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Parthenium infestation and evaluation of botanicals and bioagents for its management

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ABSTRACT

Systematic surveys of *Parthenium hysterophorus* L. infested regions on 12 selected national highways of North-Eastern India were conducted during 2009-2011. In all the surveyed sites, *Parthenium hysterophorus* was present but its abundance was more during the month of June to August. Complete inhibition of *Parthenium* seed germination was recorded at 20% of leaf and stem extracts of *Cassia sericea, Mimosa pudica* and *Cassia tora*. Different stages of *Zygograma bicolorata* (grubs to adult) showed reduction in plant height, shoot length, root length and biomass *of Parthenium* when exposed in mosquito net cages.

Key words: Allelopathic effect, Biological control, *Parthenium hysterophorus*, Survey, *Zygogramma bicolorata*

Parthenium hysterophorus L. commonly known as Congress grass, gajar ghas or white top is an annual herbaceous weed which has spread like a wild fire in almost every state of India. It is known as a noxious weed because of its allelopathic effect (Wakjira *et al*. 2005, Kohli *et al*. 2006, Wakjira 2009), strong competitiveness with both crops and pasture for soil moisture and nutrients (Singh *et al*. 2003, 2005) and the hazard it poses to humans and animals (Wiesner *et al*. 2007, Sushilkumar and Varsheny 2007) and biodiversity (Tefera 2002). Due to its prolific cover, known hazardous properties and lack of previous report from North–Estern region, proper management of *Parthenium* using adequate measure are needed in this region. The present study was undertaken with the objective to asses intensity of infestation of *Parthenium hysterophorus* on selected national highways of North-East India, quantify allelopathic effects of certain plant extracts on *Parthenium* germination and seedling growth and to test the damage potential of *Zygogramma bicolorata* on seedling growth of *Parthenium*.

MATERIALS AND METHODS

The study site had three main seasons in a year, *viz.* summer (April to May), rainy (June to October) and winter (November to March). Sporadic winter rains were common during November to January. The annual mean temperature was 27–30^{0}C with mean maximum temperature of 32^{0}C in April–May and the mean minimum temperature of 6^{0}C in December–January.

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Systematic field surveys were conducted during 2009-2011, on 12 selected national highways (NH-31 - Bongaigoan, NH-37 - Nagaon, NH-37 - Jorhat, NH-39 - Manipur, NH-39 - Nagaland, NH-40 - Shillong, NH-44 - Agartala, NH-52 - Tezpur, NH-52A - Itanagar, NH-53 - Manipur, NH-54 – Aizawl and NH-150 Manipur) from the nearest city of each highway in North-East India. Road surveys were done by vehicle along the highways by driving at moderate speed and observing the infestation of *Parthenium*. The distances of the infested region along both sides of the highways were noted in field notebook and photographs were taken. If the distance between two infested site was within 100 m, it was taken as one group. The longitude and latitutdes of each high ways was recorded with the help of GPS.

Bioassays were conducted with aqueous leaf and stem extract of *Cajanus cajan, Sida spinosa, Mimosa pudica, Rumex maritimus, Ipomoea carnea, Gynura cusimba, Cassia tora* and *Cassia sericea* on germination and seedling growth of *Parthenium*. 100 g each of the different parts of the selected botanical agents were chopped and homogenized in 100 ml of the sterilized distilled water in a fine grinder. The extract was filtered through Whatman No.1 filter paper and the filtrates were taken as 100% aqueous extract. Then 5, 10, 20, 30, 50 and 75% aqueous extract of each of the different parts of selected botanical agents were prepared by diluting 100% aqueous extract with distilled water.

Seeds of *Parthenium* were thoroughly washed with tap water and surface was sterilized with 0.1% $HgCl_2$ for 2 to 3 minues and further washed with distilled water for

4 to 5 times. Then, the seeds were soaked for 2 h in 10 ml of 5, 10, 20, 30, 50 and 75% extracts of different parts of selected botanical agents and in distilled water for control. Ten seeds each were allowed to germinate in a Petridish lining by filter paper moisture with different concentrations of extracts and distilled water as control. For each concentration, three replicates were made. The Petridishes were kept undisturbed for 15 days in a plant growth chamber at 26±2^{0}C. The germination of seeds, root and shoot length of *Parthenium* seedlings were recorded on 15th day and dry weight per plant (biomass) was recorded after drying in an oven at 55-60^0 C for 24 h. The vigour index of *Parthenium* seedling was calculated following Abdul-Baki and Anderson (1973).

