Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

JEZS Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(6): 1150-1156

Received: 14-09-2017
Accepted: 17-10-2017

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Relative effectiveness of plant products against tobacco caterpillar (*Spodoptera litura*) and Bihar hairy caterpillar (*Spilarctia obliqua*)

Preeti Sharma and Neeta Gaur

Abstract
Antifeedant and growth inhibitory activities of hexane, diethyl ether and acetone extracts of seven plant species viz., Vasaka, *Adhatoda vasaka* leaves, Jatropha, *Jatropha curcas* seeds, Mandukparni, *Centella asiatica* leaves, Kundru, *Coccinia grandis* leaves and roots, Karipatta, leaves *Murraya koenigii*, Marigold, *Tagetes erectus* leaves, Brahmi, *Bacopa monnieri* leaves were tested against 8 and 6 day old larvae of *S. litura* and *S. obliqua*. All extracts showed antifeedant and growth inhibitory activities in a dose dependent manner. Among all the treatments most effective extracts were *J. curcas* (Hexane) extract against *S. litura* while *J. curcas*, (Diethyl ether) against *S. obliqua* as they showed maximum larval period (13.66 and 28.66 d), pupal period (21.00 and 12.33 d) and terminal larval mortality (33.33 and 33.33%), minimum mean pupal weight (0.117 and 0.304 gm), pupation (43.33 and 63.33 %) and adult emergence (33.33 and 33.33%) over control respectively. Least effective were *J. curcas* (Diethyl ether) extract against *S. litura* and *V. negundo* (Acetone) against *S. obliqua*. This study provides a means of plant screening to find out compounds with antifeedant and growth inhibitory activities against insects which can be useful for future studies in Plant Health management.

Keywords: Plant extracts, antifeedant, growth and development, *S. litura* and *S. obliqua*

1. Introduction
Extensive uses of chemical pesticides in agriculture leads to adverse effects such as pesticide resistance, pest out breaks, pest emergence, undesirable environmental effects Negahban, *et al.*, 2006 [1]. Plant based insecticides are the environmentally safe alternative in the place of synthetic insecticides and harmful chemicals. The botanical insecticides are generally pest-specific and are relatively harmless to non-target organisms, biodegradable and safe to the environment. Furthermore, plant derived insecticides comprise an array of chemical compounds (secondary plant metabolites) which act on both behavioral and physiological processes Leatemia and Isman, 2004 [2]. The most promising botanicals belong to families Meliaceae, Rutaceae, Asteraceae, Annonaceae, Labiatae and Canellaceae. Different types of plant preparations are being used for preparing botanicals or plant based insecticides, such as powders, solvent extracts and essential oils extraction or by using whole plants Isman, 2000 [3]; Weaver and Subramanyam, 2000 [4]; Koul, 2004 [5]; Mordue, 2004 [6]; Erturk, 2004 [7]; Negahban and Moharramipour, 2007 [9]. Plant based insecticides showed activities such as fumigants, repellents, anti-feedants, anti-ovipositions and insect growth regulators and do not leave any toxic residues in the environment and selectively toxic to insects hence these pesticides have been receiving global attention among the researchers and farmers Raghavaiah and Babu, 2011 [10]. Out of 27,500 species of flowering plants, about 2,121 plant species are documented to possess pest management properties, 1,005 species of plants exhibiting insecticide properties, 384 with anti-feedant properties, 297 with repellant properties, 27 with attractant properties and 31 with growth inhabiting properties have been identified Sinha and Biswas, 2008 [11]. Recently plant protection researchers revealed the importance of plant products that disrupt the normal insect growth and development. The usage of plant products and secondary plant metabolites are being considered as the best alternative to synthetic insecticides. So, in the present investigation effect of some plant extracts was studied on feeding, growth and development parameters against the larvae of *S. litura* and *S. obliqua*.

2. Materials and Methods

a. Maintenance of Insect culture

Wild population of *S. litura* and *S. obliqua* were collected from Norman E. Borlaug Crop Research Centre (NEBCRC), Pantnagar. Rolling culture of test insects was maintained on castor leaves, under laboratory conditions (Temperature 28 ºC and relative humidity 88%). Then the required larvae were taken from the culture, as and when required. All the experiments were conducted during 2013-14 in the Integrated Pest Management Laboratory of the Department of Entomology, College of Agriculture, and Govind Ballabh Pant University of Agriculture and Technology Pantnagar.

b. Preparation of plant extracts

The fresh plant parts of seven plants viz., Vasaka, *Adhatoda vasaka* (Acanthaceae), Jatropha, *Jatropha curcas* (Euphorbiaceae), Mandukparni, *Centella asiatica* (Apiaceae), Kundru, *Coccinia grandis* (Cucurbitaceae), Karipatta, *Murraya koenigii* (Rutaceae), Marigold, *Tagetes erectus* (Asteraceae), Brahmi, *Bacopa monnieri* (Scrophulariaceae) were washed in running tap water and dried in shade for a week. The dried plant samples were weighed and macerated in electric grinder into a fine paste, each powdered plant materials were sieved using strainer, and 100 gm powdered plant material was sequentially extracted with hexane, diethyl ether for a period of 72 hours each and then filtered. The filtered content of plant extracts was then subjected to rotary vacuum evaporator until solvents were completely evaporated to get the solidified crude extracts. The crude extracts thus obtained were stored in sterilized amber colored bottles maintained at 4°C in a refrigerator. Standard one per cent stock solution (1000 ppm) was prepared by dissolving 100 mg of crude extract in 100 ml of acetone Arivoli and Tennyson, 2012 [12].

