Research Article

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Bio-activity of *Xanthium strumarium* extracts against tea mosquito bug, *Helopeltis theivora*

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Abstract

Laboratory and field experiments were conducted to study the antifeedant, repellent, ovicidal, longevity, anti-ovipositional properties and bio-efficacy of *Xanthium strumarium* extracts against adult tea mosquito bug, *Helopeltis theivora.* All the extracts exhibited significant bio-activity compared to control. The results were also compared with a commercial neem formulation, Azadirachtin. Among all the different solvent extracts, acetone extract recorded the highest antifeedant activity. The antifeedant activity possessed by this extract at 3 per cent concentration was significantly superior over azadirachtin at 5 per cent concentration. Fraction IV of silica gel column chromatography proved to be the most active fraction among those partitioned from the acetone extract by bioassay-guided separation. The extracts exhibited 86-99 per cent repellency at all tested concentrations. Fecundity, hatching of eggs and longevity of *H. theivora* were also significantly reduced with all the extracts, the highest being exhibited by the acetone extract. All the extracts exhibited promising bioactivity in reducing infestation of *H. theivora* in the field. Among all the tested extracts the acetone extract gave the highest significant efficacy.

Keywords: Antifeedant, *Helopeltis theivora*, ovicidal, ovipositional detterent, plant extracts, repellent

Introduction

Tea mosquito bug, *Helopeltis theivora* (Miridae; Hemiptera) is one of the most serious pests of tea in North-East India. It remains active from March to November and attains peak population during June-July causing severe damage to tea (Sarmah and Phukan, 2004). Both nymphs and adults of tea mosquito bug cause damage by sucking the sap of the young leaves, buds and tender stems. Use of synthetic pesticides has been the main management approach to combat this pest during recent decades. The hazardous effects of synthetic insecticides and stringent regulatory measures necessitate measures for reduction of pesticide load and search for safer alternatives. Many plant products had been reported to possess good insecticidal or acaricidal or both properties against various crop pests (Pandey *et al.,* 1977; Akhtar and Isman 2004; Murugesan and Murugesh, 2008; Peta and Rani, 2008). Environmental, economic and social benefits of using botanical pesticides are gaining importance and have been well documented. So, plant extracts possessing insecticidal properties could be one of the safer alternatives for pest management. This study was undertaken during at Tocklai Experimental Station, Jorhat, Assam to evaluate the bioactivity of *Xanthium strumarium* against tea mosquito bug.

Materials and methods

Preparation of plant extracts

Aqueous extract

The leaves and succulent stems of *Xanthium strumarium* was collected locally from nearby areas of Tocklai Experimental Station, Jorhat during March to May 2010, shade dried and powdered to 20 mesh size. The powdered plant material was mixed separately with distilled water to prepare 2, 4, 6 and 8 per cent water extract. Each mixture was

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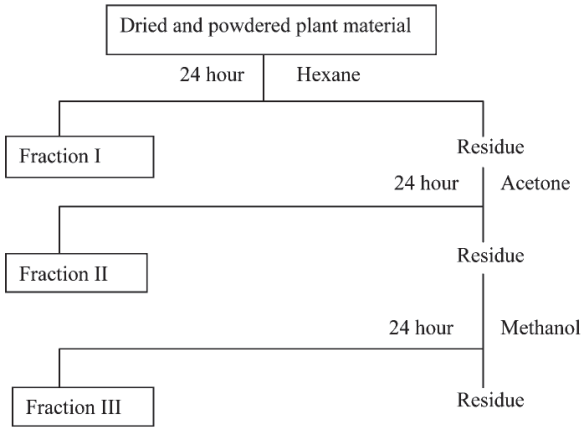
shaken for 24 hours in a mechanical shaker. The extract so obtained was filtered through Whatman No. 40 filter paper and the volume was adjusted with water to get the respective concentration. Triton X-100 (1 ml 1000 ml^{-1} of water) was used as a surfactant.

Solvent extract

For the preparation of solvent extract, 250 g powdered plant material was extracted in a soxhlet extractor using hexane, acetone and methanol as solvent in a sequence on the basis of their polarity (Bhatnagar and Sharma, 1994). The extraction was carried out for 24 hours with each solvent as shown below.



