International Journal of Tea Science
Vol. 8(4) 2012

Potential of some plant extracts to control termite pest of tea (*Camellia sinensis* L. (O) Kuntze) plantations of Barak Valley, Assam, India

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ABSTRACT: Aqueous extracts (AEs) of *Ipomea carnea* (Jacq.), *Cleome viscose* L. and *Pavonia glechomifolia* L. were evaluated under both laboratory and field conditions against tea termites, *Microcerotermes beesoni* Snyder and *Microtermes obesi* Holmgren. The AEs were evaluated at different concentrations ranging from 0.5% to 8%. The Parameters assessed were termiticidal activity and antifeeding activity. All the AEs showed >50% mortality of termites at concentrations between 2% and 8% *in vitro*, while field evaluation of AEs at 10% concentrations recorded 32–90% termite reduction. More termite control activity was noticed in *Ipomea carnea* Jacq. as compared to *Cleome viscose* L. and *Pavonia glechomifolia* L. under field condition. The AEs caused significant change in termite feeding after 24 hrs in comparison with untreated control. Crude plant extracts of *Ipomea carnea*, *Cleome viscosa* and *Pavonia glechomifolia* can effectively be utilized as safer phytopesticidal products in tea estates as one of the potent tools in integrated termite management.

Keywords: *Cleome viscosa*; *Ipomea carnea*; *Pavonia glechomifolia*; Plant extracts; Tea termites; Termite control; Phytopesticides; Assam

Introduction

Since the beginning of tea plantations, pest and disease problems were found to be an integral part of the tea plant, which is under monoculture for over 150 years in the northeastern India including Barak Valley. Among the important and predominant pests, the damage caused by termite to mature and young tea areas has been found to be enormous ranging from 30% to 90%.[1,2] Indiscriminate use of chemical pesticides for the control of insect pests has contributed to a number of biological and environmental hazards. These men-created problems have further resulted in phytotoxicity, mammalian toxicity, biomagnification of pesticide residue, insect resistance, insect resurgence and increased cost of production. Such problems suggest finding an alternate strategy for the insect pest control. Biological control methods including phytochemicals seem to be the only effective alternative to control insect pests, which is getting worldwide attention these days.

Plants are known to have chemicals that protect them from different insect pests and microorganisms. Insecticides of plant origin have received considerable attention in recent years due to their effectiveness on many economically important insect pests and their environment compatibility.[3] Plant products are considered as safer and alternative to toxic synthetic chemicals currently in use. Many chemicals in plants are found to either inhibit or induce insect feeding, which adversely affect the metamorphosis and growth in a number of insect pests.[4–10] This approach may help enhancing natural entomopathogenic enemy activity in crop fields and may find a role in the Integrated Termite Pest Management in tea as well. Hence in this study an attempt was made to explore the potential and utilization of *Ipomea carnea* Jacq., *Cleome viscose* L., *Pavonia glechomifolia* L. against the termite pest of tea under the laboratory and field conditions in the tea growing areas of Barak valley, Assam, India.

Materials and Methods

Collection and Preparation of Plant Sample

Plants (as summarized in Table 1) were collected from the fields and washed thoroughly with tap water and air dried. These were subsequently finely powdered separately using an electronic grinder. Crude plant extracts were made by dissolving 250 g each of the powdered plant material in distilled water. Only 500 ml of distilled water were sufficient enough to immerse the powder in it. These were kept for 24 hr and then filtered through the Whatman no. 1 filter paper. Subsequently, fresh solvent was added to the residue and filtered again. The process was repeated 2–3 times. All the filtrates were pooled and

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ISSN: 0972-544X (print)

Table 1: Plants Evaluated for Insecticidal Properties against Tea Termites (*i.e. Microcerotermes beesoni* and *Microtermes obesi*)

Plants	Family	Parts Used	Common Name
Cleome viscose L.	Capparidaceae	Leaves & stem	Asian Spider Flower
Ipomea carnea (Jacq.)	Convolvulaceae	Leaves & stem	Bush Morning Glory
Pavonia glechomifolia	Malvaceae	Leaves	Swamp Mallow

the solvents were evaporated leaving only the concentrated extracts.

The extracts were dissolved in distilled water to make 10% solution. This was taken as stock solution. A control without any extract was kept for all the experiments. From the stock solutions a series of dilutions in distilled water were prepared ranging from 0.01% to 8%. All the dilutions were used against the worker castes of termite to get 50% mortality (LC_{50}) after 24 hr exposure. All the experiments include three replicates of 30-termite worker each for each conc. of the plant extracts used and repeated for three times. All the plant extract solutions were sprayed on the worker castes of termites by using a hand-operated sprayer.

