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Impact of *Mikania micrantha* Kunth ex HBK Invasion on Micro-environment Component of Bherjan- Borajan–Podumoni Wild Life Sanctuary, Assam

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A B S T R A C T

The open sunny patches of the forest of upper Assam had been tremendously infested by the noxious alien vine *Mikania micrantha* and might be the prime factor for forest conversion. Present study was carried out in Bherjan-Borajan-Podumoni Wild Life Sanctuary situated in Tinsukia district of Assam. Extensive field surveys were conducted during the period 2014-2018 for evaluation of changes of microenvironment component viz. soil nutrient status, soil temperature, light interception and biomass production due to infestation of *M. micrantha*. Soil samples were and nutrient status were analyzed by standard analytical methods. Biomass study was done seasonally from *M. micrantha* infested forest sites by harvest method in sample plot of 1m x 1m. Seasonal structural changes of *M. micrantha* showed that the maximum dominancy of the weed was recorded in post monsoon season and highest infestation was found in Padumoni site of the WLS with IVI of 158.90 and biomass contribution of 2603.3 kg/ha. The average maximum temperature varies from 24ºC to 33.9ºC which supported the luxuriant growth of the weed. Soil was observed more acidic in natural forest than *Mikania* infested sites. Comparatively high value of moisture content, organic carbon, nitrogen content, potassium and phosphorus concentration were recorded in *Mikania* un-infested soil rather than infested soil. Correlation of environmental data, soil data and the biomass data revealed that *Mikania* biomass was highly significant with the interception of light by the canopy among the entire segment of Bherjan-Borjan-Padumoni WLS. Invasion of *Mikania* support the enrollment of light demanding deciduous species which facilitated the expansion of the weed and helped in degradation of the forest. Smothering effect of this fast growing vine triggered the deciduous species and displacing several indigenous species which may alter the forest scenario in near future. Maintaining close canopy coverage of the forest might be one of the precautionary measures against the rapid invasion of the weed.

Introduction

The stability and ecological function of natural wild lands depend on a diverse population of native plants. Native vegetation provided resilience against drought and flood, minimizes erosion, and promotes water infiltration and storage, along with providing wildlife and recreation values. Otherwise, the forest community was altered due to habitat fragmentation or invasion of foreign species (Pimm, 1986). Any biological species which establishes outside its native habitat and aggressively out-competes the native species was called an invasive alien species (Tiwari, 2005). Convention on Biological Diversity (1992) emphasized on the invasion of alien species which was considered as the second worst threat for biodiversity.

The invasive plants differ from native one, on their requirements and more consumption that may cause changes in soil structure, profile, decomposition rate, moisture and nutrient content, Singh (2001). Drake *et al.*, (1989), Brown *et al.,* (1998) also stated that exotic invasion in the natural ecosystem have undesirable impacts on economic and ecological sustainability. Wide-ranging infestations of weeds can permanently degrade natural forest ecosystem. Ehrenfeld (2003) declared that changes of vegetation composition due to exotic invasion are always connected with the changes of soil properties.

Mikania micrantha Kunth. ex. H.B.K. is one of the world's most aggressive tropical alien perennial vines of Asteraceae family native from South and Central America and placed amid the 10 worst exotic species in South and South East Asia (Lowe *et al.,* 2000).

Because of its vigorous and ramet growth habit, it successfully competes with trees and other crop plants for soil nutrients, water and reduces sunlight interception by covering the canopy. The open patches of the forest of upper Assam severely infested by this weed and might be the prime factor for forest conversion.

Therefore, the present study was undertaken to evaluate the changes of microenvironment component of Bherjan- Borajan – Podumoni Wild Life Sanctuary, Assam due to infestation of *M. micrantha.*

Materials and Methods

Study site

Bherjan, Borajan and Podumoni were the three tiny pockets of tropical forest on the flat plains of the Brahmputra Valley named Bherjan-Borjan-Padumoni Wild Life Sanctuary (WLS) situated in Tinsukia district of Assam in between the coordinates of 27°25'22.9″ N to 27°32 '24″ N and 95°18'40.5″ E to 95°29'16.4″ E (Figure 1). This was a small WLS which covered an area of 7.22 sq.km with altitude range of 119 – 122 m from MSL. The three small forest segments were disjuncted by tea gardens and human habitations. The natural vegetation is Tropical Wet Evergreen 'rainforest' type experiences a subtropical humid monsoon climate with an average annual rainfall of 2263 mm. Average maximum temperature varied from 24ºC to 33.9ºC and minimum temperature from 6.9ºC to 24.6º C. The relative humidity was highest at 88% in the month of June and January was the driest month having average relative humidity was 70.6 %. Soil was rich loamy with old alluvium deposition of Brahmaputra and acidic in nature with pH ranging from 4.07 to 4.7.