c. Feeding activity

Two concentrations (5% and 10%) of above mentioned medicinal plants were tested using ‘no-choice feeding’ bioassay method following Srivastava *et al*., 1990 [12] and Srivastava and Proksch, 1991 [13]. Control consisted of Castor plant (*Ricinus communis)* leaf discs only. The treated leaf discs (5x5 cm^2) were kept in the center of pre-sterilized corning glass petri dishes (dia. meter 9cm) containing an inner lining of moist filter paper. All the treatments were replicated three times. Prestarved (3h) and freshly molted larvae (n=2) of same age were released in each petridis and were allowed to feed until more than 75% of the leaf disc area was eaten away in control. The observations on leaf area consumed was recorded on graph paper sheets and used for calculations of other parameters viz., Mean leaf area consumed (MLAC, cm^2), Feeding percentage (%) Purwar and Srivastava, 2003 [14], Antifeedant activity Singh and Pant, 1980 [15], feeding inhibition (%) Pandey and Srivastava, 2003 [16], Preference index (C-value) Kogan and Goeden, 1970 [17] and Antifeedant category were determined following methods:

d. Effect of plant extracts against growth and development of *S. litura* and *S. obliqua*

Selected plants on the basis of their antifeedant activity were further studied for growth and developmental parameters of 6 d old larvae of *S. litura* and *S. obliqua.* The experiment was conducted under laboratory conditions (27±5ºC, 85±5%) in plastic boxes (10 larvae/ box). Pre-starved (2h) and freshly moulted larvae of same age were released. Control consisted of castor (*Ricinus communis*). The data on the leaf area consumed was recorded and used for the calculation of the larval weight gain at 3 days after feeding (DAF) for 6 day old larvae. The other observations were recorded on the following parameters:-larval weight (g), larval period (d), pupal period (d), pupal weight (g), adult emergence (%) and terminal larval mortality (%).

e. Statistical analysis

The data collected in laboratory were statistically analyzed following the standard methods. The percentage data were transformed to angular while simple means transformed to square root. The data were analyzed by one way Analysis of Variance (ANOVA) and the means were separated using, Duncan Multiple Range Test (DMRT) based SPSS16 computer program at the Computer Center, College of Basic Science and Humanities of this University.

3. Results and Discussion

a. Effect of medicinal plants on feeding activity of 8d old larvae of *S. litura* and *S. obliqua*

The antifeedant activity of seven plant species viz., *A. vasaka, J. curcas*, *C. asiatica*, *C. grandis*, *M. koenigii*, *T. erectus*, *B. monnieri* against 8d old larvae of *S. litura and S. obliqua* are presented in table1 and 2.

At 5% concentration, lowest feeding was observed with *J. curcas* (diethyl ether) and maximum in *C. grandis* (diethyl ether) over control (MLAC=18.78 cm^2) in case of *S. litura*. Also *J. curcas*, diethyl ether (1.89) and *C. grandis*, diethyl ether (12.9) showed feeding percentage (7.56 and 51.6 %), antifeedant activity (89.92 and 31.23 %) and inhibition of feeding (81.69 and 18.50 %) respectively. On the basis of preference index *J. curcas* (hexane, diethyl ether, and acetone), *A. vasaka* (hexane and acetone) proved to be extremely antifeedant, *C. asiatica* (Acetone), *C grandis* roots (hexane, diethyl ether, and acetone) were strong antifeedant, *C grandis* leaves (diethyl ether, and acetone) and *B. monnieri* (Hexane and acetone) were slightly antifeedant while remaining extracts were found to be moderately antifeedant. At 10 % conc. hexane extracts of *B. monnieri*, and *A. vasaka* were found with maximum and minimum feeding respectively. Along with that (*B. monnieri*, and *A. vasaka*) hexane extracts showed feeding percentage (47.92 and 5.68 %), antifeedant activity (91.47 and 37.36 %) and inhibition of feeding (36.14 and 92.43 %) respectively. On the basis of preference index *J. curcas* (hexane, diethyl ether, and acetone), *A. vasaka* (hexane, diethyl ether, and acetone), proved to be extremely antifeedant, *C. asiatica* (Acetone), *C. grandis* leaves (Acetone), *C grandis* roots (hexane, diethyl ether, and acetone) were strong antifeedant, *C grandis* leaves (diethyl ether) *B. monnieri* (Hexane and acetone) slightly antifeedant while remaining extracts were found to be moderately antifeedant.