Table 2: Termicidal Activity of Aqueous Plant Extracts against *Microcerotermes beesoni* under Laboratory Condition

Plants	Parts Used	Concentration (%)	%Mortality* (±S.E.)
Ipomea carnea	Leaf	0.5	14.44±0.88
		1	24.44±1.45
		2	36.67±1.53
		4	44.44±1.33
		8	70.00±1.53
	Stem	0.5	16.67±0.57
		1	27.78±0.8
		2	34.44±1.33
		4	42.22±1.20
		8	62.22±1.20
Cleome viscosa	Leaf	0.5	12.22±1.20
		1	18.88±1.45
		2	28.88±2.02
		4	53.37±1.73
		8	74.44±1.45
	Stem	0.5	12.22±0.64
		1	20.00±1.11
		2	32.22±1.69
		4	42.22±1.69
		8	72.22±1.69
Pavonia glechomifolia	Leaf	0.5	14.44±1.20
		1	26.66±0.58
		2	42.26±0.88
		4	70.00±1.15
		8	95.54±0.66
Control (water)			4.44±1.15
CV (%)			11.217
CD (P = 0.05)			8.475

*Mean of three observations (30 termite workers/obs).

Water extracts of the plant parts were also tested for their antifeedent/repellent properties against *M. beesoni*. The experiment was performed by mixing 1 g of saw dust with the extracts (10% concentration) which was subsequently air-dried. This air-dried saw dust was provided as food material to the worker castes of termites and observed until the death of all the termites. All the treatments include three replicates of 30 termite workers each. In control treatment, the saw dust was mixed with distilled water only.

Phytochemical Screening of the Selected Plant Species

The plant material samples were air-dried and ground into uniform powder using an electronic grinder. The aqueous and solvent extracts were prepared by soaking 100 g of dried powdered samples in 200 ml of distilled water/solvent for 12 hr. The extracts were filtered using Whatman filter paper no. 42 (125 m), dried and used for the tests. Chemical tests were carried out on the extract and on the powdered samples using standard procedures to identify the constituents. To test alkaloids, 3 g of dried plant material was used for extraction with ethanol containing tartaric acid. To the filtrate Mayer's reagent was added. A precipitate observed in the filtrate indicated the presence of alkaloids.[11] For the tannins test, 10 ml of freshly prepared 10% potassium hydroxide (KOH) in a beaker, 10 ml of ethanolic extract of the plant was added. A dirty precipitate observed in the extract indicated the presence of tannins.[11,12]

For test for saponins, five drops of olive oil was added to 30 ml of the ethanolic extract of the test plant

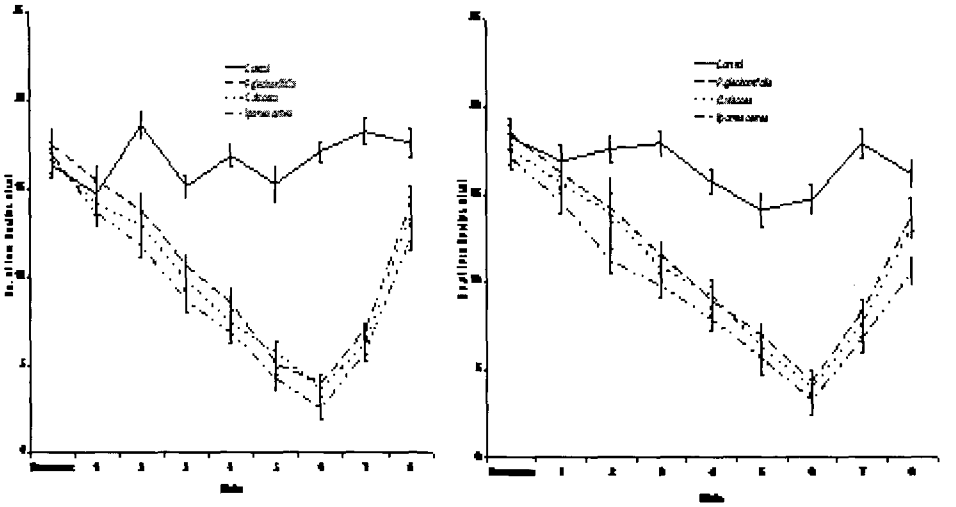

Figure 1. Termite control achieved through application of plant extracts under field conditions: **(A)** 1st year observation; **(B)** 2nd year observation.