The solvents were removed under reduced pressure in a rotary evaporator to obtain semi-solid material. This material was dissolved in methanol to prepare 20 per cent stock solution from which different concentrations ranging from 1 to 4 per cent were prepared in distilled water from the stock solution.

Fractionation of acetone extract through column chromatography

The acetone extract was chromatographed on a silica gel column (60-120 mesh) and successively eluted with step-wise gradient of hexane, ethyl acetate : hexane (1:3, 1:1 and 3:1), ethyl acetate, acetone : ethyl acetate (1:3, 1:1 and 3:1), acetone, methanol:acetone (1:3, 1:1 and 3:1) and finally methanol. The solvents of all the fractions were removed under reduced pressure in a rotary evaporator. Residues so obtained were dissolved in acetone and 0.5 per cent solution in distilled water was prepared and evaluated to test the biological activity against tea mosquito bug.

Antifeedant test

For the assessment of antifeedant properties of the extracts, seven days old shoots (two leaves and a bud) of a susceptible tea variety, TV1 were used. Five such shoots wrapped with absorbent cotton were kept in a reagent bottle containing water. Four ml of different concentrations of each extract was sprayed thoroughly with the help of a calibrated hand atomizer. The sprayed shoots were later on air dried. The tea shoots maintained as control were sprayed with an equal amount of water. Laboratory reared adult *H. theivora* starved for six hours was released on treated shoots and caged with lantern chimney (one insect $cage^{-1}$). Each cage was taken as one replication and each treatment was replicated for six times. The adults released were allowed to feed upon treated as well as control shoots for 48 hours and the number of spots produced in each replication was counted.

Repellent test

To explore the repellence effect of plant extracts, the treated and control shoots were placed equidistantly in a wooden insect rearing box. Laboratory reared fifty adult *H. theivora* starved for six hours were released at the center for 6 hours (Pandey *et al*., 1977). Data on the number of adults which have reached treated and control shoots as well as number of feeding spots induced was recorded. The experiment was replicated six times.

Ovicidal, fecundity and adults longevity tests

The ovicidal property of the extracts at different concentrations of extracts was tested by spraying on the shoots bearing eggs of uniform age using hand atomizer. Water was sprayed in case of control. Twenty five eggs were used in each replication and each treatment was replicated six times. Hatching was recorded in both control and treated shoots till the last emergence in control. The per cent egg hatch was subjected to completely randomized block design analysis of variance.

The shoots of a susceptible tea genotype (TV1) sprayed with different plant extracts and concentrations were transferred to oviposition chamber. Fecundity of tea mosquito bug was studied

by releasing one pair of adult bug within 24 hours of emergence into each oviposition chamber. Treated shoots were replaced by untreated ones after five days. The adult female was allowed to lay eggs and the number of eggs laid by each female during its total life was recorded. Each treatment was replicated six times. The data was subjected to completely randomized block design analysis of variance.

For determining the adult longevity of tea mosquito bug, fresh tea shoots were collected from the field and treated separately. Five shoots of each treatment were kept in a reagent bottle with water and covered with lantern chimney. One pair of tea mosquito bug adult within 24 hours of post eclosion was released into each chimney. The subsequent shoots supplied were untreated ones. The adults were allowed to feed till death. Adult longevity was recorded. Each treatment was replicated six times. All the data were subjected to completely randomized block design analysis of variance.

Field efficacy of plant extracts

Field experiments were conducted at Borbhetta Experimental Tea Estate, Tocklai Experimental Station, Tea Research Association, Jorhat, Assam in randomized block design (RBD) with three replications against tea mosquito bug during June-July for the year 2010. Sixty tea bushes of genotype TV9 (a susceptible Tocklai variety) were selected for the study with a spacing of 105 x 60 cm. Each plot was separated by two rows of tea bushes. Four concentrations (2, 4, 6 and 8%) of aqueous extracts and four concentrations (1, 2, 3 and 4%) of solvent extracts (petroleum ether, acetone and methanol) were used to evaluate the efficacy of the extracts. A commercial neem formulation Neemazal-F 5 per cent (Azadirachtin 5%) at 1:1500 dilution (0.0033% concentration), one systemic insecticide Thiomethoxam 25 WG (Actara 25WG) at 1:4000 dilution (0.0063% concentration) and one untreated control were included for comparison. Bushes were sprayed twice at an interval of fourteen days with hand operated Knapsak sprayer fitted with a NMD/ 60450 nozzle. For the observation of *Helopeltis* infestation ten bushes were randomly selected from each plot and number of healthy and infested shoots was counted before 24 hours and after 7 and 14 days of first and second spraying. The per cent shoot infestation and reduction was calculated by following formulae.

