

INSECTICIDAL ACTIVITY OF SOME MEDICINAL PLANTS OF SRI LANKA

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Abstract: A wide range of solvent extracts prepared from different parts of Sri Lankan medicinal plants (101 extracts from 55 plants) were evaluated for insecticidal activity on the groundnut aphid, *Aphis craccivora* Koch. and the diamond back moth, *Plutella xylostella* (L.). Of the 94 plant extracts tested for insecticidal activity against *Aphis craccivora* Koch., *Celtis cinnamomea*, *Cestrum auranticum*, *Costus speciosus*, *Curcuma zedoaria*, *Hortonia angustifolia*, *Ocimum gratissimum*, *Pleiospermium alatum* and *Zingiber zerumbet* reported significantly high mortality (56-90%). Of the 23 extracts tested for activity against *P. xylostella*, only *Cestrum aurantiacum*, *Hortonia angustifolia*, *Pleiospermium alatum*, *Curcuma zedoaria* showed insecticidal activity, low pupation, adult emergence and anti-feedant activity.

Key words: Insecticidal activity, medicinal plants.

INTRODUCTION

Pesticides are an integral aspect of pest control in modern agriculture. However, most synthetic pesticides are associated with a number of undesirable side effects.¹ Many insects and other plant pathogens have become resistant to chemical pesticides.² For example, 423 species of insects and acarines were resistant by the end of 1980.³ Of these 260 species (60%) are of agricultural importance. Furthermore, due to greater biological productivity in the tropics the development of resistance to insecticides by pests may be more rapid.² Therefore, the discovery of new pest control agents with novel modes of action and greater selectivity on target pests while addressing the human safety concerns remains an urgent need. Many plant species have developed highly sophisticated defence systems, consisting of a complex array of defence chemicals.⁴ These disrupt pest physiology and behavioural activity and provide us with a diverse group of complex chemical structures with different modes of action.

The present study was conducted to identify insecticidal plants of potential value in Sri Lanka. Two agriculturally important insect pests, the groundnut aphid, *Aphis craccivora* Koch. (Homoptera : Aphididae) and the diamond back moth, *Plutella xylostella* (L) (Lepidoptera : Yoconomutidae) were used as test

insects. The groundnut aphid, *A. craccivora* is a major pest of groundnut and other plants of the Leguminosae. They cause wilting in hot weather but the most serious damage is caused by the transmission of the groundnut rosette virus and other viruses.⁴ The other test insect *P. xylostella* is a very common pest of cabbage and turnip. Severe attacks occur during hot and dry weather.

METHODS AND MATERIALS

Solvent extracts from 55 plants (94 extracts) were screened against *A. craccivora* (Table 1) while 15 plants (23 extracts) were screened against *P. xylostella* (Table 2).

Plant Material: Plants used in this study were of reproductive maturity. Plant specimens were collected (1-5 kg) from different localities of Sri Lanka, especially from the Central Province and were identified by comparison at the National Herbarium, Royal Botanic Gardens, Peradeniya. The plant material was immediately washed with running water to remove contaminated soil and other surface impurities. They were then cut into small pieces (3-6 cm in length), shade-dried immediately and powdered in a laboratory mill.

Plant Extracts: The air-dried, ground plant material (100 g) was extracted successively with 500 ml each of hot hexane/light petroleum (40-60°C), dichloromethane, ethyl acetate and methanol in a Soxhlet apparatus. Some were extracted directly with cold ethyl acetate and cold methanol in a bottle shaker. The solubles were concentrated to dryness separately using a rotavapor keeping the water bath temperature below 45°C. The extracts were subjected to insecticidal activity tests as described below.

Test Insects : *A. craccivora* was cultured in one-week old cowpea, *Vigna unguiculata* (L.) Walp., seedlings (cv: Bushitavo) kept in insect proof cages (105 x 45 x 45 cm) at a low population level (5 adults per plant).⁵ One-day-old apterous female adults were used in all experiments. They were handled by means of a moistened camel-hair brush.

