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Comparative toxicological computability of turmeric, Curcuma *domestica* Valeton, Pavettia, *Adhatoda vasica* Nees and Hulhul, *Cleome monophylla* Linn. Against Bihar hairy caterpillar, *Spilarctia obliqua* Walk. (Lepidoptera: Arctiidae)

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Abstract
In the present investigation alcoholic extract of two indigenous plant extracts *viz*., leaves of Pavettia, *Adhatoda vasica* Nees. (Acanthaceae), rhizomes of Turmeric, *Curcuma domesticus* Volten (Zingiberaceae), seeds of hulhul, *Cleome monophylla* Linn. (Capparidaceae), with control (benzene + emulsified water) were prepared with the help of the soxhlet apparatus under the laboratory conditions. These extracts were tested to find out insecticidal effects against third instars larvae of Bihar hairy caterpillar, *Spilarctia obliqua* Walk. (Lepidoptera: Arctiidae). The data depicted from results that rhizomes extract of *C. domesticus* Vol. gave the maximum mortality. It killed 66.35 per cent *Spilarctia obliqua* larvae followed by *A. vasica Nees.* (65.70 per cent), and *C. monophylla* Linn (64.16 per cent) whereas untreated control showed only 12.26 per cent mean mortality to the caterpillar of *S. obliqua*. The plant extract of *C. domesticus* differed significantly from remaining once except *C. monophylla*, from which it does not differs significantly to one another.

Keywords: Bihar hairy caterpillar, *Spilarctia obliqua*, *Curcuma domesticus*

1. Introduction
The tests insect Bihar hairy caterpillar, *Spilarctia obliqua* Walk. (Lepidoptera: Arctiidae) is a the serious pests, causing enormous qualitative and quantitative losses to various Cruciferous crops and vegetables. The Bihar hairy caterpillar, *Spilarctia obliqua* (Walker) (*Spilosoma obliqua* Walker) is considered as a dominant polyphagous pest of various crops including soybean, pulses, oilseeds, legumes etc. (Bhattacharya and Rathore, 1977) [1]. This pest has been recorded in India, Pakistan, Sri Lanka, eastern Asia, Borneo, China and Japan (Biswas 2006) [2]. Use of various pesticides is widespread among farmers and plantation growers for the control of this pest. If other agrochemicals which are usually applied in the field for other purposes then controlling insects, and have insecticidal activity, then their use in combination to lesser concentration of insecticide can be incorporated in IPM module for the first instar larvae of this pest. Though, a large amount of literature is available for the management of this pest but there is a lot of variation is found among dosage used of different insecticides. This may be the reason that insects develop resistance to particular insecticide and so the labeled dose keeps on changing with time. Present research investigation has been focused on the role of agrochemicals in an integrated manner with the use of bio-rational insecticides in combination with other agrochemicals (fungicide, Plant growth regulator PGR) for the control of this pest**.**

2. Materials and Methods
2.1.Culture: Culture: A nucleus culture of *Spilarctia obliqua* (Walker) (=*Spilosoma obliqua*) was established in the laboratory by collecting larvae from the soybean field at the Crop Research Centre of CSAU, Agriculture & T, Pantnagar, in the month of June-July, 2004 and 2005. These larvae were reared on castor leaves at 30±10 C and relative humidity 80±5 per cent.

All rearing was carried out in glass jars (21´15 cm) covered with muslin cloth. Adults obtained from this culture were kept in glass jars (21 x 15 cm) lined with filter paper and covered with muslin cloth, for egg laying. Sucrose solution (10 per cent) was provided for adults, as food, by placing the soaked absorbent cotton in a small glass petri dishes in the bottle of glass jars. Eggs obtained from these adults were kept in glass petri dishes. Newly hatched larvae (0-24 h old) were obtained for experiments.

2.2 Experimental Site

Experiments were conducted in the Department of Zoology, Dayanand Brijendra Swaroop Post-Graduate College, Kanpur. Geographically, the districts Kanpur is located in between latitudes 25.26º and 26.58º North and longitudes 19.31º and 84.34º East, Kanpur is situated at an elevation of about 127.117º metres above the mean sea level and has a semi-arid subtropical climatic conditions.