At 5% concentration, minimum and maximum feeding was found with diethyl ether extracts of *J. curcas* and *C. grandis* over control (MLAC=18.76 cm^2) at p=0.05 in case of *S. obliqua* with feeding percentage (5.72%) (50.24%), antifeedant activity (92.36%) (32.97%) and feeding inhibition (85.82%) (19.74%) respectively. On the basis of preference index *A. vasaka* (hexane and acetone), *J. curcas* (diethyl ether, and acetone) were found to be extremely antifeedant. *A. vasaka* (Diethyl ether), *J curcas* (Hexane), *C. asiatica* (Acetone), *C. grandis* (hexane, diethyl ether, and acetone) were strong antifeedant, *B. monnieri* (Hexane and acetone) slightly antifeedant while remaining extracts were moderately antifeedant. At 10 % concentration *J. curcas* (diethyl ether) and *B. monnieri* (acetone) showed minimum and maximum feeding with feeding percentage (4.2 and 45.92 %), antifeedant activity (94.39 and 38.74 %) and inhibition of feeding (89.38 and 24.02 %) respectively. On the basis of preference index *J. curcas* (hexane, diethyl ether, and acetone), *A. vasaka* (hexane, diethyl ether, and acetone), *C. grandis* root (Acetone) proved to be extremely antifeedant, *C. asiatica* (Acetone), *C. grandis* leaves (Hexane), *C grandis* roots (hexane and diethyl ether), *M. koenigi* (diethyl ether and acetone), were strong antifeedant, while remaining extracts were found to be moderately antifeedant.

Among all the extracts at 10% concentration *A. vasaka* (hexane, diethyl ether, acetone), *J. curcas*, (hexane, diethyl ether, acetone) and *J. curcas* (acetone) showed better antifeedant activity than other plants. Various authors also found plant based compounds of the same plants as well as some other plants effective to control these pest as Raja *et al.*, (2003) [18] screened eleven locally available plants species in Maharastra, India, (*Acorus calamus*, *Adhatoda vasika*, *Azadirachta indica*, *Calotropis gigantea*, *Clerodendrum inerme* (=*Clerodendrum inerme*), *Lantana camara*, *Piper nigrum*, *Pongamia pinnata*, *Strychnos nux-vomica* and *Vitex negundo*). Seven extracts gave 30% mortality against *S. litura* and *Lipaphis erysimi*. Devanand and Rani, 2008[19] studied antifeedant and toxic effects of leaf extracts of *Syzygium cumini* L., *Ocimum basilicum* L., *Luffa aegyptiaca* Mill., *Eichhornia crassipes* Mart., *Tamarindus indica* L., *Terminalia catappa* L., *Limonia acidissima* L., *Murraya koenigii* L., *Breynia retusa* (Dennst.)., *Jatropha curcas* L., *Tectona grandis* L., *Momordica charantia* L., *Mangifera indica* L., *Ricinus communis* L., and the seed extract of *Madhuca indica* Gmelin., against the third instar larvae of, *S. litura* Fab. and *Achaea janata* L. (Noctuidae: Lepidoptera). In which they found moderate effect of *J. curcas* extract against *S. litura* while in our study it showed extremely antifeedant activity. Bisht, 2010 [20] evaluated aqueous extracts of plants at 5, 10 and 20% concentration. Plant extracts were found more effective at 20% concentration than 10 and 5% concentration. Bhagat and Kulkarni, 2012 [21] determined larvicidal and adulticidal properties of three Jatropha species (Family- Euphorbiaceae) against third instar larvae of tobacco cutworm *S. litura*. In antifeedent studies five extracts viz. seed oil, methanol and petroleum ether extract of leaves and root of *J. gossypifolia*, seed oil and methanol extract of leaves from *J. glandulifera* were found effective and according to our study *J. curcas* extracts showed pronounced activities. This was an ultimate eco-friendly approach to control the agricultural pest using plant resources.

b. Effect of medicinal plants on development of 6d old larvae of *S. litura* and *S. obliqua*

On the basis of described no-choice feeding experiments four medicinal plant extracts viz., *A. vasaka* (hexane and acetone) and *J. curcas* (diethyl ether and acetone) against 6 day old larvae of *S. litura* and *S. obliqua* respectively presented in Table 3 and 4.