$$\text{Per cent shoot infestation} = \frac{\text{Infested shoots per replicate}}{\text{Total no. of shoots per replicate}} \times 100$$

$$\text{Per cent reduction of infestation} = \frac{\text{Pretreatment infestation} - \text{Post treatment infestation}}{\text{Pretreatment infestation}} \times 100$$

Table 1. Antifeedent activity of plant extracts on adults of *H. theivora*

Treatment	Conc.	Antifeedant activity after 48h							
		Aqueous		Hexane		Acetone		Methanol	
		FS	Per cent reduction of FS over control	FS	Per cent reduction of FS over control	FS	Per cent reduction of FS over control	FS	Per cent reduction of FS over control
X. strumarium	1% (2%)*	76.17±3.02	44.67	67.33±2.69	51.09	49.83±2.54	63.8	61.50±3.20	55.32
extract	2% (4%)*	63.67±2.13	53.75	61.50±2.22	55.32	36.67±2.98	73.36	50.67±2.13	63.19
	3% (6%)*	56.50±1.71	58.95	47.67±2.29	65.37	30.50±1.71	77.84	46.83±3.02	65.98
	4% (8%)*	47.67±4.07	65.37	38.50±2.50	72.03	23.83±2.54	82.69	36.83±2.91	73.24
Neemazal-F 5%	0.0033%	36.50±1.71	73.48	36.50±1.71	73.48	36.50±1.71	73.48	36.50±1.71	73.48
Control	-	137.67±5.88	-	137.67±5.88	-	137.67±5.88	-	137.67±5.88	-
CD (P=0.01)		4.85		5.63		5.48		5.3	
CV (%)		4.65		5.48		6.56		5.38	

*Values in parentheses are concentration tested in case of aqueous extracts; Each figure represents the mean number of feeding spots ± SD (n=6) FS: Feeding spot

All the data were subjected to RBD analysis of variance and significant differences between means were determined by comparing critical differences at 5 per cent probability level.

Results and discussion

Antifeedant activity of aqueous, hexane, acetone and methonal extracts of *X. strumarium* against adult tea mosquito bug is presented in Table 1. It was found that all the extracts exhibited significant repellence and antifeedant effect compared to control. Among all the extracts tested, acetone extracts showed the highest reduction of 64-82 per cent feeding spot after 48 hours of treatment over control followed by methanol (55-73%), hexane (51-72%) and aqueous extract (44-65%). Neemazol F 5 per cent, a commercial neem formulation @ 0.0033 per cent recorded 73 per cent reduction of feeding spots which is comparable with 2 per cent concentration of acetone and 4 per cent concentration of hexane and methanol extracts. The fractionation of the most biologically active fraction *i.e*. acetone extract of *X. strumarium* through column chromatography revealed that the fraction IV isolated with the solvent ethyl acetate and hexane @ 3:1 ratio exhibited the highest reduction of 85.4 per cent feeding spot after 24 hours of treatment even at 0.5 per cent concentration (Table 2). The results of the present study are comparable with the findings of Gogoi *et al*. (2003), have reported that petroleum ether, chloroform and methanol extracts of *Pogostemon parviflorus, Pongamia glabra* and *Annona squamosa* leaf exhibited antifeedant activity against *H. theivora.* The present results are also in conformity with the results of Kathirvelu *et al.* (2009) where, hexane extracts of *Atlantia monophylla* leaf were indicated good antifeedant activity against third instar larvae of *Helicoverpa armigera.* They further separated 12 fractions from this extract by silica gel column chromatography and found that the fraction IX exhibited the highest antifeedant activity.