Methodology

Extensive field surveys were conducted during the period 2014-2018 for evaluation of impact of *M. micrantha* on microenvironment of native species in Bherjan-Borjan-Padumoni WLS. The forests were divided into two position i) *M. micrantha* un-infested, ii) *M. micrantha* infested site.

To study the micro environmental characters, the parameters like soil nutrient status, soil temperature, light interception and biomass production were taken. Soil samples were collected from the forest with three different depths of 0-15 cm, 15-25 cm and 25-50 cm.

Bulk density, pH and NPK were determined by the methods as described by Jackson (1973). Organic carbon percentage was estimated following modified Walkley and Black's wet oxidation method (Jha, 2005). Soil temperature was recorded through soil thermometer at seasonal intervals. Biomass study was done seasonally from *M. micrantha* infested forest sites by harvest method with twenty five replications in sample plot of 1m x 1m. Samples were kept in the oven at 60-70^0 C until constant weight will obtained. Total production was estimated by adding the biomass accumulation and standing dead material i.e. litter at seasonal intervals, by following Swamy and Ramakrishnan (1987 b). Population study of *M. micrantha* was carried out by randomly laid 125 quadrats of 1m x1m in each site. Quantitative analysis for density and Importance Value were calculated following Misra (1968) and Kershew (1973). Light intensity was recorded periodically from above the canopy and at ground level through lux meter and interception of light by the canopies was calculated by deduction method.

Correlation of environmental data, soil data with the vegetation data recorded from infested forest sites was analyzed by using SPSS 16.0 software.

Results and Discussion

Rapid invasion of *M. micrantha* in natural ecosystems during recent years was correlated with the extinction of native species (Leeand Klasing, 2004). Vigorous vegetative and sexual reproductive ability of this invader species and its population dynamics was already described by Swamy and Ramakrishnan (1987a; 1987b) for north east India. It has now become a most troublesome in the Bherjan –Borjan-Padumonbi WLS of Assam.The forest was a mosaic of disturbed open canopy patches along with little closed canopy areas. Seasonal structural changes of *M. micrantha* showed that the weed was strongly invaded in the forest and the maximum dominancy was recorded in the monsoon and post monsoon season. Population density of *Mikania* declined in pre monsoon season and minimum density was found in the month of March to April (Figure 2). Puzari (2010) reported that the population of *Mikania* was positively correlated with temperature. Our present study revealed a similar observation in density and biomass production of *Mikania* correlated to atmospheric temperature. The average maximum temperature varied from 24ºC to 33.9ºC in the study sites which supported the luxuriant growth of the weed. The highest infestation was recorded in Padumoni segment of the WLS with IVI of 158.90. Aravind *et al.*, 2010 reported that in Karnataka invasion of *Lantana camara* found higher in open forest areas. Study also found that the most preferred habitat for growth and development of *Mikania* was also in open sunny place with moist soil and cannot normally tolerate most impenetrable sites. Presently it was observed that the weed flourished mostly in canopy gap areas and the peripheral region of natural forests and absent in closed shaded areas. Frequent tree felling and lopping of trees created localized canopy gap patches in the WLS and acted as window for successful invasion of *Mikania* in the forest.

Invasive weeds have tremendous potential to produce massive amount of biomass and Anonymous, 2007 reported that *Parthenium* produces 5-20 kg/m^2, 9.3 kg/m^2 in *Chromolaena*, 3 kg/m^2 in *Cassia*, 1-1.5 kg/m^2 in *Lantana* and 10-11.5 kg/m^2 in Water hyacinth. *Mikania* also contributed a notable amount of biomass in the studied infested forest areas. Biomass accumulation was high in post monsoon season for all the forest sites and it was found maximum in Padumoni segment (2603.3 kg/ha) during the full growing season. Seasonal Biomass and Litter Production (kg/ha) of *Mikania* and other species was given in Table 1.

Average maximum soil temperature was observed in monsoon season of infested forest site of all three segments. The summer temperature of WLS was varied from 30.23^{0}C ±0.50 to 32.37^{0}C ±0.55 and Padumoni segment exhibited the highest one. In un–infested natural forest site the temperature goes up to 31.3^{0}C ±0.56 in monsoon season (Table 2).

The exotic invader has a greater capacity to efficiently utilize light energy by producing more foliage that essential for growth and development (Feng *et al.,* 2007).Comparative assessment of light interception percentage and *Mikania* biomass at different growth season revealed that the highest biomass was accumulated in the post monsoon season related to maximum light intercepted by the *Mikania* canopy. In pre monsoon season *Mikania* seedlings were in sprouting condition hence, intercepted minimum extent of light (Figure 3).