in a test tube, and the mixture was vigorously shaken. Formation of soluble emulsion in the extract indicated the presence of saponin.[11] For glycosides, 1 g of the powdered sample was added into two different beakers. To one of the beakers 5 ml of dilute sulphuric acid (5%) was added, and 5 ml of water was added to the other beaker. These two beakers were heated for 3–5 min, and then, contents were filtered into the labeled test tubes. The filtrate was made alkaline with 5% sodium hydroxide and heated with Fehling's solution for 3 min. The presence of reddish brown precipitate in the acid filtrate and absence of such a precipitate in the aqueous filtration was regarded as positive for glycosides.[11,12] For test of flavonoids, dilute ammonia solution (5 ml) was added to a portion of the aqueous filtrate of plant extracts followed by addition of concentrated H_2SO_4. A yellow colouration observed in each extract indicated the presence of flavonoids. The yellow colouration disappeared on standing.[13,14] LC_{50} have been determined by subjecting the data to Log -probit Analysis (**Finney, 1971**). ANOVA has been done to calculate the CV% and CD ($P = 0.05$) values.

Results

The application of the aqueous extract of the leaves of *Ipomea carnea*, *Cleome viscosa* and *Pavonia glechomifolia* in different concentrations on the worker castes of *Microcerotermes beesoni* caused significant mortality. At the 8% concentration, the highest mortality of termite was registered with the leaf extracts of *P. glechomifolia* (95.5%) followed by *C. viscosa* (74.44%) and *I. carnea* (70%). In case of the stem extracts of *I. carnea* and *C. viscosa* the mortality recorded were 62.22% and 72.22%, respectively (Table 2). At the lowest concentration (0.5%), the highest mortality was recorded with stem extract of *I. carnea* (16.6%) and the lowest (12.2%) with the stem and leaf extract of *C. viscosa*. The mortality was observed in a linear fashion, *i.e.* increasing with the increase in concentration (Table 2). In case of *M. obesi*, the highest mortality was registered at the highest concentration (8%) with the leaf extracts of *P. glechomifolia* (93.3%) followed by *C. viscosa* stem extract (75.5%) and *I. carnea* leaf extract (72.2%). The lowest mortality at the highest concentration was recorded with the stem extract of *I. carnea* (60.0%). At 0.5% concentration the maximum mortality was recorded with the leaf extract of *I. carnea* (15.5%) and the minimum (13.3%) with the leaf extracts of *C. viscosa* and *P. glechomifolia* (Table 3). The trend of mortality of *M. obesi* was also showing the trend similar to that of *M. beesoni*.

The aqueous extract of the leaves were found to be more toxic to both the termite species as compared to the stem extract. The lowest LC_{50} value for *M. beesoni* was recorded with the leaf extract of *P. glechomifolia* (2.13%) and *C. viscosa* (3.63%) while the highest LC_{50} value was with stem extract of *I. carnea* (6.48%) (Table 4). For *M. obesi* the lowest LC_{50} value was recorded with leaf extract of *P. glechomifolia* (2.24%) and *C. viscosa* leaf extract (3.86%) and the highest with the stem extract of *I. carnea* (6.03%) (Table 4). The repellent/antifeedent properties of *I. carnea*, *C. viscosa* and *P. glechomifolia* have been evaluated by mixing the water extracts with saw dust. The saw dust has been provided as food material to the worker castes of *M. beesoni*. It has been observed that the food material mixed with plant extracts have not been preferred by the termites. Although the termites have consumed significant amount

Table 3: Termicidal Activity of Aqueous Plant Extracts against *M. obesi* under Laboratory Condition

Plants	Parts Used	Concentration (%)	%Mortality* (±S.E.)
Ipomea carnea	Leaf	0.5	15.56±0.88
		1	22.22±1.20
		2	33.33±1.00
		4	45.56±0.66
		8	72.22±1.45
	Stem	0.5	14.44±0.88
		1	26.67±0.57
		2	35.55±1.20
		4	44.44±1.45
		8	60.00±1.00
Cleome viscosa	Leaf	0.5	13.33±1.15
		1	20.00±1.52
		2	30.00±1.15
		4	52.22±1.20
		8	71.11±0.88
	Stem	0.5	14.44±0.88
		1	21.11±0.88
		2	33.33±1.00
		4	41.11±1.45
		8	75.56±1.20
Pavonia glechomifolia	Leaf	0.5	13.33±1.15
		1	27.78±0.88
		2	40.00±0.57
		4	73.33±1.15
		8	93.33±0.57
Control (water)			3.33±0.58
CV (%)			9.34
CD ($P = 0.05$)			5.72