All the extracts of *X. strumarium* exhibited good repellent activity against adult tea mosquito

Table 2. Antifeedant activity of column chromatography fractions of acetone extract of *X. strumarium*

Solvent used	Fractions (0. 5%)	No. of feeding spots after 24 hrs
Hexane	I	fraction not extracted
Ethyl acetate/hexane (1: 3)	II	20.4 ± 1.02
Ethyl acetate/hexane (1: 1)	III	14.2 ± 1.17
Ethyl acetate/hexane (3: 1)	IV	10.6 ± 1.02
Acetone	V	17.2 ± 0.75
Methanol/acetone (1:3)	VI	23.2 ± 0.75
Methanol/acetone (1:1)	VII	27.6 ± 1.02
Methanol	VIII	33.4 ± 2.42
Control		72.8 ± 1.72
CD (P=0.01)		3.4

Each figure represents the mean number of feeding spots ± SD (n=6)

Table 3. Repellent activity of plant extracts on adults *H. theivora*

Treatment	Concentration	Repellent activity of plant extract							
		Aqueous		Hexane		Acetone		Methanol	
		Adults reached to the treated shoots	No. of spots per adult	Adults reached to the treated shoots	No. of spot per adult	Adults reached to the treated shoots	No. of spots per adult	Adults reached to the treated shoots	No. of spots per adult
X.strumarium extract	1% (2%)*	7.00±1.29	5.00±0.96	5.00±0.82	3.50±0.82	3.00±0.82	2.50±0.58	7.00±1.29a	5.00±1.19a
	2% (4%)*	4.50±0.96	2.00±0.82	4.00±0.82	3.50±0.82	2.00±0.58	1.50±0.41	5.50±0.96a	4.00±0.65a
	3% (6%)*	3.00±1.15	1.33±0.47	2.50±0.76	2.00±0.58	1.00±0.58	0.92±0.61	3.50±0.96a	2.50±0.58a
	4% (8%)*	0.83±0.67	0.92±1.02	1.67±0.47	1.50±0.76	0.50±0.50	0.67±0.75	2.50±0.96a	2.00±0.82a
Neemazal-F	5%0.0033%	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Control	-	35.00±3.16	9.50±2.55	36.83±1.34	9.5±1.26	43.16±1.57	8.83±1.34	31.17±2.54	9.67±1.11
CD (P=0.01)		2.48	1.99	1.41	1.39	1.47	1.28	2.37	1.43

* Values in parentheses indicate concentration tested in case of aqueous extracts

Each figure represents the number of adults reached to the treated shoots or feeding spots ±SD (n= 6) after 6 hrs

Table 4. Effect of plant extracts on the fecundity of *H. theivora*

Treatment	Concent-ration	Aqueous		Hexane		Acetone		Methanol	
		Fecundity	Per cent reduction in fecundity	Fecundity	Per cent reduction in fecundity	Fecundity	Per cent reduction in fecundity	Fecundity	Per cent reduction in fecundity
X.strumarium	1% (2%)*	49.50±2.36	55.13	50.50±2.80	54.16	43.50±2.43	60.51	53.00±3.06	51.89
extract	2% (4%)*	47.67±2.75	56.79	44.33±2.75	59.76	38.33±2.21	65.2	46.33±2.81	57.94
	3% (6%)*	46.17±1.95	58.15	38.17±3.24	65.35	33.00±2.38	70.04	41.33±2.36	62.48
	4% (8%)*	44.17±1.57	59.96	35.00±2.38	68.23	28.50±2.06	74.13	38.00±3.87	65.5
Neemazal-F 5%	0.0033%	36.16±1.34	67.22	36.33±3.14	67.02	36.33±3.14	67.02	36.33±3.14	67.02
Control	-	110.33±2.36	-	110.17±4.06	-	110.17±4.06	-	110.17±4.06	-
CD (P=0.01)		3.55		9.42		5.69		7.68	
CV (%)		4.21		16.18		9.24		11.69	

* Values in parentheses indicate concentration tested in case of aqueous extracts

bug. Acetone extract recorded the highest repellency of 94-99 per cent followed by hexane (90-96%), aqueous (86-98%) and methanol (86-95%) extract. However, Neemazol F 5 per cent, a commercial neem formulation exhibited 100 per cent repellency (Table 3). The present results are in conformity with the earlier findings of Sarmah and Bhola (2008) where they found that aqueous extracts of *A. indica* and *X. strumarium* exhibited good antifeedant and repellent activity against nymphs and adults of tea mosquito bug. Similarly Yasodha and Natarajan (2007) confirm the repellency property of certain plant extracts against *Leucinodes orbonalis.* They observed that organic solvent extracts exhibited more repellency than the aqueous extract.