In forest ecosystems the understory plants were highly sensitive to their micro environment governed by the light intensity, wind velocity, temperature, soil moisture, etc. Any change of these environmental parameters might be detrimental for the existence of some of the sensitive species as seen due to invasion of *Mimosa diplotrica*, in Kaziranga National Park of Assam or *M. micrantha* in Chitwan National Park of Nepal (Vasu, 2003; Ram, 2008). Infestation of *M. micrantha* was considered as of high risk as it smothered the vegetation causing tree death. Presence of the weed in the canopy gaps where light intensity is higher which indicated that an increase in light through disturbance in the forest canopy encourages invasion into the forest. The dense shade below canopies of the weed suppresses the growth of other plant species (Huang *et al.*, 2000). *Mikania* caught up light intensity on ground surface of the forest and affected the regeneration of several tree seedlings. Invasion of the weed supported the enrollment of some light demanding deciduous species such as *Alstonia scholaris, Balakata baccata, Bombax ceiba, Ficus hispida, Lagerstroemia speciosa, Premna latifolia*, which facilitated the expansion of the weed and helped in degradation of the forest. Once the weed colonized the areas they increasingly penetrated the forest very tactfully. Through rapid proliferation and ramet formation, the weed entangled immediately the crown of the sapling and small seedlings. Sankaran *et al.,* (2001) was reported similar problem in case of young plantation of Teak in Kerala. Barua and Hazarika (2016) also confirmed that *Mikania* encourage the alteration of evergreen species in Dilli reserve forest of Assam.

Physico chemical properties of soil in different seasons in both infested and uninfested sites of Bherjan-Borjan-Padumoni WLS were given in Table 3–5. pH value ranges from 4.07 to 4.70 which indicate acidic nature of soil, this may be due to release of acidic compounds by the decomposition of organic residues from forest vegetation (Gogoi *et al.,* 2011; Acharya and Shrestha, 2012 and Anup *et al.,* 2013). The humification and leaching of basic ions were the two contributing factors along with rainfall and acidic parent materials. Comparatively high amount of litterfall in un infested natural forest contributed more organic matter to soil ultimately creating favourable environment to microbes responsible for production of organic acids into soil (Jha *et al.,* 1979).

Moisture Content of the soil was changeable according to the quantity of rainfall in the study sites. It was recorded more in un-infested forest site than the infested site and gradually increased with increasing depth. Maximum proliferation of surface absorbing roots of *M. micrantha* contributed to higher absorption of moisture in the surface layer. Highest moisture content was recorded in natural forest site of Bherjan segment (39.87 ± 0.03 due to high humid closed canopy cover of *Dipterocarp-Mesua-–Artocarpus* association. The percentage of moisture was higher in monsoon and post monsoon season (Table 3).

Table.1 Biomass and Litter Production (kg/ha) in Infested sites of Bherjan-Borjan-Padumoni WLS

Season	*Mikania*	Other	Litter	Total Production
Bherjan				
Pre-monsoon	428.6±0.39	320±0.07	909.3±0.72	1657.9±0.99
Monsoon	960.3±0.48	728±0.28	183±0.20	1871.3±0.59
Post-monsoon	1103.6±0.53	776.6±0.10	170.6±0.29	2050.8±0.37
Winter	792.6±0.20	506.6±0.05	846±0.04	2145.2±0.25
Borjan				
Pre-monsoon	387.6 ±0.24	303.6±0.08	684.6±0.35	1375.8±0.51
Monsoon	763.6±0.17	624±0.22	214.3±0.20	1601.9±0.22
Post-monsoon	964.6±0.36	711.3±0.53	264.3±0.07	1940.2±0.80
Winter	455.3±0.09	345±0.76	805±0.34	1605.3±0.99
Padumoni				
Pre-monsoon	1154.6±0.52	452.3±0.32	653.6±0.11	2260.50±0.24
Monsoon	2304.3±0.28	596±0.93	196.3±0.35	3096.6±0.89
Post-monsoon	**2603.3±7.45**	578.6±0.31	248.6±0.13	3430.50±7.28
Winter	1649.3±0.16	550.3±0.32	404±0.59	2603.6±0.64

Table.2 Seasonal variation of Light interception (%) and Soil Temperature of Bherjan-Borjan-Padumoni WLS

Trait		Site	Pre Monsoon	Monsoon	Post Monsoon	Winter
Soil temperature(^{0}C)	**Bherjan**	**I**	22.40±1.05	31.37±0.64	27.50±1.57	17.50±0.79
		UI	21.57±1.65	29.7±0.72	26.00 ±0.92	17.07±0.65
Light interception (%)		**I**	45.2±0.30	70.36±0.57	79.75±0.06	53.25±0.28
		UI	81.33±0.40	87.8±0.70	87.8±0.90	79.67±0.75
Soil temperature(^{0}C)	**Borjan**	**I**	19.73±0.50	30.23±0.50	26.93±1.46	17.53±0.75
		UI	19.53±1.21	28.17±1.15	26.37^{0}C±0.80	16.47±0.57
Light interception (%)		**I**	41.82±0.76	60.06±0.47	65.33±0.50	49.34±0.41
		UI	82.03±1.43	90.83±0.93	88.4±0.62	80.73±1.00
Soil temperature(^{0}C)	**Padumoni**	**I**	24.33±1.16	32.37±0.55	28.30±0.95	19.57±1.26
		UI	22.87±0.93	31.3±0.56	27.63±0.25	18.17±0.81
Light interception (%)		**I**	69.37±0.49	86.53±0.59	98.75±0.03	86.25±0.52
		UI	51.47±1.04	74.27±1.11	68.33±0.75	61.40±1.15

