Larvicidal and growth regulatory activities of some essential oils against Asian army worm, *Spodoptera litura* (Fab.)

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ABSTRACT

Six medicinal plant essential oils *viz*., *Foeniculum vulgare* (saunf), *Hedychium spicatum* (kapoor kachri), *Jatropha curcas* (ratanjot), *Piper nigrum* (black pepper), *Syzygium aromaticum* (clove) and *Vetiveria zizanioides* (khas) were evaluated for their insecticidal and growth regulatory activities against third instar larvae of Asian army worm, *Spodoptera litura.* During preliminary screening, essential oils were tested at 1 and 2% concentrations. Highest mortality (100%) was found in saunf and khas oil, followed by clove oil (93.33%), ratanjot oil (73.33%) and black pepper oil (43.33%) and lowest in kapoor kachri oil (16.66%) at 2%.Lowest weight gain per larva 2DAF (days after feeding) was seen in clove oil (-0.025g and -0.06g) at 1 and 2% respectively and black pepper oil (-0.06g) at 2%, while ratanjot, khas and kapoor kachri oil did not show any significant effects on weight gain parameter in comparison to control. Similar trend was observed in growth of the larvae, where clove and black pepper oils caused reduction in growth over control by -15.15 and -11.11% and 37.37 and 21.21% at 1 and 2% respectively. Based on this data, further five concentrations *viz*., 2.5, 2.0, 1.5, 1.0 and 0.5% were used to determine LC_{50} of ratanjot, clove and khas oil. Khas and clove oils were toxic at 6 and 12 HAE (hrs after exposure), the LC_{50} values being 1.95% and 0.85% at 6 hrs , 2.25% and 1.38% at 12 hrs respectively. Ratanjot oil was toxic at 12, 24, 36, 48 and 72 HAE with LC_{50} values of 1.37, 1.22, 1.15, 1.06 and 1.04%. A comparative dose mortality response expressed in terms of relative toxicity (RT) indicated that at 12 HAE, the RT values for ratanjot, clove and khas oils were 1.00, 1.00 and 1.86 respectively. The results demonstrate that essential oils of ratanjot, khas and clove may serve as a tool in the management of *S. litura.*

Keywords: Essential oil, larvicidal activity, management, *Spodoptera litura*

INTRODUCTION

Essential oils are volatile, natural, complex compounds characterized by a strong odour and are formed by aromatic plants as secondary metabolites (Bakkali *et al*., 2008). The interest in essential oils has regained momentum during the last decade, primarily due to their fumigant and contact insecticidal activities and the less stringent regulatory approval mechanisms for their exploration due to their long history of use (Isman, 2008). It is primarily because of essential oils are easily extractable, ecofriendly being biodegradable and get easily catabolized in the environment (Zygadlo and Crosso, 1995), do not persist in soil and water (Isman, 2000) and play an important role in plant protection against pests (Sahayaraj and Amalraj, 2005; Isman, 2006; Bakkali *et al.,* 2008; Sahayaraj, 2008; Mala and Muthalagi, 2008; Reddy *et al*., 2009; Seema and Devaki, 2010; Roman Pavela, 2012).

Many plant essential oils from various families such as Apiaceae, Asteraceae, Lamiaceae, Lauraceae, Myrtaceae, Poaceae, Verbenaceae, Zingiberaceae, etc.. have been studied for insecticidal activity. In the present study, insecticidal and growth regulatory activity of plant essential oils *i.e Foeniculum vulgare* (saunf), *Hedychium spicatum* (kapoor kachri), *Jatropha curcas* (ratanjot), *Piper nigrum* (black pepper), *Syzygium aromaticum* (clove) and *Vetiveria zizanioides* (khas) have been reported against *S. litura.*

MATERIAL AND METHODS

Insect

The nucleus culture of *Spodoptera litura* was reared in the Bioactive Plant Natural Product Laboratory, Department of Entomology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.The culture was maintained on castor leaves (*Ricinus communis* L.) at temperature 26 ± 2ºC and 61 ± 5% RH. Third instar larvae of *S.litura* were used for the study because at this stage they possess considerable feeding and damaging potential. Dried plant parts of medicinal plant oils *viz Foeniculum vulgae* Mill., *Hedychium spicatum* Buch., *Jatropha curcas* L., *Piper nigrum* L., *Syzygium aromaticum* L. Merr.Perry L. and *Vetiveria zizanioides* (L.) Nash. were obtained from Medicinal Plants Research and Development Centre (MRDC), Pantnagar and extracted by hydrodistillation method (Ray *et al.,* 2008) using Clevenger apparatus. The distilled oils were separated from water by a separating funnel and stored in refrigerator.