An experiment was carried during 2011-2012 by using Mexican beetle (*Zygogramma bicolorata*) procured from Directorate of Weed Science Research (DWSR), Jabalpur (India) by maintaining the temperature at 25^{0}C and relative humidity at 55%. Healthy and mature seeds of *P. hysterophorus* were collected and sown in pots filled with steam sterilized soil with farm yard manure (FYM). The emerging seedlings with 4-5 leaves stage were transplanted to 12 earthen pots, each with 20 plants filled with garden soil. The potted plants were transferred to the 12 insect proof nylon net cages (87 x 43 cm). Grubs (2nd instar) and freshly emerged adult (fourdays) of *Z. bicolorata* were released to the potted plants of 6 to 8 cm in height. Out of 12 cages, 6 cages were selected for 15 days observation and another 6 cages for 30 days observation. In both the cases, out of 6, three (50%) were kept as control and another three (50%) were exposed to insects.

Plant height, shoot length, root length, stem diameter and plant biomass were recorded. Plants biomass obtained by drying in an oven at 55^{0}C for 72 h and dry weight were recorded. For taking observations, 10 plants from each pot were randomly selected.

The percentage reduction of *Parthenium* plant growth was calculated following the formula of Pant and Mukhopadhyay (2001)

Q = (a-b/a) x 100; where Q = % reduction in growth; a = average growth in healthy plant: b = average growth in treated plant.

Tests of significance ('t' value) were determined between healthy and treated plants under parameters like plant height, shoot length, stem diameter, root length and plant biomass. Data were subjected to ANOVA (analysis of variance) and mean was compared using LSD (least significant difference) test at P=0.05.

RESULTS AND DISCUSSION

Survey of *Parthenium* infestation

Severe infestation of *Parthenium* was recorded in NH-31 (Bongaigoan), high in NH-37 (Nagoan) and NH-39 (Imphal), medium in NH-37 (Jorhat), NH-44 (Agartala, Tripura), NH-52 (Tezpur) and NH-53 (Imphal-Jiri), mild in NH-39 (Nagland), NH-40 (Shillong, Meghalaya), NH-54 (Aizawl, Mizoram) and NH-150 (Imphal) while negligible infestation was observed in NH-52A (Itanagar, Arunachal Pradesh) (Table 1). Infestation of *Parthenium* was more prominent near the city and generally on the road commenced from the city. It might be due to disturbed natural habitat of native vegetation because of human disturbance like construction work, vehicular movements *etc*. This condition might have harboured and influenced the speedy succession of *Parthenium* in such habitat. Vehicular movements also facilitated the spread of *Parthenium*. The wide spread of *Parthenium* throughout India was reported by Sushilkumar (2012). Spread and infestation level was medium in Assam and low in Arunachal Pradesh, Manipur, Mizoram, Meghalaya and Nagaland in North-East India as compared to other states of India. However, in reference to North-East India, infestation level was found high in Assam, medium in Manipur and low in Arunachal Pradesh, Meghalaya, Mizoram Nagaland and Tripura.

Till 1980, *Parthenium* spread was restricted mostly to uncultivated land, on road side and raiwlway track side and that time it was not considered a problem in North-East India (Sushilkumar and Varshney 2007) but in a span of 30 years, the arid and hilly areas in North–East India have been infested with *Parthenium* and may become a serious problem to health of human beings, animals and agricultural fields. In the present study, the growth of *P. hysterophorus* was observed throughout the year in all the surveyed sites with greater abundance during the month of June to August. This might be due to congenial climatic conditions like high rainfall, optimum temperature and high relative humidity which favoured the growth of *Parthenium*. Till now, it was found to be growing only along the road side, waste land and non-cropped area but if timely control measure are not taken, it may cause a serious threat to crop land and biodiversity.