I: Infested UI: Un-infested

Table.3 pH and moisture content of soil in Bherjan-Borjan-Padumoni WLS

Forest		pH								MOISTURE CONTENT							
		Pre-M		Monsoon		Post- M		Winter		Pre-M		Monsoon		Post- M		Winter	
		IN	UI	IN	UI	IN	UI	IN	UI	IN	UI	IN	UI	IN	UI	IN	UI
Bherjan Segment	A	4.14 ±0.02	4.11 ±0.03	4.26 ±0.02	4.17 ±0.02	4.70 ±0.02	4.32 ±0.02	4.21 ±0.02	4.12 ±0.02	16.44 ±0.03	18.20 ±0.25	26.52 ±0.016	31.28 ±0.02	20.55 ±0.02	26.85 ±0.02	22.88 ±0.016	25.27 ±0.008
	B	4.18 ±0.01	4.21 ±0.02	4.29 ±0.02	4.23 ±0.03	4.61 ±0.02	4.26 ±0.01	4.17 ±0.02	4.07 ±0.02	25.94 ±0.05	26.74 ±0.05	30.14 ±0.03	36.57 ±0.02	22.59 ±0.02	28.72 ±0.02	24.59 ±0.03	25.66 ±0.01
	C	4.15 ±0.01	4.15 ±0.01	4.21 ±0.02	4.19 ±0.02	4.55 ±0.03	4.22 ±0.01	4.21 ±0.02	4.13 ±0.01	28.70 ±0.04	35.86 ±0.02	32.24 ±0.03	39.87 ±0.03	25.78 ±0.01	32.82 ±0.02	26.37 ±0.01	28.26 ±0.01
Borjan Segment	A	4.37 ±0.02	4.28 ±0.01	4.32 ±0.02	4.28 ±0.02	4.41 ±0.04	4.30 ±0.02	4.22 ±0.02	4.18 ±0.03	14.55 ±0.03	15.81 ±0.02	24.75 ±0.03	29.46 ±0.04	16.22 ±0.05	27.66 ±0.03	22.41 ±0.01	24.37 ±0.03
	B	4.32 ±0.02	4.24 ±0.02	4.28 ±0.02	4.14 ±0.02	4.30 ±0.04	4.26 ±0.02	4.22 ±0.03	4.15 ±0.03	16.55 ±0.02	20.62 ±0.03	28.68 ±0.02	32.56 ±0.04	21.45 ±0.02	28.74 ±0.04	26.39 ±0.03	26.88 ±0.04
	C	4.30 ±0.04	4.19 ±0.06	4.24 ±0.02	4.19 ±0.02	4.26 ±0.02	4.13 ±0.02	4.18 ±0.03	4.12 ±0.04	20.62 ±0.02	31.57 ±0.04	30.76 ±0.03	34.55 ±0.03	21.86 ±0.04	30.54 ±0.04	28.88 ±0.04	29.76 ±0.03
Padumoni Segment	A	4.24 ±0.02	4.12 ±0.05	4.30 ±0.17	4.22 ±0.04	4.28 ±0.03	4.22 ±0.04	4.18 ±0.03	4.17 ±0.03	12.99 ±0.06	21.31 ±0.03	24.57 ±0.03	30.48 ±0.02	22.56 ±0.03	25.76 ±0.05	12.87 ±0.04	17.76 ±0.02
	B	4.22 ±0.02	4.11 ±0.03	4.27 0.04	4.20 ±0.03	4.25 ±0.02	4.16 ±0.02	4.11 ±0.03	4.07 ±0.02	18.76 ±0.04	22.24 ±0.04	29.42 ±0.03	34.58 ±0.02	24.59 ±0.03	25.77 ±0.03	13.55 ±0.03	18.88 ±0.03
	C	4.19 ±0.05	4.05 ±0.03	4.25 0.02	4.19 ±0.02	4.19 ±0.03	4.12 ±0.03	4.07 ±0.04	4.08 ±0.03	19.61 ±0.02	29.87 ±0.02	33.48 ±0.03	38.46 ±0.04	26.48 ±0.05	28.84 ±0.04	19.87 ±0.05	21.84 ±0.05

I= infested, UI= un- infested, A: 0-15 cm, B: 5-25 cm, C: 25-50 cm

Table.4 Organic carbon and Available Nitrogen content of soil in Bherjan-Borjan-Padumoni WLS