Fecundity of tea mosquito bug was also adversely affected when treated with these extracts (Table 4). The highest reduction on fecundity (60-74%) was exhibited by acetone extract followed by hexane (54-68%), methanol (51-65%) and water (55-59%) extracts. Hexane and acetone extracts at 2, 3 and 4 per cent concentration were statistically at par with Neemazol-F 5 per cent. However, acetone extract at 4 per cent concentration was found to be superior to that of Neemazol-F 5 per cent. The results of the present investigation are also in agreement with the findings of Erdogan and Toros (2007) that the fecundity of Colorado potato beetle, *Leptinotarsa decemlineata* was adversely affected when treated with methanol extract of *X. strumarium*.

Longevity of both male and female *H. theivora* was adversely affected when exposed to all the tested extracts (Table 5). Acetone extract was found

Table 5. Effect of plant extracts on the longevity of *H. theivora*

Treatment	Concent-ration	Aqueous		Hexane		Acetone		Methanol	
		male	female	male	female	male	female	male	female
X.strumarium	1% (2%)*	18.83±1.34	23.16±1.07	19.00±1.53	20.50±1.71	13.33±1.60	14.50±1.89	21.83±2.61	23.00±1.91
extract	2% (4%)*	15.83±1.07	20.00±1.29	17.17±1.77	18.67±1.49	11.67±1.70	13.00±2.00	18.33±1.97	22.00±1.53
	3% (6%)*	13.83±0.69	17.50±0.96	15.50±0.96	17.00±2.16	9.50±1.38	10.83±1.34	18.33±1.97	19.33±1.60
	4% (8%)*	12.00±1.29	15.00±0.82	14.33±1.60	15.50±1.71	8.33±1.60	9.50±1.71	15.00±1.91	18.00±1.91
Neemazal-F 5%	0.0033%	7.33±1.11	8.00±1.29	7.33±1.11	8.00±1.29	7.33±1.11	8.00±1.29	7.33±1.11	8.00±1.29
Control	-	31.50±1.26	33.50±2.36	31.50±1.26	33.50±2.36	31.50±1.26	33.50±2.36	31.50±1.26	33.50±2.36
CD (P=0.01)		5.96	6.4	6.25	6.79	3.73	3.78	3.62	3.67

* Values in parentheses indicate concentration tested in case of aqueous extracts

Table 6. Ovicidal activity of plant extracts against *H. theivora*

Treatment	Concent-ration	Aqueous		Hexane		Acetone		Methanol	
		Per cent egg hatched	Per cent reduction in egg hatching over control	Per cent egg hatched	Per cent reduction in egg hatching over control	Per cent egg hatched	Per cent reduction in egg hatching over control	Per cent egg hatched	Per cent reduction in egg hatching over control
X. strumarium	1% (2%)*	52.67±2.75	22.54	57.33±5.96	18.10	48.67±5.37	30.47	64.00±6.53	8.57
extract	2% (4%)*	48.67±2.75	28.42	51.33±4.27	26.67	46.00±3.83	34.28	55.33±4.27	20.95
	3% (6%)*	45.33±4.42	33.33	46.00±3.83	34.28	40.00±3.27	42.85	50.00±3.83	28.57
	4% (8%)*	42.00±3.83	38.23	42.00±3.83	40.00	37.33±4.99	46.67	46.00±3.83	34.28
Neemazal-F 5%	0.0033%	35.33±2.75	48.08	36.00±4.27	48.57	36.00±4.27	48.57	36.00±4.27	48.57
Thiomethoxam	0.0063%	5.33±1.89	92.16	4.00±3.27	94.28	4.00±3.27	94.28	4.00±3.27	94.28
Control	-	68.00±3.27	-	70.00±3.83	-	70.00±3.83	-	70.00±3.83	-
CD (P=0.01)		5.6		10.53		7.53		8.44	
CV (%)		8.56		15.56		11.90		12.10	