Allelopathic effect of botanicls

Application of 20% concentration of leaf extract of *Mimosa pudica*, *Cassia sericea* and *Cassia tora* resulted in 100% inhibition of *Parthenium* germination (Table 2). Allelochemicals present in *Cassia tora*, *Cassia sericea* and

Mimosa pudica might have inhibited the process of seed germination. The reduction in germination was higher under leaf extract than stem extract. The effect of all the selected plant's extract on *Parthenium* seed germination increased with the increase in concentration. Nearly 89.7 and 96.7% reduction in *Parthenium* germination were observed in stem extract of *Sida spinosa* and *Ipomoea carnea* and stem extracts of *Cajanus cajan* and leaf extract of *Ipomoea carnea* at 30% concentration, respectively. No *Parthenium* seed germination was observed in 30% con-

Table 1. Survey sites of selected National highways of North–East India

No.	Highway	Longitude and latitude of survey area	Place/state	Remark
1	NH-31	N26^{0}9.513$'$, E91^{0}40.370$'$ N 26^{0}30.169$'$, E90^{0}33.240$'$	Adabari to Bongaigoan, Assam	Severe
2	NH-37	N 26^{0}9.311$'$, E 91^{0}40.581$'$ N 26^{0}32.266$'$, E 92^{0}55.677$'$	Jalukbari to Kaliabor through Nagoan, Assam	High
3	NH-37	N27^{0}10.994$'$, E94^{0}54.897$'$ N26^{0}38.341$'$, E93^0 45.650$'$	Moranhat Town to Kamargoan through Jorhat , Assam	Medium
4	NH-39	N 24^{0}57.892$'$, E93^{0}53.162$'$ N 24^{0}29.801$'$, E 94^{0}0.707$'$	Imphal, Manipur	High
5	NH-44	N 23^{0}40.440$'$, E 91^{0}16.915$'$ N 24^0 9.749$'$, E 92^{0}2.270$'$	Bishalgarh to Pabiachhara part through Agartala, Tripura	Medium
6	NH-52	N26^0 53.271$'$, E93^{0}37.920$'$ N26^{0}33.357$'$, E92^{0}11.994$'$	Gohpur to Dalgoan through Tezpur, Assam	Medium
7	NH-53	N24^{0}33.357$'$, E92^{0}11.994$'$ N24^{0}44.750$'$, E93^{0}25.540$'$	Sagolband Silchar parking, Imphal to Nungba, Manipur	Medium
8	NH-54	N 23^{0}44.193$'$, E 92^{0}47.820$'$ N 24^0 48.708$'$, E 92^{0}47.841$'$	Tuirial jail to Rangirkhari bus stand through Aizawl, Mizoram	Mild
9	NH-39	N25^{0}40.095$'$, E94^{0}6.285$'$ N25^{0}54.811, E93^{0}43.709$'$	Kohima – Dimapur Road, Nagaland	Mild
10	NH-40	N25^0 26.826$'$, E 91^{0}50. 394$'$ N26^{0}5.959$'$,E91^{0}52.576$'$	Laitlyngkot to Jorabat through Shillong, Meghalaya	Mild
11	NH-150	N 24^{0}52.188$'$, E 94^{0}3.866$'$ N 24^{0}29.827$'$, E 93^{0}45.919$'$	Lamlai to Moirang Lamkhai, Manipur	Mild
12	NH-52A	N27^{0}6.524$'$, E93^{0}49.447$'$ N26^{0}56.790$'$, E93^{0}35.725$'$	Banderdewa police outpost to Itanagar, Arunachal Pradesh	Negligible

Table 2. Allelopathic effect of selected plant extract on *Parthenium* seed germination

Plants	Germination (%)											
	5% conc.		10% conc.		20% conc.		30% conc.		50% conc.		75% conc.	
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
Cajanus cajan	26.7	30.0	16.7	26.7	10	16.7	0.0	6.7	0.0	0.0	0.0	0.0
Sida spinosa	26.7	40.0	20.0	23.3	16.7	20.0	0.0	10.0	0.0	0.0	0.0	0.0
Mimosa pudica	23.3	26.7	13.3	20.0	0.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0
Rumex maritimus	53.3	56.7	30.0	43.3	16.7	23.3	13.3	16.7	0.0	0.0	0.0	0.0
Gynura cusimba	60.0	63.4	46.7	50.0	33.3	43.3	23.3	16.7	0.0	0.0	0.0	0.0
Ipomoea carnea	36.6	43.3	23.3	26.7	16.7	23.3	6.7	10.0	0.0	0.0	0.0	0.0
Cassia tora	16.7	26.7	10.0	20.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
Cassia sericea	23.3	30.0	16.7	26.7	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
Control	96.7*											

*Mean value of all the control; conc. - concentration

centration of leaf and stem extract of *C. tora, C. sericea* and *M. pudica* and leaf extract of *C. cajan* and *S. spinosa.* The high reduction in the former and total failure of seed germination in the latter species as compared to control was an indication that allelochemicals were released by all these plant species. The quantum of allelochemicals leached varied with the variation of the selected plant species and the part used (Evenari 1945).