All the treatments found effective against *S. litura* and *S. obliqua*. In case of *S. litura A. vasaka* (Hexane and diethyl ether) and *J. curcas* (Hexane and diethyl ether) extracts were tested which showed order of mean weight gain larva/3 DAF (gm), *J. curcas* hexane (0.232) < *A. vasaka* hexane (0.287) < *A. vasaka* diethyl ether (0.301) < *J. curcas* diethyl ether (0.312). Among all the treatments *V. negundo* (Hexane) extract was found to be most effective against the larvae of *S. litura* (figure 1) as it shows maximum larval period, pupal period and terminal larval mortality (13.66d, 21.00d and 33.33%), minimum mean pupal weight (0.117 gm), pupation (43.33%) and adult emergence (33.33 %). While *J. curcas* (Diethyl ether) was found to be least effective with minimum larval period, pupal period and terminal larval mortality (12.33 d, 18.00 d and 6.66%) respectively maximum mean pupal weight (0.185 gm), pupation (66.66 %) and adult emergence (60.00 %). Selected plant extracts viz; *A. vasaka* (Hexane and Acetone) and *J. curcas* (Diethyl ether and Acetone) were tested against *S. obliqua* (figure 2), which showed order of mean weight gain larva/3 DAF (gm), *J. curcas*, Diethyl ether (0.368) < *J. curcas*, Acetone (0.374) < *A. vasaka*, Acetone (0.387) < *A. vasaka*, Acetone (0.388). Among all the treatments *J. curcas*, (Diethyl ether) extract was found to be most effective against the larvae of *S. obliqua* as it shows with maximum larval period, pupal period and terminal larval mortality (28.66d, 12.33d, 33.33%) respectively, minimum mean pupal weight (0.304gm), pupation (63.33%) and adult emergence (33.33 %). *V. negundo* (Acetone) extract was found to be least effective than other treatment with minimum larval period, pupal period and terminal larval mortality (27.16d, 11.00d and 16.66%) respectively, maximum mean pupal weight (0.366 gm), pupation (80.00 %) and adult emergence (60.66 %). Some authors also studied the effect of plant products against insect pests as Perumal *et al.*, 2004 [22] the larvicidal properties of *Vitex negundo, Argemone mexicana, Datura metel, Annona squamosa* and *Lantana camara* were evaluated against *S. litura*. Out of the five plants screened, the petroleum ether extract of *V. negundo, A. mexicana, D. metel* and *A. squamosa* showed significant larvicidal activities at different concentrations. Hassan, 2010 [23] studied the potential of using plant material as deterrent against pest in crops, on the field and during postharvest period. Ramanagouda and Srivastava 2008 [24] were studied the aqueous extracts (1.0 and 2.0% on a dry weight basis) from 9 medicinal plants (*Jatropha curcas, Syzygium cumini, Plantago ovata, Artemisia annua, Pogostemon patchouli [P. cablin], Stellaria media, Cinnamomum camphora, Cymbopogon winterianus* and *Cnicus benedictus*) for their effects on the feeding behaviour, growth, development and survival of 6-day-old larvae of *S. litura* under laboratory conditions. The data showed that *J. curcas* and *C. benedictus* (at 2.0% each) indicated the significant impact of these treatments on the survival and developmental parameters of *S. litura*. In our study among all the treatments most effective was *J. curcas* (Hexane) extract against *S. litura* while *J. curcas*, (Diethyl ether) against *S. obliqua* while least effective was *J. curcas* (Diethyl ether) extract against *S. litura* and *V. negundo* (Acetone) against *S. obliqua* at 10 % conc. So, this study can be a better alternative against chemical insecticides for Insect-pest management.

4. Conclusion

In the present investigation *J. curcas* (Hexane) extract against *S. litura* while *J. curcas*, (Diethyl ether) against *S. obliqua* were found to be most effective as they showed maximum larval period, pupal period and terminal larval mortality, minimum mean pupal weight, pupation and adult emergence over control. These plant extracts can be used as a management tool in the insect pest management programme of *S. litura* and *S. obliqua.*

5. Acknowledgement

The authors are thankful to the Medicinal Plant Research and Development Centre (MRDC), GBPUA & T Pantnagar for

providing the plant samples and Head Entomology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar for providing necessary facilities

Table 1: Effect of medicinal plants on feeding behavior of 8 d old larvae of Tobacco caterpillar, *S. litura* (Fab.)