Insecticidal activity

An experiment was conducted to test the residue contact toxicity of essential oils against third instar larvae of *S. litura*. Test solutions were made by dissolving different concentrations (1 and 2%) of the respective oils in acetone Residue contact bioassay method (Srivastava and Proksch, 1991, 1993; Vedhamati, 2004) was followed. 1 mL of each of the concentration was coated as a thin film in the lower and upper lid of Petri plate (diameter 9cm).The solvent was allowed to dry at room temperature. After evaporation of the solvent ten third instar larvae of *S.litura* were given contact exposure for 30 mins. In the control, the larvae were exposed to acetone alone (Parvathi and Kesar, 1999). Three replications were maintained. Thereafter, the larvae were transferred to rearing boxes (size: l 24 x b 15 x ht 8cm) containing fresh castor leaves. The data on mortality was recorded, 12, 24, 48 and 72 hrs after exposure. Moribund larvae were counted as dead. The data on the leaf area consumed was recorded on graph paper in the various treatments and the calculation was made on the following parameters: Per cent feeding over control. Mean weight gain/larva and Per cent growth reduction over control. Based on the preliminary experiment five concentrations *viz*, 2.5, 2.0, 1.5, 1.0 and 0.5% of *J. curcas*, *S. aromaticum* and *V. zizanioides* oil were evaluated for determining LC_{50} against *S. litura*.

Statistical analysis

The per cent mortality in control was corrected by Abbott's formula (Abbott, 1925).The LC_{50} and LT_{50} values were determined using Probit analysis (Finney, 1971) based computer programme STPR718 at the computer centre, College of Basic Sciences and Humanities of the University. Relative toxicity (RT) was calculated per the formula, RT=LC value of the least toxic oil/LC value of the candidate oil. Further, the experiment was conducted in completely randomized design (CRD) and the data was analyzed by one way Analysis of Variance (ANOVA) following Snedecor and Cochran (1967) and the means were separated using Duncan Multiple Range Test (DMRT) based SPSS16 computer programme.

RESULTS

The results on Mean leaf area consumed (MLAC in cm^2) per larva 24 HAF (hrs after feeding) showed that *H. spicatum*, *J. curcas* at 1 and 2% and *V. zizanioides* oil at 1% did not have any significant effects on larval feeding. The feeding was at par with control, while *P. nigrum* at 1% and *S. aromaticum* at 1 and 2% showed very low feeding in comparison to control. Mean weight gain per larva 2DAF was also significantly reduced in *P.nigrum* and *S. aromaticum* at 1% and 2% in comparison to control (0.72g). Lowest growth reduction over control was also seen in *P.nigrum* at 1% and at 2% concentration, and *S. aromaticum* at 1% and 2% respectively. *F.vulgare* and *V.zizainoides* (2%) caused 100% mortality in insects.The order of toxicity for oils at 1 and 2% is as follows: *S.aromaticum*> *J.curcas*> *P.nigrum* >*V.zizanioides* and *H.spicatum* LC_{50} values could be calculated at 6 and 12 hrs exposure for *S. aromaticum* and *V. zizanioides* while *J. curcas* oil showed toxicity at 12, 24, 36, 48 and 72 HAE. *V. zizanioides* was the most toxic oil at 12 hrs exposure at all the three LC levels, the values being 0.59 (LC_{30}), 0.85 (LC_{50}) and 2.13 (LC_{90}).No

Table 1. Effect of medicinal plants oils on feeding and growth of 6 day old larvae of *Spodoptera litura*

Plant oil	Conc. (%)	MLAC*/Larva 24HAE (g)	Mean weight gain/larva 2DAF (g)	Growth reduction over control (%)
Hedychium spicatum	2	3.73±0.48^{b}	0.18±0.10^{b}	90.00
	1	3.84±0.55^{b}	0.20±0.11^{bc}	100.00
Jatropha curcas	2	4.03±1.54^{b}	0.25±0.14^{d}	125.00
	1	2.76±0.12^{b}	0.24±0.14^{bc}	120.00
Vetiveria zizanioides	2	0.00±0.00^{a}	0.00±0.00^{ab}	-
	1	2.61±0.38^{b}	0.19±0.11^{bc}	95.00
Control	-	4.03±0.42^{b}	0.20±0.11^{bc}	-
SEM (±)	-	0.68	0.02	-
CD at 5%	-	2.06	0.06	-
Foeniculum vulgare	2	0.00±0.00^{a}	0.00±0.00^{ab}	0.00
	1	0.00±0.00^{a}	0.00±0.00^{ab}	0.00
Piper nigrum	2	000±0.00^{a}	-0.06±0.01^{a}	-21.21
	1	1.35±0.98^{a}	0.09±0.09^{b}	37.37
Syzygium aromaticum	2	0.46±0.46^{a}	-0.06±0.03^{a}	-11.15
	1	0.18±0.18^{a}	-0.02±0.01^{ab}	-15.15
Control	-	9.58±0.30^{b}	0.72±0.00^{c}	-
SEM (±)	-	0.43	0.03	-
CD at 5%	-	1.31	0.11	-