P. xylostella was cultured on radish plants (cv: Bola Rambu) planted in clay pots (15 cm diameter and 11 cm high) filled with 1:1:1 mixture of top soil, sand and compost in the laboratory.

All experiments were conducted at a mean temperature of $29.5 \pm 4^\circ\text{C}$ and relative humidity (r.h) $80 \pm 4\%$. A 12-h photoperiod was maintained by employing a clock mechanism to control four fluorescent tubes (40W) hung over each cage. In all experiments, the moribund insects were counted as dead and mortality counts were taken 24 and 48 h after introduction (HAI) of insects. The experiments were in completely randomized design (CRD).

Table 1: Insecticidal activity of some plant extracts (4000 ppm emulsion) against the groundnut aphid, *Aphis craccivora* in the laboratory.

Plant (Family) [Sinhala/Tamil]	Collection	Part ^a	Solvent ^b	% Mortality ^c	
					24 HAT ^d
+ <i>Actinodaphne speciosa</i> Nees. (Lauraceae) [S-Alikan]	Horton Plains	Lf	MeOH ^h	10.00	d
<i>Allaeophania decipens</i> Thw. (Rubiaceae)	Horton Plains	Ap St	MeOH ^h MeOH ^h	13.33	d
<i>Alpinia abundiflora</i> Burt & Smith (Zingiberaceae)	Horton Plains	Rh	*Pet ^h *CH ₂ Cl ₂ ^h *MeOH ^h	13.33	d 6.66 d 13.33 d
+ <i>Alpinia fax</i> Burt & Smith (Zingiberaceae)	Rakwana	Tb	MeOH ^h	0.0	d
<i>Alpinia nigra</i> (Gaertn.) Burt (Zingiberaceae) [S-Alugas, T-Shittai rattai]	Hakgala	Ft Tb	MeOH ^h MeOH ^h	20.0	d 13.33 d
<i>Anotis richardiana</i> (Arn.) Hook. f. (Rubiaceae)	Pattipola	Wp	MeOH ^h	6.66	d
<i>Artimisia dubia</i> var. <i>grata</i> Wall (Compositae) [S-Walkolundu, T-Marukolundu]	Ambawela	Lf Lf St St Rt Rt	MeOH ^c MeOH ^h MeOH ^c MeOH ^h MeOH ^c MeOH ^h	3.33	d 0.00 d 6.66 d 3.33 d 3.33 d 0.00 d
<i>Bridelia retusa</i> (L.) Spreng (Euphorbiaceae) [S-Ketakala, T-Adamarudu]	Hakgala	Lf	MeOH ^h	13.33	d
<i>Butea monosperma</i> (Lam.) Taub. (Leguminosae) [S-Gaslela, T-Parasu]	Mahiyangana	St Bk	EtOH ^c	9.99	d
<i>Celtis cinnamomea</i> Lindl. ex Planch. (Ulmaceae) [S-Gurenda, T-Pinari]	Hakgala	Lf St	MeOH ^h MeOH ^h	83.33	ab
<i>Cestrum auranticum</i> Lindl. (Solanaceae)	Hakgala	Lf St	MeOH ^h MeOH ^h	56.66	c
<i>Chrysopogon zeylanicus</i> (steud.) Thw. (Gramaceae) [S-Gawara]	Hakgala	Wp	MeOH ^h	13.33	d
<i>Costus speciosus</i> (Koen.) Sm (Zingiberaceae) [S-Tebu, T-Khoshadam]	Kalutara	Rh	MeOH ^h	90.00	a
<i>Curcuma longa</i> L. (Zingiberaceae) [S-Kaha, T-Manchal]	Kandy	Tb Tb	EtOH ^c MeOH ^c	10.00	d 3.33 d
<i>Curcuma zeadoria</i> (Berg.) Roscoe. (Zingiberaceae) [S-Harankaha, T-Kasturimangal]	Kandy	Tb	MeOH ^h	73.33	bc
<i>Eupatorium inulifolium</i> HBK. (Compositae)	Hakgala	St St Bk	MeOH ^h MeOH ^h	0.00	d 3.33 d
<i>Eupatorium odoratum</i> L. (Compositae) [S-Podisinghomaran]	Kandy	Lf	MeOH ^h	6.66	d
<i>Eupatorium riparium</i> Regel. (Compositae)	Hakgala	Ap Rt	MeOH ^h *Hex ^h	0.00	d 3.33 d
<i>Gaultheria rudis</i> Stapt. (Ericaceae) [S-Wal kapuru]	Horton Plains	Wp-Lf Lf	MeOH ^h MeOH ^h	13.33	d 6.66 d 0.00 d
<i>Glochidion montanum</i> Thw. (Euphorbiaceae)	Hakgala	Lf	MeOH ^h	6.66	d
<i>Gynostemma laxum</i> (Wall.) Cong. (Curcubitaceae)	Hakgala	Ap	MeOH ^h	9.99	d
	Sinharaja	Lf St	MeOH ^h MeOH ^h	73.33	bc 3.33 d