S. No.	Plant species Scientific name (Common name and Family)	Plant part used	Solvents used	MLAC (cm^2)/ larva1		Feeding Percentage (%)		Antifeedant Activity (%)		Feeding Inhibition %		Preference index		Antifeedant category	
				5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%
1.	Vasika, *Adhatoda vasaka* (Acanthaceae)	Leaves	Hexane	2.42 (1.71)^{i}	1.42 (1.39)^{g}	9.68	5.68	87.10	92.43	77.14	85.92	0.22	0.14	E.A.	E.A.
			Diethyl ether	2.89 (1.84)^{i}	1.72 (1.49)^{fg}	11.56	6.88	84.59	90.83	73.30	83.20	0.26	0.16	S.A.	E.A.
			Acetone	2.04 (1.59)^{i}	1.89 (1.55)^{efg}	8.16	7.56	89.12	89.92	80.38	81.69	0.19	0.18	E.A.	E.A.
2.	Jatropha, *Jatropha curcas* (Euphorbiaceae)	Seeds	Hexane	2.00 (1.58)^{i}	1.54 (1.43)^{g}	8.00	6.16	89.33	91.79	80.73	84.82	0.19	0.15	E.A.	E.A.
			Diethyl ether	1.89 (1.55)^{i}	1.60 (1.45)^{fg}	7.56	6.40	89.92	91.47	81.69	84.28	0.18	0.15	E.A.	E.A.
			Acetone	2.09 (1.61)^{i}	1.58 (1.44)^{fg}	8.36	6.32	88.85	91.57	79.95	84.46	0.20	0.16	E.A.	E.A.
3.	Mandukparni, *Centella asiatica* (Apiaceae)	Leaves	Hexane	9.48 (3.16)^{def}	7.49 (2.83)^{c}	37.92	29.96	49.46	60.07	32.86	42.93	0.67	0.57	M.A.	M.A.
			Diethyl ether	7.92 (2.90)^{fg}	6.97 (2.73)^{c}	31.68	27.88	57.78	62.84	40.62	45.82	0.59	0.54	M.A.	M.A.
			Acetone	4.29 (2.19)^{h}	3.28 (1.94)^{def}	17.16	13.12	77.13	82.51	62.77	70.23	0.37	0.29	S.A.	S.A.
4.	Kundru, *Coccinia grandis* (Cucurbitaceae)	Leaves	Hexane	11.82 (3.51)^{bc}	10.92 (3.38)^{b}	47.28	43.68	36.99	41.79	22.69	26.41	0.77	0.73	M.A.	M.A.
			Diethyl ether	12.9 (3.66)^{b}	11.75 (3.50)^{b}	51.60	47.00	31.23	37.36	18.50	22.97	0.81	0.77	SL.A.	SL.A.
			Acetone	11.76 (3.50)^{bc}	11.2 (3.42)^{b}	47.04	44.80	37.31	40.29	22.93	25.23	0.77	0.74	SL.A.	S.A.
	Kundru, *Coccinia grandis* (Cucurbitaceae)	Roots	Hexane	5.46 (2.44)^{h}	3.67 (2.04)^{de}	21.84	14.68	70.89	80.43	54.91	67.27	0.45	0.32	S.A.	S.A.
			Diethyl ether	5.00 (2.35)^{h}	4.28 (2.19)^{d}	20.00	17.12	73.34	77.18	57.91	62.84	0.42	0.37	S.A.	S.A.
			Acetone	4.54 (2.24)^{h}	3.99 (2.12)^{d}	18.16	15.96	75.79	78.73	61.03	64.92	0.38	0.35	S.A.	S.A.
5.	Karipatta, *Murraya koenigii* (Rutaceae)	Leaves	Hexane	7.56 (2.84)^{g}	7.24 (2.78)^{c}	30.24	28.96	59.70	61.40	42.55	44.30	0.57	0.55	M.A.	M.A.
			Diethyl ether	7.86 (2.89)^{fg}	7.3 (2.79)^{c}	31.44	29.20	58.10	61.08	40.94	43.97	0.59	0.56	M.A.	M.A.
			Acetone	7.25 (2.78)^{g}	6.98 (2.73)^{c}	29.00	27.92	61.35	62.79	44.25	45.76	0.55	0.54	M.A.	M.A.
6.	Marigold, *Tagetes erecta* (Asteraceae)	Leaves	Hexane	11.00 (3.39)^{bcd}	9.29 (3.13)^{bc}	44.00	37.16	41.36	50.47	26.07	33.76	0.73	0.66	MA.	MA.
			Diethyl ether	8.98 (3.08)^{efg}	7.18 (2.77)^{c}	35.92	28.72	52.13	61.72	35.25	44.64	0.64	0.55	M.A.	M.A.
			Acetone	10.5 (3.32)^{cde}	8.97 (3.08)^{bc}	42.00	35.88	44.02	52.18	28.22	35.30	0.71	0.64	M.A.	M.A.
7.	Brahmi, *Bacopa monnieri* (Scrophulariaceae)	Leaves	Hexane	12.34 (3.58)^{bc}	11.98 (3.53)^{b}	49.36	47.92	34.22	36.14	20.64	22.05	0.79	0.77	SL.A.	SL.A.
			Diethyl ether	11.27 (3.43)^{bcd}	10.69 (3.35)^{b}	45.08	42.76	39.92	43.01	24.94	27.40	0.75	0.72	M.A.	M.A.
			Acetone	12.38 (3.59)^{bc}	11.54 (3.47)^{b}	49.52	46.16	34.00	38.48	20.48	23.82	0.79	0.76	SL.A.	SL.A.
Control				18.76 (4.39)^{a}	18.76 (4.39)^{a}	75.04	75.04					1	1	Preferred Plant	Preferred plant
SEM±				0.134	0.124										
CD at 5%				0.379	0.471										
F value				**	**										

MLAC= Mean leaf area consumed., Antifeedant category following Kogan & Goeden, 1970 [17], **= Highly significant
EA= Extremely antifeedant, MA=Moderately antifeedant, SA=Strongly antifeedant, SLA=Slightly antifeedant

Table 2: Effect of medicinal plants on feeding behavior of 8 d old larvae of Bihar hairy caterpillar, *S. obliqua* (Walk.)