*MLAC=Mean leaf area consumed; Means followed by common letter do not differ significantly by DMRT (p=0.05%)

difference was observed in the LC_{50} values of *J. curcas* and *S. aromaticum* at 12 HAE. *J. curcas* at different HAE showed LC_{50} values of 1.22 (24 HAE), 1.15 (36 HAE), 1.06 (48HAE) and 1.04 % (72HAE).A comparative dose mortality response expressed in terms of relative toxicity indicated at *J. curcas* (1.06), *S. aromaticum* (1.00) and *V. zizanioides* (1.62) were almost at par. The oils were tested for their speed of action in terms of LT50 values. *V. zizanioides* oil could cause 50 % mortality in a shortest span of 7.98 hrs followed by *S. aromaticum* (8.19 hrs) and *J. curcas*.

DISCUSSION

The mechanisms of toxicity of essential oils have not been fully identified. However, regardless of the method of administration (topical, oral or inhalation) insects acutely poisoned by certain essential oils display symptoms similar to toxins with a neurotoxic mode of action (Coats *et al*., 1991; Isman, 1999). The rapid action against some pests is evidence for interference with the neuromodulator octopamine (Kostyukovsky *et al*., 2002) by some oils and with GABA-gated chloride channels by others (Priestley *et al*., 2003). Eugenol and its derivatives were main constituents in the essential oils isolated from *Artemisia dracunculus, Carthanus tinctorius*, *Cinnamomum zelanicum* and *Syzygium aromaticum*. Eugenol was reported as toxic to *Drosophila melanogaster* and *Spodoptera litura* (Lee *et al*., 1997). Tripathi *et al*. (2003) has reported toxicity of essential oils of *Aegle marmelos* by topical application to *S.litura* larvae

Table 2. Duration-mortality response of three medicinal plant oils against 6 day old larvae of *Spodoptera litura* by residue contact bioassay

Plant Oils	Conc. (%)	LT values (hrs)			Chi square	Regression equation Y=a+bx	Fiducial limit at LC50	
		LT_{30}	LT_{50}	LT_{90}			Lower	Upper
Jatropha curcas	2.5	5.56	9.39	34.11	3.98	4.38+0.448x	7.01	12.58
Syzygium aromaticum	2.0	3.43	8.19	69.64	1.74	4.678+0.275x	4.90	13.66
Vetiveria zizanioides	1.5	3.24	7.98	73.16	6.77	4.771+0.245x	4.36	13.19

Table 3. Dosage-mortality response of three medicinal plant oils against 6 day old larvae of *Spodoptera litura* by residue contact method 12 hrs after exposure

Plant Oils	LC values (%)						Chi square	Regression equation Y=a+bx	Fiducial limit at LC_{50}	
	LC_{30}	RTat LC30	LC_{50}	RT at LC_{50}	LC_{90}	RTat LC_{90}			Lower	Upper
Jatropha curcas	0.82	1.17	1.37	1.00	4.89	1.00	0.39	3.747+0.397x	1.09	1.73
Syzigium aromaticum	0.96	1.00	1.38	1.00	3.40	1.00	0.89	3.191+0.571x	1.17	1.63
Vetiveria zizanioides	0.59	0.61	0.85	1.62	2.13	1.59	1.86	3.896+0.552x	0.672	1.02

with LD_{50} =116.3µg/larva. Essential oil of *Lippa alba* induces growth inhibition where both relative growth and feeding consumption rate of *S. litura* were conspicuously reduced. Bhathal *et al*. (1993) reported the toxicity and feeding deterrent activity of crude root oils of *Inula racemosa* and *Saussurea lappa* on third instar of *S. litura*. Similar studies were reported by Sharda *et al*. (2000) where essential oil of *Ageratum conyzoides* caused 43.0–69% mortality at 0.025–0.25µl concentration. Essential oil of Ginger, lime, and lavender (LC_{50}=15.3, 17.4, 19, LC_{95}=21.0, 20.3 and 53.1 ppm) showed highest mortality while the essential oil of calamus, basil, carnmint and rosemary (LC_{50}=66.7, 59.8, 53.1, 49.6, LC_{90}= 109.7, 125.3, 94.7 and 81.5 ppm) showed lowest larval mortality (Elumalai *et al.* 2010). Pesticides based on plant essential oils could be used to control large number of agricultural insect pests.The results presented in the study will be useful to determine new strategies for pest control based on natural products.

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