2.3 Test Insects

For the proposed study, the following insects have been used for their insecticidal activities.

1. Bihar hairy caterpillar, *Spilarctia obliqua* Walk. (Lepidoptera: Arctiidae)
1. 2. Mustard varieties for Nutrition: Varuna, SKM-9736, MJ-95-209, SKM-9631, SKM- 9529 and SKM-9556

2.4. Field Collection

Bihar hairy caterpillar, *Spilarctia obliqua* Walk. were collected from the mustard field of farmers of Ekghara village, Vidhnu Block of Kanpur Nagar for conducting the experiments. During the period of study, the feeding habits of larvae have been noted. Generally, the larvae feed in the early and later parts of the day. In remaining period, due to hot sunshine they move towards the underside of the leaves and in soil to hide themselves. In cloudy weather, the larvae continue to feed on the upper surface of leaves throughout the day.

To obtain regular supply of known aged larvae for laboratory and field study the culture was raised for Bihar hairy caterpillar, *Spilarctia obliqua* Walk on mustard leaves under laboratory. The start the culture, the larvae were collected from plots and reared in petridishes containing fresh mustard leaves. The food was changed daily and at maturation, the larvae were provided the sand in Jar for pupation. The newly emerged insects (adults) were separated according to their sexes and a pair of male and female were released on potted radish plant and kept under the glass chimneys top covered with muslin cloth and a pair of Bihar hairy caterpillar, *Spilarctia obliqua* Walk was carefully transferred to the fresh mustard plants for egg laying. The leaves having egg pouches were seen clearly and as soon as the hatching starts, the newly hatched larvae were transferred to the petridishes containing food over moist filter paper.

2.5 Selection and Extraction of Indigenous Plants

The plant materials used in the present investigation were collected mainly from wasteland; wild areas and some plants were collected from cultivated fields of the farmers. Thirty plants were collected from the nearby locality. A preliminary trial was undertaken in the laboratory by crude method to see which of them have more or less toxicity in the farm of food preference/anti-feeding/repellent/insecticide against the insects. Thirteen plant materials were used for their biological efficacy against Bihar hairy caterpillar, *Spilarctia obliqua* Walk.

The feeding deterrent and repellent activity of mentioned plant materials were tested against larvae of Bihar hairy caterpillar, *Spilarctia obliqua* Walk under laboratory conditions.

A preliminary trial was conducted to test the biological efficacy of selected naturally occurring plant extracts under laboratory as well as field condition, against the test insect.

Table 1: List of indigenous plant materials, Parts, Varnacular Name and Natural Order

Scientific Name	Vernacular Name	Part Used	Faimly
Adhatoda vasica Nees	Pavettia	Leaves	Acanthaceae
Curcuma domesticus Vol.	Turmeric	Rhizome	Zingiberaceae
Cleome monophylla Linn.	Hulhul	Seeds	Capparidaceae

2.6 Preparation of 50 percent stock solution from pure extract: 50 ml. Extract in each case was taken into reagent bottle and 50 ml. Benzene was added in it to dissolve the constituents of the materials. This was the 50 percent stock solution, the mouth of the bottles were stopped with airtight corks and kept in refrigerator.

2.7 The Insecticidal Formulations

To make various concentration of extract the required quantity of the stock solution was calculated with the help of following formula:

$$\text{Amount of Stock Solution} = \frac{\text{Amount required x Concentration required}}{\text{Concentration of Stock Solution}}$$

The calculated amount of various ingredients required to make different concentrations from the 50 per cent stock solution and amount of ingredients taken are presented in the following table: The different concentrations of the insecticides were prepared from the stock solution using benzene as solvent and Triton X-100 as emulsifier. The level of solvents and emulsifier were kept constant at the rate of 5 per cent and 0.5 per cent, respectively, in the final spray.

2.8 Preparation Of 0.5 Per Cent Emulsifiable Water:

0.5 ml. of Triton X-100 was accurately measured into a large bottle with the help of a measuring cylinder, then 99.5 ml of distilled water was added and bottle was shaken well to dissolve the emulsifier. Thus emulsifiable water of 0.5 per cent strength was obtained and used for the preparation of different concentrations of the extracted materials (Schmidt and El,1997).