S. No.	Plant species Scientific name (Common name and Family)	Plant part used	Solvents used	MLAC (cm2)/ larval		Feeding Percentage (%)		Antifeedant Activity (%)		Feeding Inhibition %		Preference index		Antifeedant category	
				5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%
1.	Vasaka, *Adhatoda vasaka* (Acanthaceae)	Leaves	Hexane	2.65 (1.77)^{kl}	1.93 (1.56)^{ij}	10.60	7.72	85.85	89.70	75.22	81.32	0.24	0.18	E.A.	E.A.
			Diethyl ether	2.95 (1.86)^{k}	2.00 (1.58)^{ij}	11.80	8.00	84.25	89.32	72.79	80.71	0.27	0.19	S.A.	E.A.
			Acetone	2.34 (1.69)^{kl}	1.67 (1.47)^{j}	9.36	6.68	87.51	91.08	77.79	83.63	0.22	0.16	E.A.	E.A.
2.	Jatropha, *Jatropha curcas*	Seeds	Hexane	2.90 (1.84)^{k}	2.01 (1.58)^{ij}	11.60	8.04	84.52	89.27	73.19	80.62	0.26	0.19	S.A.	E.A.

	(Euphorbiaceae)		Diethyl ether	1.43 (1.39)^{l}	1.05 (1.24)^{j}	5.72	4.20	92.36	94.39	85.82	89.38	0.14	0.10	E.A.	E.A.
			Acetone	2.42 (1.71)^{kl}	1.89 (1.55)^{ij}	9.68	7.56	87.08	89.91	77.12	81.67	0.22	0.18	E.A.	E.A.
3.	Mandukparni, *Centella asiatica* (Apiaceae)	Leaves	Hexane	9.56 (3.17)^{cdef}	7.67 (2.86)^{de}	38.24	30.68	48.98	59.07	32.43	41.91	0.67	0.58	M.A.	M.A.
			Diethyl ether	8.21 (2.95)^{efgh}	6.58 (2.66)^{efg}	32.84	26.32	56.18	64.88	39.07	48.02	0.60	0.51	M.A.	M.A.
			Acetone	5.32 (2.41)^{ij}	3.28 (1.94)^{hi}	21.28	13.12	71.61	82.49	55.77	70.20	0.44	0.29	S.A.	S.A.
4.	Kundru, *Coccinia grandis* (Cucurbitaceae)	Leaves	Hexane	11.34 (3.44)^{bcd}	10.05 (3.25)^{bcd}	45.36	40.2	39.48	46.37	24.60	30.18	0.75	0.69	M.A.	S.A.
			Diethyl ether	12.56 (3.61)^{b}	11.04 (3.40)^{bc}	50.24	44.16	32.97	41.08	19.74	25.85	0.80	0.74	SL.A.	M.A.
			Acetone	10.32 (3.29)^{bcde}	9.89 (3.22)^{bcd}	41.28	39.56	44.93	47.22	28.97	30.91	0.71	0.69	M.A.	M.A.
		Roots	Hexane	5.23 (2.39)^{ij}	3.26 (1.94)^{hi}	20.92	13.04	72.09	82.60	56.36	70.36	0.43	0.29	S.A.	S.A.
			Diethyl ether	5.02 (2.35)^{j}	3.18 (1.92)^{hi}	20.08	12.72	73.21	83.03	57.74	70.98	0.42	0.29	S.A.	S.A.
			Acetone	4.92 (2.33)^{j}	2.07 (1.60)^{ij}	19.68	8.28	73.74	88.95	58.41	80.10	0.41	0.19	S.A.	E.A.
5.	Karipatta, *Murraya koenigii* (Rutaceae)	Leaves	Hexane	7.25 (2.78)^{fghi}	6.86 (2.71)^{ef}	29.00	27.44	61.31	63.39	44.20	46.40	0.55	0.53	M.A.	M.A.
			Diethyl ether	6.94 (2.73)^{ghij}	5.48 (2.45)^{fg}	27.16	21.92	62.96	70.75	45.95	54.74	0.54	0.45	M.A.	S.A.
			Acetone	6.78 (2.70)^{hij}	4.69 (2.28)^{gh}	27.12	18.76	63.82	74.97	46.86	59.96	0.53	0.40	M.A.	S.A.
6.	Marigold, *Tagetes erecta* (Asteraceae)	Leaves	Hexane	10.78 (3.36)^{bcd}	8.49 (3.00)^{cde}	43.12	33.96	42.47	54.69	26.96	37.64	0.73	0.62	M.A.	M.A.
			Diethyl ether	9.28 (3.13)^{defg}	7.68 (2.86)^{de}	37.12	30.72	50.48	59.01	33.76	41.86	0.66	0.58	M.A.	M.A.
			Acetone	10.76 (3.36)^{bcd}	9.25 (3.12)^{bcd}	43.04	37.00	42.58	50.64	27.05	33.90	0.72	0.66	M.A.	M.A.
7.	Brahmi, *Bacopa monnieri* (Scrophulariaceae)	Leaves	Hexane	11.98 (3.53)^{bcd}	10.01 (3.24)^{bcd}	47.92	40.04	36.07	46.58	22.00	30.36	0.77	0.69	SL.A.	M.A.
			Diethyl ether	11.03 (3.40)^{bcd}	10.87 (3.37)^{bc}	44.12	43.48	41.14	41.99	25.89	26.57	0.74	0.73	M.A.	M.A.
			Acetone	12.01 (3.54)^{bc}	11.48 (3.46)^{b}	48.04	45.92	35.91	38.74	21.88	24.02	0.78	0.75	SL.A.	M.A.
Control				18.76 (4.39)^{a}	18.76 (4.39)^{a}	74.96	74.96					1	1	Preferred Plant	Preferred Plant
SEM±				0.147	0.137										
CD at 5%				0.419	0.390										
F value				**	**										