The stem extracts (5%) of *Rumex maritimus* and *Gynura cusimba* did not have much effect on the seedling growth of *Parthenium* as compared to control. However, high reduction of 82 and 83.5% in *Parthenium* root growth was observed over control by 20% stem extract of *C. tora* and *C. cajan* and leaf extract of *M. pudica,* respectively (Table 3). Leaf and stem extract of *Cassia tora* and *Mimosa pudica* at lower concentration of 5% could arrest the aerial growth of *Parthenium* but at the higher concentration. Almost all the selected plant species had a drastic effect to reduce aerieal grwoth as compared to control (Table 3). The reduction root and shoot length in seedlings may be attributed to the reduced rate of cell division and cell elongation due to the presence of allelochemicals in the aqueous extracts.

The dry matter accumulation of *Parthenium* seedlings was reduced by 8.3-71.3% when treated with 5% aqueous extract of different part of selected plants. Dry matter accumulation decreased with increase in concentration of aqueous extract. At higher concentrations (10% and 20%), significant reductions of 72.7-79.2% were observed in leaf and stem extracts of *C. tora* and *M. pudica,* respectively (Table 4). This might be due to the inhibition of CO_2 efficiency as allelochemicals could inhibited the carbon fixation pathway either directly or indirectly in barley (Overland 1996).

At higher concentration, all plant extracts could reduce the vigour index of *Parthenium* seedling as compared to control (Table 4). The maximum vigour indexes of *Parthenium* seedling were obtained at 5% concentration of stem extract of *Rumex meritimus* and *Gynura cusimba*. Dhawan *et al.* (1997) found that extract of *Delonix regia, Trifolium alexandrinum, Moringa indica, Tephrosia purpurea Bauhinia varigata, Albizzia procera*

Table 3. Allelopathic effect of different parts of plant aqueous extracts at different concentration on *Parthenium* root and shoot length

Plants	Concentration											
	5%		10%		20%		30%		50%		75%	
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
Root length (cm)												
Cajanus cajans	0.70	0.73	0.63	0.60	0.53	0.36	-	0.47	-	-	-	-
Sida spinosa	1.23	1.23	1.16	1.10	1.00	0.83	-	0.63	-	-	-	-
Mimosa pudica	0.63	0.74	0.53	0.67	-	0.33	-	-	-	-	-	-
Rumex maritimus	1.26	1.60	1.13	1.30	1.03	1.13	0.63	0.76	-	-	-	-
Gynura cusimba	1.33	1.53	0.76	0.90	0.50	0.50	0.46	0.53	-	-	-	-
Ipomoea carnea	1.10	1.20	0.86	1.00	0.70	0.70	0.64	0.63	-	-	-	-
Cassia tora	0.76	0.66	0.56	0.59	-	0.36	-	-	-	-	-	-
Cassia sericea	0.76	0.73	0.60	0.56	-	0.53	-	-	-	-	-	-
Control						2.00*						
LSD (P=0.05)	0.19	0.19	0.22	0.21	0.20	0.20	0.07	0.15				
Shoot length (cm)												
Cajanus cajans	0.96	1.10	0.70	0.87	0.70	0.83	-	0.53	-	-	-	-
Sida spinosa	1.13	1.30	0.90	1.27	0.83	0.93	-	0.80	-	-	-	-
Mimosa pudica	0.80	0.93	0.70	0.85	-	0.60	-	-	-	-	-	-
Rumex maritimus	1.33	1.70	1.17	1.47	0.93	1.23	0.63	0.73	-	-	-	-
Gynura cusimba	1.53	1.60	1.36	1.33	0.90	1.10	0.83	0.90	-	-	-	-
Ipomoea carnea	1.00	1.20	1.00	1.10	0.86	0.98	0.65	0.73	-	-	-	-
Cassia tora	0.63	0.77	0.53	0.63	-	0.43	-	-	-	-	-	-
Cassia sericea	0.83	0.97	0.63	0.77	-	0.63	-	-	-	-	-	-
Control						1.80*						
LSD (P=0.05)	0.20	0.15	0.19	0.14	0.12	0.19	0.09	0.14				