Table 1 Contd.

Plant (Family) [Sinhala/Tamil]	Collection	Part ^a	Solvent ^b	% Mortality ^c	
				24 HAT ^d	
+ <i>Hortonia angustifolia</i> (Thw.) Trim. (Monimiaceae)	Hakgala	Rt	MeOH ^h	6.66 d	
+ <i>Hortonia floribunda</i> Wight ex Arn. (Monimiaceae) [S-Gawara]	Hakgala	Lf	MeOH ^h	10.00 d	
		St	MeOH ^h	6.66 d	
		Rt	MeOH ^h	3.33 d	
<i>Hypericum mysurense</i> Wight & Arn. (Gutiferae)	Pattipola	Lf	MeOH ^h	6.66 d	
		St	MeOH ^h	13.33 d	
<i>Justicia betonia</i> L. (Acanthaceae) [S-Sudu puruk]	Kandy	Ap	MeOH ^h	3.33 d	
<i>Leucas biflora</i> (Vahl.) Benth. (Labiatae) [S-Gata Tumba, T-Peyt tumpi]	Horton Plains	Wp	MeOH ^h	10.00 d	
<i>Leucas zeylanica</i> (L.) Benth. (Labiatae) [S-Geta Tumba, T-Mudi tumpi]	Hakgala	Wp	MeOH ^h	3.33 d	
<i>Lobelia aromatica</i> Moon ex Wight (Lobeliaceae)	Horton Plains	Lf	MeOH ^h	10.00 d	
		St Bk	MeOH ^h	3.33 d	
<i>Lobelia nicotianifolia</i> Roth ex R. & Schult (Lobeliaceae) [S-Waldunkola, T-Kattupoillai]	Hakgala	Lf	MeOH ^h	6.66 d	
		St Bk	MeOH ^h	10.00 d	
+ <i>Mastixia tetranda</i> (Wight ex Thwaites) C.B. Clarke (Cornaceae) [S-Matawara]	Hakgala	Lf	MeOH ^h	13.33 d	
<i>Ocimum gratissimum</i> L. (Labiatae) [S-Gastala, T-Elumichantulasi]	Kandy	Ap	MeOH ^h	73.33 bc	
		Rt	MeOH ^h	86.66 ab	
<i>Osbeckia cupularis</i> D. Don ex Wight & Arn. (Melastomaceae) [S-Bowitia]	Horton Plains	Wp	MeOH ^h	10.00 d	
<i>Pedaliium murex</i> L. (Pedaliaceae) [S-Ethnerenchi, T-Perunerenchi]	Puttalam	Lf	MeOH ^h	3.33 d	
<i>Phyllanthus embilica</i> L. (Euphorbiaceae) [S-Ambula, T-Nelli]	Hakgala	Lf	MeOH ^h	6.66 d	
<i>Phyllanthus reticulatus</i> Poir. (Euphorbiaceae) [S-Welkayila, T-Pulla]	Sigiriya	Lf	MeOH ^h	13.33 d	
<i>Pimenta officinalis</i> Lindl. (Myrtaceae)	Kandy	Lf	MeOH ^h	3.33 d	
		St Bk	MeOH ^h	6.66 d	
<i>Pleiospermium alatum</i> (Wight & Arn.) Swingle (Rutaceae) [S-Tumpathkurundu, T-Mailadidurundu]	Sigiriya	St Bk	*Hex ^h	90.00 a	
		Rt Bk	*EtOAc ^h	3.33 d	
			*EtOAc ^h	6.66 d	
			*MeOH ^h	0.00 d	
<i>Psychotria bisculata</i> (Wight & Arn.) (Rubiaceae)	Horton Plains	Lf	MeOH ^h	13.33 d	
		St	MeOH ^h	3.33 d	
<i>Psychotria nigra</i> van cronata Hk.f (Rubiaceae)	Horton Plains	Lf	MeOH ^h	10.00 d	
		St	MeOH ^h	6.66 d	
<i>Ricinus communis</i> L. (Euphorbiaceae) [S-Erandu, T-Chittamanakku]	Sigiriya	St Bk	MeOH ^h	3.33 d	
<i>Saprosma foetens</i> (Wight) K.schum. (Rubiaceae)	Kandy	Lf	MeOH ^h	13.33 d	
		St Bk	MeOH ^h	6.66 d	
<i>Sarcococca pruniformis</i> Lindl. (Buxaceae)	Hakgala	Lf	MeOH ^h	10.00 d	
		St	MeOH ^h	0.00 d	
+ <i>Semecarpus coriacea</i> Thw. (Anacardiaceae) [S-Badulla]	Hakgala	Lf	MeOH ^h	6.66 d	
		St	MeOH ^h	13.33 d	
		St Bk	MeOH ^h	0.00 d	