Forest		**Organic Carbon (%)**								**Available Nitrogen (Kg ha^{-1})**							
		Pre-M		Monsoon		Post- M		Winter		Pre-M		Monsoon		Post- M		Winter	
		IN	**UI**	**IN**	**UI**	**IN**	**UI**	**IN**	**UI**	**IN**	**UI**	**IN**	**UI**	**IN**	**UI**	**IN**	**UI**
Bherjan Segment	A	1.56 ±0.02	1.83 ±0.03	1.45 ±0.02	1.65 ±0.04	1.95 ±0.02	2.71 ±0.02	1.26 ±0.01	1.58 ±0.02	147.39 ±0.47	232.06 ±0.06	123.53 ±0.03	225.5 ±0.24	257.5 ±0.65	285.3 ±0.57	107.6 ±0.28	98.5 ±0.44
	B	1.24 ±0.02	1.64 ±0.02	1.18 ±0.03	1.32 ±0.02	1.68 ±0.03	2.38 ±0.04	1.06 ±0.03	1.24 ±0.01	141.12 ±0.02	206.97 ±0.02	119.36 ±0.02	200.88 ±0.09	246.8 ±0.16	256.2 ±0.24	100.4 ±0.41	135.5 ±0.21
	C	1.16 ±0.03	1.38 ±0.02	1.12 ±0.03	1.24 ±0.02	1.36 ±0.02	1.96 ±0.02	1.02 ±0.004	1.14 ±0.02	112.89 ±0.05	197.56 ±0.03	110.68 ±0.06	158.76 ±0.18	204.4 ±0.48	178.5 ±0.42	186.5 ±0.20	108.4 ±0.36
Borjan Segment	A	1.29 ±0.04	1.58 ±0.05	1.24 ±0.02	1.36 ±0.03	1.48 ±0.04	2.08 ±0.02	1.15 ±0.03	1.29 ±0.04	238.3 ±0.32	263.42 ±0.14	216.83 ±0.15	254.86 ±0.13	251.5 ±0.38	266.4 ±0.34	135.8 ±0.65	174.6 ±0.16
	B	1.22 ±0.03	1.35 ±0.04	1.17 ±0.03	1.24 ±0.04	1.36 ±0.03	1.86 ±0.03	1.08 ±0.04	1.22 ±0.02	213.25 ±0.30	225.79 ±0.32	208.35 ±0.36	237.65 ±0.13	238.6 ±0.32	248.2 ±0.15	116.5 ±0.02	129.7 ±0.20
	C	1.14 ±0.02	1.21 ±0.03	1.08 ±0.03	1.16 ±0.04	1.19 ±0.038	1.61 ±0.020	1.02 ±0.033	1.08 ±0.032	200.7 ±0.73	219.52 ±0.10	195.45 ±0.04	208.46 ±0.28	224.5 ±0.28	241.4 ±0.48	108.5 ±0.24	113.8 ±0.17
Padumoni Segment	A	1.06 ±0.03	1.13 ±0.03	1.02 ±0.03	1.24 ±0.02	1.42 ±0.03	1.76 ±0.03	0.96 ±0.03	1.11 ±0.04	106.62 ±2.1	200.7 ±2.0	101.62 ±2.36	196.55 ±1.46	259.0 ±2.5	268.2 ±2.6	101.6 ±1.26	187.5 ±1.80
	B	1.02 ±0.03	1.09 ±0.02	0.98 ±0.04	1.12 ±0.03	1.34 ±0.04	1.58 ±0.05	0.92 ±0.03	1.06 ±0.03	103.48 ±2.28	169.34 ±3.10	100.78 ±2.32	174.72 ±1.56	241.8 ±2.60	241.6 ±1.50	101.5 ±1.20	158.4 ±1.30
	C	0.91 ±0.04	1.05 ±0.024	0.85 ±0.04	1.08 ±0.03	1.18 ±0.04	1.23 ±0.04	0.82 ±0.02	1.05 ±0.02	100.35 ±0.98	131.71 ±2.69	100.08 ±1.55	126.64 ±0.93	232.2 ±2.50	234.6 ±2.60	98.6 ±1.50	142.7 ±0.65

I= infested, UI= un- infested, A: 0-15 cm, B: 5-25 cm, C: 25-50 cm

Table.5 Available Phosphorus and Potassiun content of soil in Bherjan-Borjan-Padumoni WLS