*Mean value of all the control

and *Prosopis spicigera* had a allelopathic effect on *Parthenium* and reduced the vigour index considerably as compared to control.. Among all plant extracts, leaf and stem extract of *C. tora*, *M. pudica*, *C sericea* and *Cajanus cajan* had more inhibitory effect on vigour of *Parthenium.*

Damage potential of *Zygogramma bicolorata*

Adults and grubs of *Z. bicolorata* damaged *Parthenium* and reduced plant height, shoot length, root length, stem diameter and plant biomass than control. The damage was more pronounced after 30 days of initial introduction compared to 15 days (Table 5). The grubs fed more vigorously on leaves of *Parthenium* than the adults. However, the reduction in root length was not significant. 30 days of continuous feeding reduced 66.3% of plant height and caused 100% reduction in flower production. *Zygogramma bicolorata* was considered effective biocontrol agent for *Parthenium* suppression (Sangamitra and Monica Basu 2008). Sushilkumar (2010) discussed and reviewed the impact of bioagent *Z. bicolorata* in detail.

Table 4. Allelopathic effect of plants leaf and stem extracts at different concentration on *Parthenium* biomass and vigour index

Plants	Concentration											
	5%		10%		20%		30%		50%		75%	
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
Biomass (mg/plant)												
Cajanus cajan	2.0	2.1	1.1	1.2	1.2	1.1	-	1.1	-	-	-	-
Sida spinosa	2.7	2.8	2.4	2.5	2.0	2.1	-	1.0	-	-	-	-
Mimosa pudica	1.0	1.5	0.9	1.4	-	0.8	-	-	-	-	-	-
Rumex maritimus	3.0	3.2	2.3	2.9	2.1	2.2	1.13	1.1	-	-	-	-
Gynura cusimba	3.2	3.3	2.4	2.7	2.1	1.5	1.53	1.3	-	-	-	-
Ipomoea carnea	2.4	2.5	2.0	2.3	1.4	1.7	1.33	1.2	-	-	-	-
Cassia tora	1.2	1.1	1.0	1.0	-	0.7	-	-	-	-	-	-
Cassia sericea	1.4	1.6	1.2	1.3	-	1.2	-	-	-	-	-	-
Control						3.6*						
LSD (P= 0.05)	0.3	0.1	0.2	0.1	0.1	0.1	0.2	0.1				
Vigour index												
Cajanus cajans	443.2	549.0	222.1	392.5	123.0	198.7	-	67.0	-	-	-	-
Sida spinosa	630.1	1012	246.0	552.2	305.6	352.0	-	143.0	-	-	-	-
Mimosa pudica	333.2	445.9	163.6	304	-	123.7	-	-	-	-	-	-
Rumex maritimus	1380.5	1871.1	690.0	1199.4	327.3	549.9	167.6	248.8	-	-	-	-
Gynura cusimba	1716	1984.4	990.0	1045.0	466.2	692.8	300.6	238.8	-	-	-	-
Ipomoea carnea	768.6	1039.2	433.4	560.7	260.5	391.4	86.4	136.0	-	-	-	-
Cassia tora	232.1	381.8	109.0	244.0	-	79.0	-	-	-	-	-	-
Cassia sericea	370.5	510.0	205.4	355.1	-	193.7	-	-	-	-	-	-
Control						3674.6*						

*Mean value of all the control

Table 5. Impact of *Zygogramma bicolorata* on growth of *Parthenium* after 15 and 30 days of release

Criteria	After 15 Days				After 30 days			
	Control	Treated	% reduction	Calculated 't' value	Control	Treated	% reduction	Calculated 't' value
Plant height (cm)	10.8	6.5	39.8	13.2	18.4	6.2	66.3	15.6
Shoot length (cm)	8.1	5.3	34.2	15.3	14.3	5.6	60.8	12.6
Stem diameter (mm)	2.6	1.9	26.9	7.3	2.6	2.1	22.2	2.2
Root length (cm)	7.4	6.3	14.9	1.6	8.1	7.1	12.1	2.0
Plant biomass (mg/plant)	465.0	278.9	40.0	42.3	584.0	132.0	77.4	136.7

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