MLAC= Mean leaf area consumed., Antifeedant category following Kogan & Goeden, 1970 [17], **= Highly significant
EA= Extremely antifeedant, MA=Moderately antifeedant, SA=Strongly antifeedant, SLA=Slightly antifeedant

Table 3: Effect of medicinal plants on development of 6d old larvae of Tobacco caterpillar, *S. litura* (Fab.)

S. No	Plant Species	Solvents	Mean weight/ larva (g)	Mean weight/ Larva 3 DAF (g)	Larval period (d)	Terminal larval mortality (%)	Pupal period (d)	Mean pupal weight (g)	Pupation (%)	Adult emergence (%)
Vasaka, *Adhatoda vasika* (Acanthaceae)		Hexane	0.335 (0.913)^{a}	0.287 (0.887)^{b}	13.33 (3.71)^{a}	23.33 (28.78)^{d}	20.33 (4.56)^{a}	0.125 (0.790)^{ab}	50.00 (44.99)^{b}	40.00 (39.23)^{b}
		Diethyl ether	0.367 (0.931)^{b}	0.301 (0.894)^{b}	12.66 (3.62)^{a}	13.33 (21.14)^{c}	19.66 (4.49)^{a}	0.164 (0.815)^{abc}	63.33 (52.77)^{c}	53.33 (46.92)^{c}
Jatropha, *Jatropha curcas* (Euphorbiaceae)		Hexane	0.348 (0.920)^{ab}	0.232 (0.855)^{a}	13.66 (3.76)^{a}	33.33 (35.21)^{e}	21.00 (4.63)^{a}	0.117 (0.785)^{a}	43.33 (41.15)^{a}	33.33 (35.21)^{a}
		Diethyl ether	0.340 (0.916)^{ab}	0.312 (0.900)^{b}	12.33 (3.58)^{a}	6.66 (12.28)^{b}	18.00 (4.30)^{a}	0.185 (0.827)^{bc}	66.66 (54.78)^{d}	60.00 (50.85)^{d}
Control			0.355 (0.924)^{ab}	0.598 (1.047)^{c}	12.00 (3.53)^{a}	0.00 (0.00)^{a}	17.33 (4.22)^{a}	0.232 (0.855)^{c}	96.66 (83.85)^{e}	93.33 (77.70)^{e}
SEM±			0.005	0.005	0.298	0.137	0.447	0.012	0.227	0.342
CD at 5%			0.016	0.015	0.939	0.432	1.408	0.040	0.716	1.079
F-value			*	**	*	**	**	**	**	**

ns= non-significant, *= significant, **= Highly significant

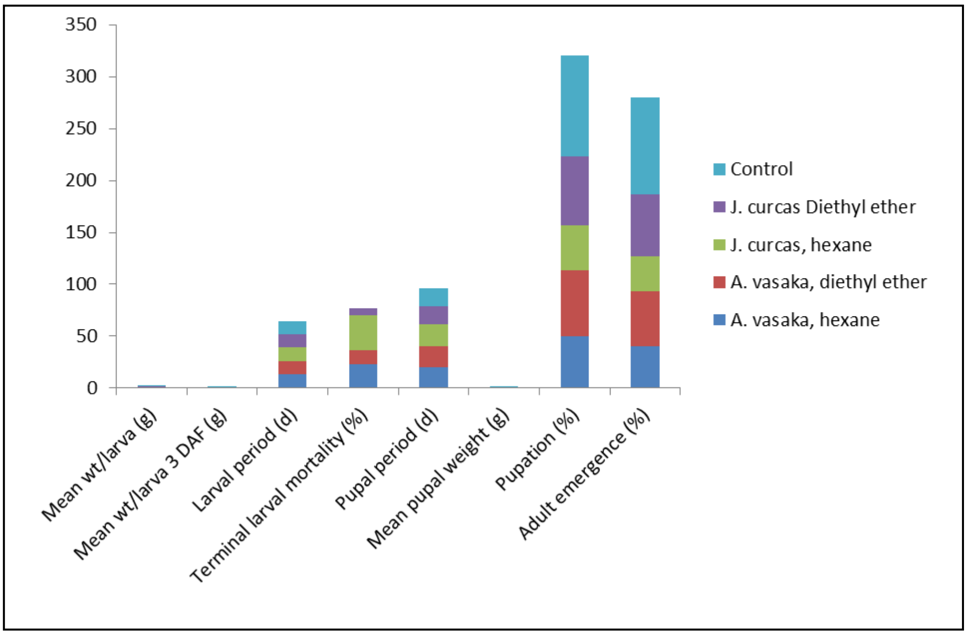

Fig 1: Effect of medicinal plants on development of 6d old larvae of Tobacco caterpillar, *S. litura* (Fab.)

