dominant species having frequency of 60%. The least dense, dominant and less frequent species is *Parthenium hysterophorus. C. odorata* was the species of most concern.

As per the observation, invasive species have displaced the native species in the study area. Open degraded areas were favorable for colonization of these species because of their ability to grow on these nutrient-limited soils. Similarly, open forests with exposed soils were observed to be more often dominated by these species. However, it was found that with increasing canopy cover in the forest areas, the growth of these species was retarded.

The Physico-chemical properties of the soil under invasive plant species and Matapahar Forest is given in table 3.

Table 3: Physico-chemical properties of the soil under invasive plant species and Matapahar Forest (control).

Parameters	Under invasive plant species	Matapahar Forest (control)
	Mean SE	**Mean SE**
Texture	Loamy sand	Silt Loam
Soil temperature (^{0}C)	25.44 ± 0.16	21.67 ± 0.25
Bulk density (g/cm^3)	1.63 ± 0.004	1.48 ± 0.006
Moisture Content (%)	17.38 ± 0.53	28 ± 0.45
pH	4.1 ± 0.08	5.13 ± 0.10
Organic Matter (%)	2.34 ± 0.06	3.14 ± 0.08
NO_3^- N (mg/kg)	1.6 ± O.5	1.9 ± 0.60
AP (kg/ha)	11.84 ± 1.5	15.82 ± 1.6
AK (kg/ha)	26 ± 1.8	43.29 ± 1.7

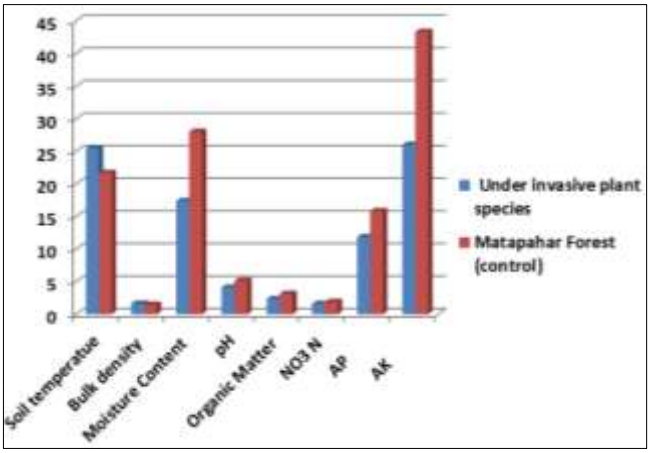

Fig 3: Comparative study of Physico-chemical parameters of soil under invasive plant species and Matapahar forest (Control).

Soil texture is one of the most important factors and affects many properties like structure, chemistry, and most notably, soil porosity, and permeability. The soil texture under the invaded sites was loamy sand whereas it was silt loam under the natural forest.

The soil temperature found under invasive sp. was 25.44^{0}C whereas the soil temperature of the natural forest was 21.67^{0}C. It may be due to the presence of thick plant cover on the natural forest during the sampling time. The average moisture content of soils was 17.38% under invasive sp. and 28 % under natural forest. The results show that the temperature and moisture content of soils have an inverse relationship which has also been observed by (Mekki *et al.* 2013). Bulk density under the invasive was found 1.63 gm/cm^3; in contrast, the bulk density under natural forest was 1.48 gm/cm^3. It shows that the soil under the invasive species is compact and the low bulk density of the natural forest is attributed to higher organic matter content in the soil. The same has also been observed by Chaudhari *et al.* (2013) [7]. PH indicates the acidity, neutrality, and alkalinity of the soil. Acidic soils have a pH of less than 5.6 and usually below pH 5.0. Soils in the range 5.6 to 6.0 are moderately acidic and below 5.5 are strongly acidic in nature (ICAR, 2005). The average value of pH ranged from 4.1 under invasive sp., whereas it was 5.13 under natural forest. The high acidity may be the factor for soil quality deterioration.

A low amount of soil organic matter (SOM) was found under invasive sp. (2.34 %), whereas 3.14% was noted under natural vegetation. However, most of the soil samples under study revealed soil organic matter near or above 3%, which was moderate according to ICAR rating, 1997.

The amount of nitrate-nitrogen was found 1.6 ppm under invasive sp. and 1.9 ppm under natural forest. The amount of phosphorus under invasive sp. was found 11.84 Kg/ha, while it was 15.82 (Kg/ha) under natural forest. The amount of available potassium under invasive sp. was found 26 kg/ha, while a higher amount of available potassium 43.89 kg/ha was found under natural forest. Low nitrogen and phosphorus content under invasive sp. may be attributed to a low amount of organic matter.

4. Conclusion

The study revealed that most of the fallow lands were invaded by invasive species. A total of 6 invasive plant species belonging to 3 families were recorded during the study period. *C. odorata* was the species of most concern. Soil quality was found to deteriorate under the invasive species when compared with the natural vegetation. Open areas with exposed soils were found to be under the direct control of the invasive sp. However, a dense canopy has been observed to retard the growth of this invasive species. The invasive species are one of the major threats to native plant diversity. It is, therefore, necessary to check the invasion of these species. Management of the land resource through afforestation with native species can be done as per the soil conditions. Limiting soil disturbances, immediate re-vegetation of disturbed sites, and invasive plant survey and awareness generation about invasive sp. may be taken up on priority.

5. Acknowledgment

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