Table 1 Contd.

Plant (Family) [Sinhala/Tamil]	Collection	Part ^a	Solvent ^b	% Mortality ^c	
				24 HAT ^d	
+ <i>Semicarpus nigro-viridis</i> Thw. (Anarcardiaceae) [S-Getabadulla]	Hakgala	Lf	MeOH ^h	10.00	d
		St	MeOH ^h	6.66	d
		St Bk	MeOH ^h	13.33	d
+ <i>Semicarpus obscura</i> Thw. (Anarcardiaceae) [S-Badulla]	Hakgala	Lf	MeOH ^h	13.33	d
		St	MeOH ^h	3.33	d
		St Bk	MeOH ^h	6.66	d
<i>Sesamum indicum</i> L. (Pedaliaceae) [S-Walthala, T-Ellu]	Rambukkana	Lf	EtOH ^c	10.00	d
<i>Solanum giganteum</i> Jacq. (Solanaceae)	Hakgala	Ft	MeOH ^c	9.99	d
		Ft	MeOH ^h	3.33	d
<i>Strobilanthes auriculatus</i> Nees. (Acanthaceae)	Horton Plains	Lf	MeOH ^h	10.00	d
		St	MeOH ^h	3.33	d
		Rt	MeOH ^h	6.66	d
<i>Strobilanthes hookeri</i> Nees. (Acanthaceae)	Horton Plains	Lf	MeOH ^h	13.33	d
		St	MeOH ^h	3.33	d
<i>Strobilanthes viscosa</i> (Nees) T. Anders. (Acanthaceae)	Horton Plains	Lf	MeOH ^h	9.99	d
		St	MeOH ^h	0.00	d
<i>Theobroma cacao</i> L. (Sterculiaceae) [S-Cocoa, T-Coco]	Kalutara	Ft	EtOAc ^c	10.00	d
<i>Thespesia populnea</i> (L.) Soland ex Corr. (Malvaceae) [S-Gansuriya, T-Kavarachu]	Kandy	Lf	MeOH ^h	6.66	d
		St	MeOH ^h	3.33	d
<i>Ulex europaeus</i> L. (Leguminosae)	Horton Plains	Wp	MeOH ^h	0.00	d
<i>Wendlandia bicuspidata</i> Wight & Arn. (Rubiaceae) [S-Balalhulla]	Hakgala	Lf	MeOH ^h	10.00	d
		St	MeOH ^h	0.00	d
		St Bk	MeOH ^h	9.99	d
<i>Zingiber zerumbert</i> (L.) Sm. (Zingiberaceae) [S-Walinguru]	Hakgala	Tb	MeOH ^h	60.00	d
Untreated Control				13.33	d
CV (Coefficient of Variation)				13.58	