Forest		Available Phosphorus (Kg ha^{-1})								Available Potassium (Kg ha^{-1})							
		Pre-M		Monsoon		Post- M		Winter		Pre-M		Monsoon		Post- M		Winter	
		IN	UI	IN	UI	IN	UI	IN	UI	IN	UI	IN	UI	IN	UI	IN	UI
Bherjan Segment	A	28.98 ±0.02	31.89 ±0.03	28.64 ±0.05	30.58 ±0.02	16.35 ±0.01	25.63 ±0.04	15.86 ±0.06	23.76 ±0.04	254.72 ±0.06	288.44 ±0.0 6	188.99 ±0.77	236.67 ±0.06	214.62 ±0.02	258.1 ±0.06	157.5 ±0.44	205.8 ±0.77
	B	28.78 ±0.04	22.67 ±0.03	25.57 ±0.03	26.86 ±0.03	15.96 ±0.05	22.77 ±0.02	13.64 ±0.04	19.62 ±0.02	223.9 ±0.11	231.75 ±0.64	188.95 ±0.06	212.57 ±0.06	208.55 ±0.77	229.6 ±0.28	142.8 ±0.20	188.4 ±0.69
	C	26.56 ±0.03	19.98 ±0.05	21.68 ±0.03	24.76 ±0.03	14.77 ±0.04	20.85 ±0.02	12.49 ±0.04	15.44 ±0.04	169.87 ±0.09	196.59 ±0.57	174.6 ±0.16	192.66 ±0.02	158.4 ±0.36	208.5 ±0.41	128.4 ±0.41	164.5 ±0.36
Borjan Segment	A	34.44 ±0.04	36.67 ±0.06	27.85 ±0.04	29.88 ±0.05	15.28 ±0.02	27.25 ±0.05	12.89 ±0.03	24.56 ±0.04	234.72 ±0.06	259.44 ±0.06	208.44 ±0.04	224.58 ±0.14	164.4 ±0.02	173.2 ±0.32	138.5 ±0.32	156.8 ±0.16
	B	29.30 ±0.04	26.77 ±0.03	26.75 ±0.03	24.56 ±0.03	14.66 ±0.02	25.66 ±0.04	10.48 ±0.04	18.54 ±0.06	218.50 ±0.20	227.75 ±0.13	195.80 ±0.03	208.43 ±0.20	152.8 ±0.16	164.8 ±0.16	124.7 ±0.20	144.5 ±0.57
	C	22.34 ±0.05	20.11 ±0.07	18.68 ±0.07	20.69 ±0.04	13.59 ±0.07	24.72 ±0.05	10.08 ±0.03	12.52 ±0.06	156.87 ±0.06	185.54 ±0.04	185.25 ±0.03	189.57 ±0.80	136.4 ±0.20	156.8 ±0.16	118.4 ±0.40	132.5 ±0.24
Padumoni Segment	A	28.55 ±0.04	28.59 ±0.06	27.58 ±0.05	26.67 ±0.06	21.87 ±0.07	26.64 ±0.06	12.55 ±0.07	14.69 ±0.04	248.79 ±1.69	268.44 ±0.06	207.64 ±0.05	237.3 ±0.05	213.55 ±0.10	254.6 ±0.23	132.6 ±0.25	168.6 ±0.33
	B	24.56 ±0.05	22.64 ±0.04	22.49 ±0.06	23.88 ±0.05	21.56 ±0.09	26.46 ±0.04	10.24 ±0.03	13.46 ±0.04	211.14 ±0.08	239.98 ±0.03	190.85 ±0.09	196.54 ±0.04	228.5 ±0.19	225.8 ±0.72	118.8 ±0.82	149.8 ±0.40
	C	19.89 ±0.04	16.99 ±0.04	18.47 ±0.04	22.55 ±0.06	20.78 ±0.02	23.77 ±0.04	9.76 ±0.05	10.54 ±0.05	153.23 ±0.24	178.49 ±0.11	148.48 ±0.11	158.65 ±0.07	140.6 ±0.24	168.6 ±0.28	108.6 ±0.24	134.4 ±0.56

I= infested, UI= un- infested, A: 0-15 cm, B: 5-25 cm, C: 25-50 cm

Table.6 Correlation of different parameters relevant to *Mikania* infestation A: Bherjan B: Borjan C: Podumoni

Season	ST	LI	BM	SM
Bherjan				
ST	-	0.7262	0.5362	0.4248
LI	0.7262	-	0.9471**	0.4905
BM	0.5362	**0.9471****	-	0.6443
SM	0.4248	0.4905	0.6443	-
Borjan				
ST	-	0.8102	0.8275	0.2908
LI	0.8102	-	0.9772**	0.2678
BM	0.8275	**0.9772****	-	0.0751
SM	0.2908	0.2678	0.0751	-
Padumoni				
ST	-	0.2855	0.6466	0.4166
LI	0.2855	-	0.9156**	0.6438
BM	0.6466	**0.9156****	-	0.8966*
SM	0.4166	0.6438	**0.8966***	-