*Mean of three observations after 24 hr (30 termite workers/obs).

of the food material (28.3%) mixed only with water but consumed only 5%, 10% and 19.3% of the food material mixed with aqueous extracts of *I. carnea*, *C. viscosa* and *P. glechomifolia*, respectively (Table 5). This suggests that among the plant extracts *I. carnea* has the maximum repellent properties on the said termite species followed by *C. viscosa* and *P. glechomifolia*, respectively. Qualitative phytochemical analyses of the tested plants having antitermite properties have revealed to contain chemicals such as alkaloids, tannins, saponin, cadiac glycoside and flavonoids (Table 6). Among the plants, *I. carnea* and *C. viscosa* have shown to possess all the above-mentioned chemicals. In *P. glechomifolia*, both tannin and saponin are found to be absent.

Field Application of the Plant Extracts

The tea plantation areas of the Borakhai Division of Silcoorie TE of Cachar district was selected for the field application of the plant extracts. Termites cause great damage to the tea bushes of the valley. The degree of the extent of damage by the termites to the tea bushes varies in different plantation areas. The termites also caused damage to the shade trees in the tea plantation. Different sections of the plantation having termite infestation were selected and marked for the application of the aqueous plant extracts as described earlier. Extracts of the plants *viz. Ipomea carnea, Pavonia glechomifolia, Cleome viscosa* when applied on the termite-infested tea plants have shown promising results (Fig. 1). Among the plants used, *I. carnea* showed the best result in controlling the termite population. They kept the termite population significantly under control up to 1.5 months as compared to control (CD 5.8 and 7.3 for 1st & 2nd yrs, respectively, at $P = 0.05$). The experiment was conducted twice for 2 yr in different termite infested tea growing sections of the Bhorakhai Division of Silcoorie Tea Estate. Data obtained from 1st and 2nd yr observation did not show much difference (Fig. 1).

Discussion

Pesticides have become an integral part of modern agriculture. However, their excessive and non-judicious use has not only resulted in environmental pollution but also developed resistance in several pests, causing pest resurgence and adversely affecting the beneficial organisms like honeybee, pollinators and natural enemies like parasites and predators. In conjunction with improved quality of seeds and fertilizers, pesticides however continue to play a crucial role in increasing productivity. Since emphasis is gradually shifting from insect kill to management of insect, new agrochemicals need not be always broad spectrum, highly toxic and persistent. To be environmentally benign, they should be biodegradable, capable of reducing the damage level and safe to fishes, bees, pollinators and other non-target organisms. Biopesticides, being biodegradable, have a very high level of safety to humans, animals, fish and other non-target organisms. Entomopathogenic fungi, nematodes, bacteria and viruses and natural products of plant origin are important sources of biopesticides.

In view of the problems associated with the indiscriminate use of synthetic chemical pesticides, there is

Table 4: LC_{50} Values of the Workder Castes of the Termites after Treatment with the Aqueous Plant Extracts

Plants	Parts Used	Termite Sp.	LC_{50} (%) ±S.E.	$\chi 2$ (d.f. = 3)	Fiducial Limits (95% for LC_{50})
Ipomea carnea	Leaf	*M.beesoni*	5.962±1.203	0.024	0.7801±0.0700
		M.obesi	5.574±1.063	0.047	0.7601±0.0673
	Stem	*M.beesoni*	6.487±1.211	0.016	0.8094±0.0512
		M.obesi	6.035±1.406	0.021	0.7978±0.0655
Cleome viscosa	Leaf	*M.beesoni*	3.637±0.911	0.035	0.6806±0.1362
		M.obesi	3.862±1.446	0.048	0.6829±0.1563
	Stem	*M.beesoni*	4.007±1.196	0.037	0.7899±0.1011
		M.obesi	4.216±1.078	0.053	0.8014±0.0995
	Leaf	*M.beesoni*	2.138±0.314	0.992	0.3362±0.1281
Pavonia glechomifolia		*M.obesi*	2.243± 0.421	0.874	0.3486±0.1358

The LC_{50} values also reflect on the fact that the leaf extracts are more toxic compared to the stem extracts.

an urgent need to evolve alternate coherent pest management strategy which is effective and environment friendly. Natural products of plant origin have been exploited to a limited extent for their pest control properties. Most of the higher plant species remained unexplored or much less surveyed for their pesticidal properties. Over the past few decades, numerous plant species have shown potential for pest control. Some of them are *Azadirachta indica* Juss, *Melia azadirach* L., *Annona squamosa*, *Tagetes erecta*, *etc*. Among these plant species *A. indica* has shown great potential in controlling over 200 species of insect pests of cultivated plants. An excellent review on the properties and pesticidal potential of neem has been reported.[15]