+ : Species endemic to Sri Lanka

* : Successive extraction

a : Ap - Aerial Part; Lf - Leaf; Rh - Rhizome; Rt - Root; St Bk - Stem Bark; Tb - Tuber

b : h - Hot extraction; Hex - n-hexane

c : Mean of 3 replicates each containing 10 aphids

d : Hours after treatment

Means followed by the same letter are not significantly different ($p \geq 0.05$) according to Duncan's Multiple Range Test. Arc sign percentage transformation was used.

Relative toxicity against A. craccivora^{5,6}: The spray solutions were prepared as follows: each extract (64 mg) was mixed with 128 mg of the detergent, LF 12 R (supplied by Ciba-Geigy Ltd., Basel, Switzerland), in 1:2 (w/w) ratio and was dissolved in analytical grade methanol or acetone and diluted with distilled water in 1:9 (v/v) ratio to obtain 16 ml of a 4000 ppm emulsion.

Fifteen aphids were placed on the underside of a detached young (one-week-old) cowpea leaf. Each leaf was placed on a moistened filter paper (Whatman No. 1) kept in the basal plate of a petri dish (9 cm diameter). After the aphids had settled (about 30 min), each leaf was turned upside down and sprayed with a 4000 ppm emulsion of an extract using a Potter's spray tower. For each spraying, 4.0 ml of the above emulsion was used in the spray tower under a pressure of 20 g cm⁻². The leaf was turned right-side up and the base of the petiole was inserted into a moistened cotton plug to slow down desiccation. The basal plate of each petri dish was covered with a tight-fitting plastic lid containing windows of fine gauze. A mixture of the particular solvent, distilled water and the detergent was used as standard control and distilled water alone as an untreated control. The experiment was replicated four times. Mortality counts were taken 24 and 48 HAI.

Table 2: Insecticidal activity of some plant extracts against the diamond back moth, *Plutella xylostella* in the laboratory (Only the plants which showed significant activity are listed).

Plant Extract (Part ^a , Solvent ^b)	% Mortality ^c 24 HAT ^d	48 HAT	% Pupation	% Adult Emergence	Feeding Area mm ² 48 HAI ^e
<i>Hortonia angustifolia</i> (Thw.) Trim. (Rt, MeOH ^b)	86.66 a	86.66 a	0.00 c	0.00 b	16.60 de
<i>Pleiospermium alatum</i> (Wight & Arn.) Swingle (St Bk, Hex ^b)	93.33-a	93.33 a	0.00 c	0.00 c	38.00 d
<i>Cestrum auranticum</i> Lindl. (Lf, MeOH ^b)	23.33 bc	80.00 ab	6.66 b	3.33 b	18.60 de
<i>Costus speciosus</i> (Koen.) Sm (Rh, MeOH ^b)	13.33 cd	40.00 bc	10.0 b	3.33 b	73.30 c
<i>Curcuma zedoaria</i> (Berg.) Roscoe. (Tb, MeOH ^b)	40.00 b	53.33 bc	0.00 c	0.00 b	0.00 e
<i>Zingiber zerumbet</i> (L.) Sm (Tb, MeOH ^b)	40.00 b	53.33 bc	10.0 b	0.00 b	96.60 b
Untreated Control	3.33 d	16.66 c	70.0 a	66.66 a	198.60 a
CV	24.04	28.93	46.40	60.82	19.88

a : Lf - Leaf; Rh - Rhizome; Rt - Root; St Bk - Stem Bark; Tb - Tuber

b : Hot extraction

c : Mean of the three replicates each containing ten larvae

d : Hours after treatment

e : Hours after introduction of larvae

In each column, the letters followed by the same letter are not significantly different ($p \leq 0.05$) according to DMRT. Arc sign percentage transformation was used.