* Values in parentheses indicate concentration tested in case of aqueous extracts

to be the best in reducing the survival of male and female tea mosquito bug to the tune of 8.3-13.3 and 9.5-14.5 days respectively compared to 31.5 and 33.5 days in the control. Neemazol-F 5% exhibited the highest activity by reducing the survival period to the tune of 7.3 and 8.0 days in male and female *Helopeltis* respectively which was statistically comparable with the acetone extracts at 3 and 4 per cent concentration. The present results are in conformity with the earlier findings of Sarmah and Bhola (2011) where they found that aqueous extracts of *A. indica, A. calamus, X. strumarium* and *Polygonum hydropiper* exhibited significant reduction of hatching of eggs and adult longevity of tea mosquito bug. This is also in agreement with the findings of Chander and Bhargava (2003) wherein they reported that longevity of adults *Spodoptera litura* was reduced when exposed to neem seed extract.

All the extracts also possessed ovicidal activity against *H. theivora* (Table 6). The highest ovicidal action was exhibited by the acetone extract which showed 30-46 per cent reduction of egg hatching over control followed by hexane, aqueous and methanol extracts. Acetone extracts at 3 and 4 per cent and hexane extracts at 4 per cent recorded 43-46 per cent and 40 per cent reduction of egg hatching respectively which were comparable to that of Neemazol-F 5 per cent (48.5%). Thiamethoxam 25 WG at 0.00625 per cent exhibited 92-94 per cent reduction of egg hatching over control and found to be significantly superior to all other treatments. Similar observations were also made earlier by Roy *et al.* (2009). They found that methanol, acetone and petroleum ether extract of *Clerodendron infortunatum* possess ovicidal activity against *H. theivora.* Similarly Sarmah *et al.* (2007) also reported ovicidal activity of petroleum ether, acetone and methanol extracts of *X. strumarium*, *A. calamus*, and *Pongamia pinnata* against tea red spider mite, *Oligonychus coffeae*.

The bioefficacy of all the extracts at all tested concentration was found to be promising in reducing the infestation of tea mosquito bug in the field (Table 7A). Among all the extracts, acetone extract was found to be the best in reducing *Helopeltis* infestation to the tune of 46.22-58.26 per cent followed by hexane (33.55-48.70%), aqueous (29.05-49.40%) and methanol (28.52-44.10%) extracts (Table 7B). However, the commercial product Neemazol-F 5 per cent recorded 52.72-59.33 per cent reduction of infestation and this is comparable with acetone extract at 3 and 4 per cent concentration. Another commercial product Thiamethoxam 25 WG used for comparison exhibited 87.21-98.36 per cent reduction of infestation and found to be significantly superior to all other treatments. The present findings are in agreement with the findings of Deka *et al*., 2000 and 2001 where they reported that *Lantana camara, Adhatoda vasica, Clerodendrum inerme* and *Pongamia pinnata* extracts prepared with water,