Aqueous extracts of *Ipomea carnea*, *Cleome viscose* and *Pavonia glechomifolia* were tried against two termite species infesting tea plantations to explore their antitermite properties. The aqueous extracts of *I. carnea*, *C. viscosa*, *P. glechomifolia* were found to be toxic to the worker castes of *M. beesoni* and *M. obesi*. But, the leaf extract was found to be more toxic to the termites compared to the extracts of stem. These plant species which showed antitermite properties against *M. beesoni* and *M. obesi* have not been studied earlier against termites. The presence of significant amount of chemicals such as alkaloids, cardiac glycoside, flavonoids in these plants may have contributed to the toxic effect against the termites. These potential plant extracts might well be tried against other insect pests also. However, a detailed and thorough investigation is required for the proper identification of the natural compounds with termiticidal properties present in these plants. Termiticidal properties of other plant species have been reported earlier. The termiticidal properties of neem products have been demonstrated.[16] Some researchers have reported anti-termite properties of castor products; while others reported anti-termite properties of *Pongamia pinnata*, *Annona squamosa* and *Ricinus communis*; termiticidal properties of the extract of the flower of *Butea monosperma* and toxic effect of *Polygonum hydropipier* and *Cannabis sativa* plant extracts against *Heterotermes indicola*.[17–21] Choudhury *et al.*[2] also evaluated the antitermite properties of *Andrographis paniculata*, *Allium sativa*, *Lantana camara* and *Curcuma* sp., the extract of which helped to control the termites significantly.

Field Application of Plant Extracts

Most of the works on termites have been done using laboratory bioassays by disturbing the termites from their natural environment and allowing them to crawl/feed on the baits containing the control material. Direct field trials by treating the colonies in their natural habitat are meager. Plant parts and plant extracts seems to be used effectively against the termites in the field conditions.

Table 5: Repellent/Antifeedent Properties of Aqueous Plant Extracts against Termite (*M. beesoni*) *In Vitro*

Plants	Initial Wt (g)*	Final Wt (g)	%Difference (±S.E.)
Control (distilled water)	1	0.717	28.33^{a}±0.009
Ipomea carnea	1	0.950	5.00^{b}±0.009
Cleome viscosa	1	0.896	10.04^{c}±0.003
Pavonia glechomifolia	1	0.807	19.33^{c}±0.005

*Mean of three observations.
Within the column means followed by different letters are significantly different ($P = 0.05$).
Food Material = Saw dust.

Table 6: Qualitative Analysis of the Phytochemicals from Some Plant Extracts with Pesticidal Properties

Plants	Family	Parts	Alkaloids	Tannins	Saponin	Cardiac Glycoside	Flavonoids
Ipomea carnea	Capparidaceae	Leaves	1	+	++	++	+
Cleome viscosa	Convolvulaceae	Leaves. stem	1	+	++	++	+
Pavonia glechomifolia	Malvaceae	Leaves	1	–	–	+	+

++ High, + low, – Absent.

Although references of plant products used for the control of termites in the field conditions are very meager. *Azadirachta indica* and *Piper guineense* seed extracts at 10% concentration were used against the termite species of *Microtermes* sp., *Macrotermes bellicosus* and *M. subhyalinus* causing damage to maize plants under the field conditions and achieved significant control.[22] Significant control of termites by using the extracts of *Lantana camara*, *Chromolena odorata*, *Alliuum sativum* and *Andrographis paniculata* against *Micotermes obesi* causing damage to tea plants has also been reported.[2]

In the investigation, leaf extracts of *Ipomea carnea*, *Cleome viscosa*, *Pavonia glechomifolia* were used against the termites causing damage to the tea plantations under the field conditions. All the extracts were applied directly to the tea plants at 10% concentration. The plant extract of *Ipomea carnea* was found to be more promising compared to *Pavonia glechomifolia* and *Cleome viscosa* (Fig. 1). Barak valley tea plantations use a huge amount of termiticide to keep their termite prone sections under the economic damage threshold level from termite infestation. These above-mentioned results suggest the potential of the use of these plant extracts as an alternative to chemical pesticides. They can also be used in combination with the traditional inorganic/chemical pesticides as a part of the IPM strategy, which will reduce the load of chemical pesticides from the agroecosystem.

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