Relative toxicity against *P. xylostella*: Cabbage leaf disks (9 cm diameter) were dipped in 4000 ppm emulsion of each extract and were left to air dry. The dry disks were offered to 10, second instar larvae of *P. xylostella* obtained from the above culture. The cabbage leaf disks and larvae were confined into a glass petri dish (9 cm diameter) with a moistened filter paper placed at the bottom. Cabbage leaf disk dipped in the solution without the plant extract was used as the untreated control. The treatments were replicated three times and arranged in CRD in the laboratory. After the introduction, larval mortality and their developmental abnormalities, if any, were recorded daily. The leaf area consumed by the 10 larvae were recorded at 48 HAI using a graph paper, and then the treated leaf disks were replaced by fresh untreated ones.

Evaluation of the field performance of *Hortonia angustifolia*: Field performance of *Hortonia angustifolia* (Rt) methanol extract against cabbage leaf eating caterpillars was comparatively evaluated, with neem oil (Kandy Ayurvedic Drugs Ltd.) and some other commercially available pesticides, at the open prison camp Pallekalle, in the Kandy district (Table 3). In this experiment, cabbage (cv : SD cross) was planted in plots of 12 m² at a spacing of 40 x 50 cm; each plot was separated by a one-meter wide strip of land. Different treatments were sprayed to individual plots, using a high volume knapsack sprayer, at 10 day intervals commencing two weeks after transplanting. Each treatment of insecticide was replicated three times and arranged in Randomized Complete Block Design (RCBD).

Table 3: The comparative efficacy of different pest-control agents against-leaf eating caterpillars of cabbage - Yala 1989.

Insecticide	Rate (g or l/ha)	No. of larvae	Leaf damage	% yield loss
Triflumuron (Alsystine 480 SC)	200-400 g (ai)	4.22 a	1.33 bc	25.5 ab
<i>Bacillus thuringiensis</i> (Thuricide HP)	500-1000 g	5.44 ab	2.00 d	24.6 ab
Diflubenzuron (Dimilin WP25)	75-100 g (ai)	6.22 ab	1.66 cd	28.3 ab
Chlorofluazuron (Atabron 5EC)	50-100 g (ai)	2.89 a	1.00 ab	27.3 ab
Methamidophos (Tamaron LC 60)	420-500 g (ai)	5.55 ab	2.66 de	28.1 ab
<i>Azadirachta indica</i> (Neem oil)	11.16 l	2.11 a	0.66 a	18.4 a
<i>Hortonia angustifolia</i> (Root - methanol extract)	2200-4400 g	4.78 a	1.66 cd	28.3 ab
Untreated control	-	8.89 b	3.00 e	28.7 ab
CV		26.0	19.2	13.6

In each column, the values followed by the same letter do not differ significantly according to DMRT at $p \leq 0.05$

(ai) = active ingredient

Immediately before each insecticide application, the number of leaf eating caterpillars in 10 randomly selected and labelled plants in each plot was recorded. Before harvesting, leaf damage was visually estimated using the 1 - 4 scale (Leaf Damage: 0-25% = 1; 26-50% = 2; 51-75% = 3; 76-100% = 4). After the harvest, the percentage of yield loss due to caterpillar damage was determined.

RESULTS

Relative toxicity against *A. craccivora*

Out of the 94 plant extracts (from 55 plants) tested for insecticidal activity against *A. craccivora*, the following showed significant activity ($p \leq 0.05$) with high percentage mortality (56-90%) [compared to the Untreated Control (UC)] at 24 HAI (Table 1); the hexane extract of *Pleiospermium alatum* (St Bk) and the methanol extracts of *Costus speciosus* (Rh), *Ocimum gratissimum* (Rt), *Celtis cinnamomea* (Lf), *Curcuma zedoaria* (Tb), and *Cestrum aurantiacum* (Lf).