Table 4: Effect of medicinal plants on development of 6d old larvae of Bihar hairy caterpillar, *S. obliqua* (Walk.)

S. No	Plant species	Solvents	Mean weight/ Larva (g)	Mean weight/ Larva 3 DAF (g)	Larval period (d)	Terminal larval mortality (%)	Pupal period (d)	Mean pupal weight (g)	Pupation (%)	Adult emergence (%)
Vasaka, *Adhatoda vasika* (Acanthaceae)		Hexane	0.415 (0.956)^{a}	0.388 (0.942)^{a}	27.16 (5.25)^{a}	16.66 (23.85)^{b}	11.00 (3.38)^{a}	0.366 (0.930)^{d}	80.00 (63.43)^{d}	53.33 (46.92)^{c}
		Acetone	0.410 (0.953)^{a}	0.387 (0.941)^{a}	27.66 (5.30)^{a}	23.33 (28.78)^{c}	11.33 (3.43)^{a}	0.343 (0.918)^{c}	73.33 (59.00)^{c}	60.00 (50.76)^{d}
Jatropha, *Jatropha curcas* (Euphorbiaceae)		Diethyl ether	0.417 (0.957)^{a}	0.368 (0.931)^{a}	28.66 (5.40)^{a}	33.33 (35.21)^{e}	12.33 (3.58)^{a}	0.304 (0.897)^{a}	63.33 (52.77)^{a}	33.33 (35.21)^{a}
		Acetone	0.419 (0.958)^{a}	0.374 (0.935)^{a}	28.50 (5.38)^{a}	26.66 (30.99)^{d}	11.66 (3.48)^{a}	0.321 (0.906)^{b}	66.66 (54.78)^{b}	46.66 (43.07)^{b}
Control			0.421 (0.959)^{a}	0.612 (1.054)^{b}	27.00 (5.24)^{a}	0.00 (0.00)^{a}	10.33 (3.29)^{a}	0.378 (0.937)^{d}	100.00 (90.00)^{e}	100.00 (90.00)^{e}
SEM±			0.008	0.006	0.408	0.128	0.394	0.002	0.198	0.202
CD at 5%			0.025	0.021	1.286	0.403	1.242	0.008	0.626	0.638
F-value			ns	**	*	**	*	**	**	**

ns= non-significant, *= significant, **= Highly significant

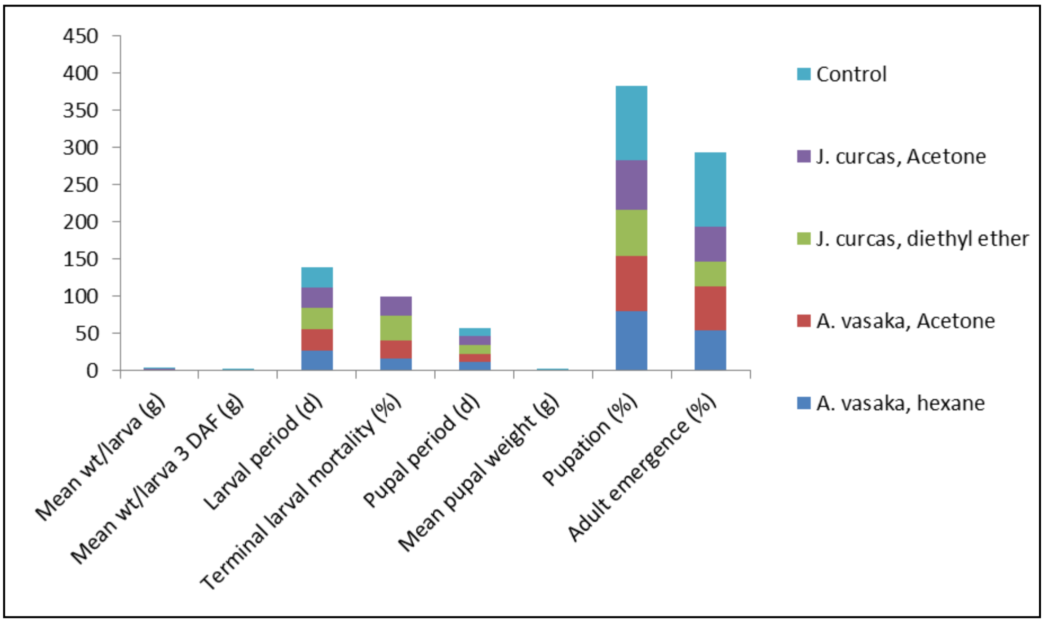

Fig 2: Effect of medicinal plants on development of 6d old larvae of Bihar hairy caterpillar, *S. obliqua* (Walk.)

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