ST: soil temperature LI: light interception BM: biomass SM: soil moisture

Fig.1 Map of Bherjan-Borjan-Padumoni WLS

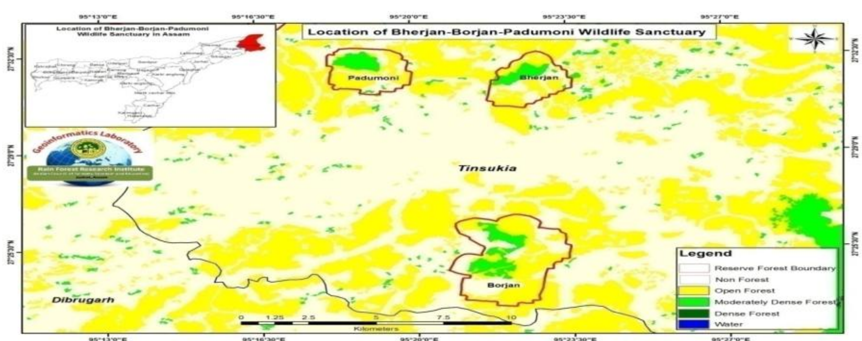


Fig.2 Structural changes of *Mikania micrantha* in different season

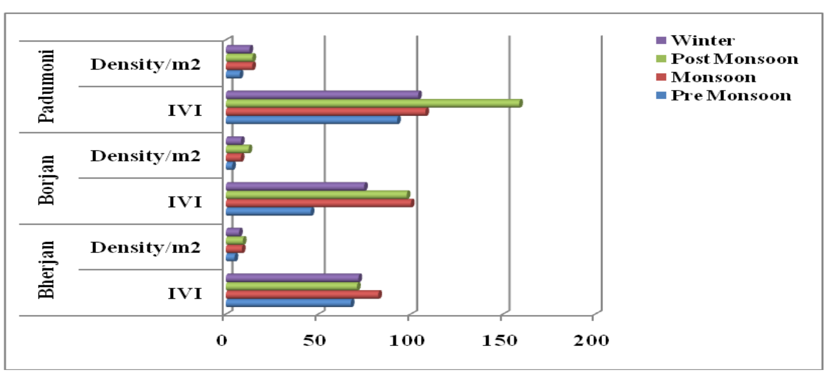


Fig.3 Comparative assessment of light interception % and *Mikania* biomass at different growth season in Bherjan-Borjan-Padumoni WLS

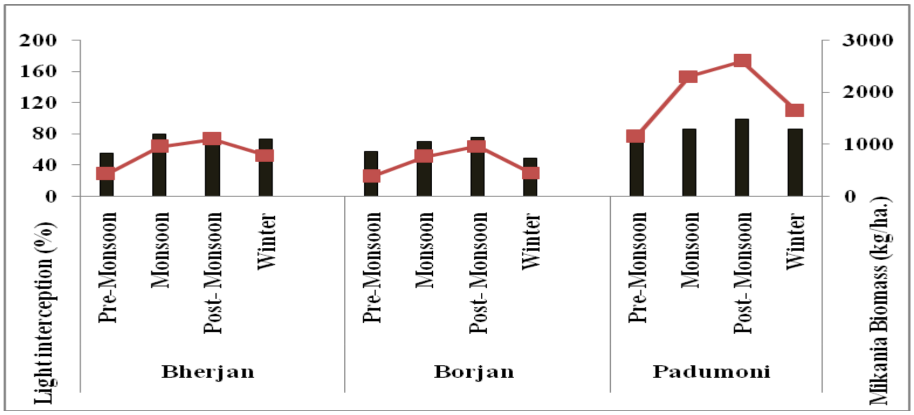
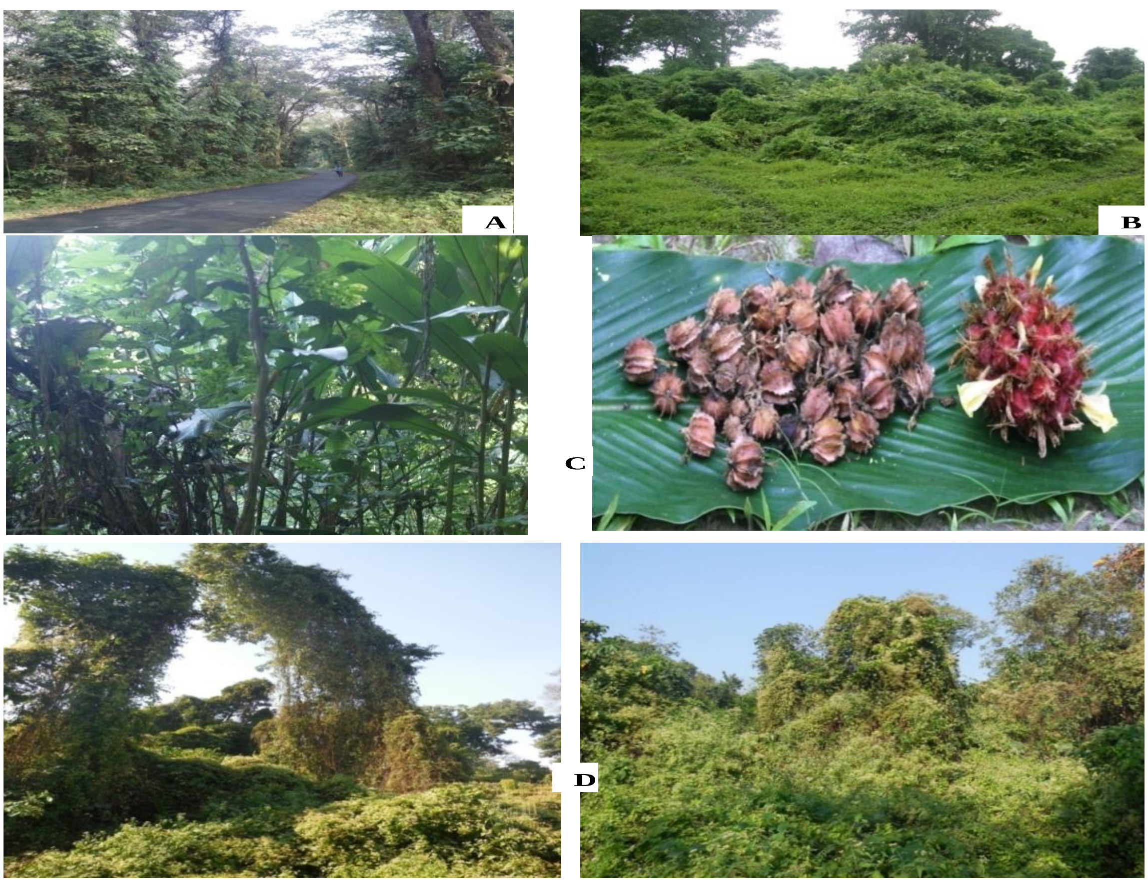