A number of reports on the ethnomedical uses and isolation of chemical constituents have been reported for *C. speciosus*, *C. zedoaria*, *P. alatum* and *Z. zerumbet*. The antifungal principle of the rhizome of *C. speciosus* has been identified as the methyl ester of *p*-coumaric acid;^{7,8} this plant which possesses a variety of biological activities, is also a source of diosgenin.⁹ The rhizome of *C. zedoaria* is applied externally on wounds, ulcers, sprains and certain types of dermatitis; *C. zedoaria* is reported to have antibacterial and antifungal activity.¹⁰ The anti-fungal agent in *P. alatum* has been identified as seselin;¹¹ alkaloids and coumarins have also been isolated from this plant. The powdered rhizome of *Z. zerumbet* is used as an antidiarrhoeic agent; chemical constituents present in this plant are zerumbone, zerumbone oxide, humulene in addition to a number of sesquiterpenes.^{12,13,14}

Relative toxicity against *P. xylostella*

In the laboratory experiments, at 24 HAI significantly high ($p \leq 0.05$) insecticidal activity on *P. xylostella* was observed with *P. alatum* (St Bk) and *H. angustifolia* (Rt) treatments. At 48 HAI, *C. aurantiacum* (Lf) also showed significant mortality effect on larvae. Significantly low pupation and adult emergence was observed in larvae fed with cabbage leaf disks treated with all the tested plant extracts (Table 2). Second instar larvae fed on leaves treated with *C. zedoaria* (Tb) and *C. aurantiacum* (Lf) showed some developmental inhibitory activity. These larvae could not develop into the third instar stage and while becoming motionless their anterior part of the body became dark in colour and half-cast exuviae were found at the posterior end of the body. As a result, the second instar did not develop into the third instar and died.

C. zedoaria (Tb), *H. angustifolia* (Rt) and *C. aurantiacum* (Lf) also exhibited significant ($p \leq 0.05$) antifeedant activity against *P. xylostella* when compared with the untreated control.

Evaluation of field performance of *Hortonia angustifolia* methanol extract against cabbage leaf eating caterpillars

Plots treated with neem oil, chlorofluazuron, triflumuron and the methanol extract of *H. angustifolia* (Rt) reported significantly low ($p \leq 0.05$) number of leaf eating caterpillars when compared with the untreated control and the rest of the treatments with *Bacillus thuringiensis* and methamidophos (Table 3). All treatments, except methamidophos significantly reduced the leaf damage when compared with the untreated control. However, plots treated with neem oil and chlorofluazuron reported significantly ($p \leq 0.05$) lower leaf damage than the rest of the treatments. But at harvesting, none of these treatments gave significant reduction ($p \leq 0.05$) of the yield loss due to caterpillar damage when compared to the untreated control.

DISCUSSION

From the tested plant extracts hexane extract of *P. alatum* (St Bk), and methanol extract of *C. speciosus* (Rh), *O. gratissimum* (Rt), *C. cinnamomea* (Lf) reported the highest insecticidal activity against the adult *Aphis craccivora*. The methanol extracts of *C. zedoaria* (Rt), and *H. angustifolia* (Rt) also showed moderate insecticidal activity against the same insect.

The hexane extract of *P. alatum* (St Bk) and the methanol extract of *H. angustifolia* reported a strong toxic effect on larvae of *P. xylostella*. Methanol extracts of *C. zedoaria* (Tb), *C. aurantiacum* (Lf) and *H. angustifolia* (Rt) showed antifeedant activity and some adverse effect on the development of *P. xylostella*. In a field assay the extract of *H. angustifolia* was significantly more effective on the reduction of cabbage caterpillar compared to an untreated blank whereas it was much less effective in the above reduction compared to some commercially available insecticides.

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