Table 7A. Per cent pretreatment and post treatment shoot infestation

Treatments	Conc. (%)	% shoot infestation																			
		Aqueous					Hexane					Acetone					Methanol				
		Pre treatment	Post treatment % shoot infestation				Pre treatment	Post treatment % shoot infestation				Pre treatment	Post treatment % shoot infestation				Pre treatment	Post treatment % shoot infestation			
			First spray		Second spray			First spray		Second spray			First spray		Second spray			First spray		Second spray	
			7 Days	14 Days	7 Days	14 Days		7 Days	14 Days	7 Days	14 Days		7 Days	14 Days	7 Days	14 Days		7 Days	14 Days	7 Days	14 Days
X. strumarium	1 (2)*	55.75	38.25	39.55	37.5	38.75	58.11	37.11	38.61	35.86	35.21	55.17	27.97	29.67	27.37	27.57	53.64	35.64	38.34	35.24	35.44
extract	2 (4)*	54.14	31.99	34.04	31.79	33.24	54.75	33.25	35.75	31.95	32.25	53.64	25.64	26.64	24.64	25.14	52.09	32.09	33.59	31.39	31.89
	3 (6)*	55.11	30.86	32.97	30.11	31.31	57.29	31.79	34.79	30.99	31.29	53.78	24.58	26.28	23.68	24.18	53.5	32	33.5	31.5	31.8
	4 (8)*	54.85	28.35	29.65	27.75	28.85	55.23	28.53	30.23	29.03	28.33	52.35	22.35	23.85	21.85	22.55	54.42	30.92	33.42	30.42	30.62
Neemazal-F 5%	0.0033	55.95	24.45	26.45	22.75	23.35	55.95	24.45	26.45	22.75	23.35	55.95	24.45	26.45	22.75	23.35	55.95	24.45	26.45	22.75	23.35
Thiomethoxam 25 WG	0.0063	55.61	5.46	7.11	1.11	0.91	55.61	5.46	7.11	1.11	0.91	55.61	5.46	7.11	1.11	0.91	55.61	5.46	7.11	1.11	0.91
Control (untreated)		54.48	53.48	55.38	53.98	55.98	54.48	53.48	55.38	53.98	55.98	54.48	53.48	55.38	53.98	55.98	54.48	53.48	55.38	53.98	55.98
S.Em ±		1.37	1.31		1.07	1.13	1.22	0.98	0.55	0.3	1.39	1.25	1.53	1.05	0.42	1.36	1.24	1.3	1.26	1.35	1.33
CD(P=0.05)		3.98	3.81		3.12	3.28	3.54	2.84	1.61	0.87	4.03	3.65	4.44	3.04	1.22	3.94	3.6	3.77	3.66	3.92	3.86
CV%		3.08	5.34		4.54	4.61	2.7	3.96	2.11	1.26	5.8	2.86	7.2	4.64	2.07	6.54	2.83	5.26	4.79	5.66	5.49

* Values in parentheses indicate concentration tested in case of aqueous extracts

Table 7B. Field bioefficacy of plant extracts against tea mosquito bug

Treatments	Conc. (%)	Aqueous				Hexane				Acetone				Methanol			
		Percentage reduction after															
		First spray		Second spray		First spray		Second spray		First spray		Second spray		First spray		Second spray	
		7 Days	14 Days	7 Days	14 Days	7 Days	14 Days	7 Days	14 Days	7 Days	14 Days	7 Days	14 Days	7 Days	14 Days	7 Days	14 Days
X. strumarium extract	1 (2)*	31.39	29.05	32.73	30.49	36.13	33.55	38.28	39.4	49.3	46.22	50.38	50.02	33.55	28.52	34.3	33.92
	2 (4)*	40.91	37.12	41.28	38.6	39.26	34.7	41.64	41.09	52.19	50.33	54.06	53.13	38.39	35.51	39.73	38.77
	3 (6)*	44	40.17	45.36	43.18	44.51	39.27	45.9	45.38	54.29	51.13	55.96	55.03	40.18	37.38	41.12	40.56
	4 (8)*	48.31	45.94	49.4	47.4	48.34	45.26	47.43	48.7	57.3	54.44	58.26	56.92	43.18	38.58	44.1	43.73
Neemazal-F 5%	0.0033	56.3	52.72	59.33	58.26	56.3	52.72	59.33	58.26	56.3	52.72	59.33	58.26	56.3	52.72	59.33	58.26
Thiomethoxam 25 WG	0.0063	90.18	87.21	98	98.36	90.18	87.21	98	98.36	90.18	87.21	98	98.36	90.18	87.21	98	98.36
Control (untreated)		1.83	-1.65	0.91	-2.75	1.83	-1.65	0.91	-2.75	1.83	-1.65	0.91	-2.75	1.83	-1.65	0.91	-2.75

* Values in parentheses indicate concentration tested in case of aqueous extracts

chloroform, petroleum ether and methanol solvents were found to be promising against *H. theivora* under field condition. Effectiveness of plant extracts under field conditions have also been reported by Sakthivel *et al*. 2007 against sucking pests of okra.

Thus the present study revealed that all the solvent extracts of *X. strumarium* exhibited significant bioactivity against tea mosquito bug and can be effectively integrated in pest management strategies for managing *Helopeltis theivora.*

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