Plate.1 Glimpses of Bherjan- Borajan–Podumoni Wild Life Sanctuary A& B: Fragmentation by road and Infestation of *Mikania* in Bherjan segment C: *Amomum maximum*- an important spice species in forest floor of Borjan segment D: *Mikania* Converted Padumoni segment -a degraded forest



Vegetation played a major role in soil organic carbon content which increases through ample supply of organic residues by litter decomposition and mineralization. The value of organic carbon was noticed high in post monsoon season of Bherjan segment followed by Borjan and Padumoni segment. Significant increment of organic carbon was recorded in top layers due to accumulation of sizeable amount of humus and in subsurface layers it consisted of leached fraction and decayed products of underground biomass which decreased with soil depth (Sharma and Gupta, 2015). During present study higher values of organic C and N were observed in un-infested forest compared to *Mikania* invaded areas (Table 4). The invasive plants have potential to alter the N cycling process through their litter production (Allison and Vitousek, 2004). Chen *et al.*, (2009) reported that invasion of *M. micrantha* decreased nitrogen content in soil due to quick absorption. They also observed more total C and N in soil from the rhizosphere of *Mikania.*

Maximum litter accumulation by the invasive species and nutrient release from decomposing litter possibly created condition for continuous invasion, Kourtev *et al.*, (2003). Nitrogen content was found maximum in post monsoon season of all the study sites and in winter season the value was recorded least with the increase of soil depth. Value of phosphorus ranged from 14.69 kg /ha to 36.67 kg /ha in surface layer of different un infested forests sites, however it was ranged from 12.55 kg /ha to 34.44 kg /ha in infested sites. In *Mikania* infested forest potassium concentration was less in compared to un infested forest sites which was also supported by the observation of Gogoi *et al.*, (2011). Highest value of phosphorus and potassium were observed in pre monsoon season and least value was in winter season (Table 5).

Mikania has an optimum growth stage in post monsoon season along with less environmental variation. Therefore, this season was the ideal for interpretation of correlation on microenvironment data. Correlation of environmental data, soil data and the biomass data recorded from *Mikania* infested forest sites revealed that *Mikania* biomass was having highly significant correlation with the interception of light by the canopy among all the segment of Bherjan-Borjan-Padumoni WLS. Borjan and Bherjan segment showed positive correlation with soil temperature and light interception, where as in Padumoni segment biomass and soil moisture percent exhibited significant correlation that indicated the maximum spreading out of *Mikania* (Table 6).

Impact of changes of micro environmental factors on plants is more acute in forest ecosystems, particularly in rain forests, where stratification is governed by a number of environmental factors. Prevalence of such factors of environmental change for a prolonged period may be responsible for permanent shift of vegetation composition, soil seed bank as well as the corresponding ecological functions. Randall (1996) stated that alien invasive species were the second largest threat to biodiversity. *M. micrantha* is one of the most troublesome driver species of Assam and extreme capacity for alteration of native community and entire ecosystem functions.

It showed tremendous capability to form monoculture community that was supported by Mack *et al.*, (2000). Smothering effect of this fast growing vine triggered the deciduous species and displacing several indigenous species which may alter the forest scenario in near future. Maintaining close canopy coverage of the forest might be one of the precautionary measures against the rapid invasion of the weed.

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