Table 2: Preparation of different formulations of the selected plant materials

Concentration (%)	Amount of Stock Solution (ml)	Amount of Benzene (ml)	Amount of Emulsifiable Water (ml)	Total Amount (ml)
0.25	2.50	22.50	475.00	500.00
0.50	5.00	20.00	475.00	500.00
1.00	10.00	15.00	475.00	00.00
1.50	15.00	10.00	475.00	500.00
2.00	20.00	5.00	475.00	500.00

3. Experimental protocols

After conducting the preliminary trials the regular experiments were carried out under laboratory conditions. The third instars larvae of Bihar hairy caterpillar, *Spilarctia obliqua* Walk., were used for the purpose. The insecticides of the plant origins were tested by dry film technique. The spraying of the insecticides was done in glass petridishes (10cm diameter) by potters spray tower, using 1.0 ml. of solution (insecticical preparation) per petridish. Three or five concentrations were tested in three replications, along with over control (Benzene + emulsified water). To record the mortality, the spray petridishes were gently shaken under an electric fan till the liquid phase evaporated leaving behind a uniform dry film of insecticide on the glass surface. The spray tower was thoroughly rinsed with the insecticide solution. Ten larvae of known age were then released inside each pair of petridishes and allow remaining there up to two hours. After which, they were transferred to the fresh petridishes containing fresh food for feeding.

These petridishes were kept as such under control conditions (27±2 ºC temp. 75±5% relative humidity) and mortality count was taken after 6, 12, 24 hours of exposure. For contact toxicity test, the fresh leaves of mustard were taken from unsprayed field and washed thoroughly with tap water. The each leaf was dipped into desired concentration of each extract and dried under the fan, then kept them into petridishes (15 cm in diameter) separately. A control with Benzene + emulsified water was run simultaneously. Now, ten known healthy caterpillars of *Spilarctia obliqua* Walk. were released into each petridishes after drying the extract of treated leaf. The mortality of caterpillar, *Spilarctia obliqua* Walk. were counted after 24, 48, 72 hours of the released.

Table 3: Mean mortality percentage of *S. obliqua* larvae using different botanicals under laboratory trials

Treatment	Con.	Lab.	Mean	Mortality	%	After	
		6	Hrs.	12	Hrs.	24	Hrs.
(Plant extracts)	(%)	T_1	T.B.V.$_1$	T_2	T.B.V.$_2$	T_3	T.B.V.$_3$
A. vasica Nees.	0.5	48.85	56.7	48.85	56.7	54.78	66.7
A. vasica Nees.	1.0	54.78	66.7	56.79	70.0	63.44	80.0
A. vasica Nees.	2.0	83.85	98.9	90.00	100.0	90.00	100.0
C. domesticus Vol.	0.5	46.92	53.4	50.77	60.0	52.78	63.3
C. domesticus Vol.	1.0	52.78	63.3	63.93	80.7	66.15	83.6
C. domesticus Vol.	2.0	83.85	98.9	90.00	100.0	90.00	100.0
C. monophylla Linn.	0.5	41.15	43.3	46.92	53.4	52.8	46.95
C. monophylla Linn.	1.0	54.78	66.7	56.79	70.0	61.22	76.7
C. monophylla Linn.	2.0	83.85	98.9	90.00	100.0	90.00	100.0
Control	-						

Table 4: Mean mortality % of *S. obliqua* in exposure periods irrespective of concentration

Treatment	Lab.	Mean	mortality	%	after		Mean	%
	6	Hrs.	12	Hrs.	24	Hrs.	mortality	
(Plant extracts)	T_1	TBV_1	T_2	TBV_2	T_3	TBV_3	G.T.	TBV
A. vasica Nees..	62.49	78.7	65.21	82.4	69.40	87.6	65.7	82.3
C. domesticus Vol.	61.18	76.6	68.23	86.2	69.64	87.9	66.35	84.0
C. monophylla Linn.	59.93	74.9	64.57	81.6	68.00	86.0	64.16	81.0
Control (Benzene+ H_2O)	0.00	0.00	18.44	10.00	18.44	10.00	12.26	4.25

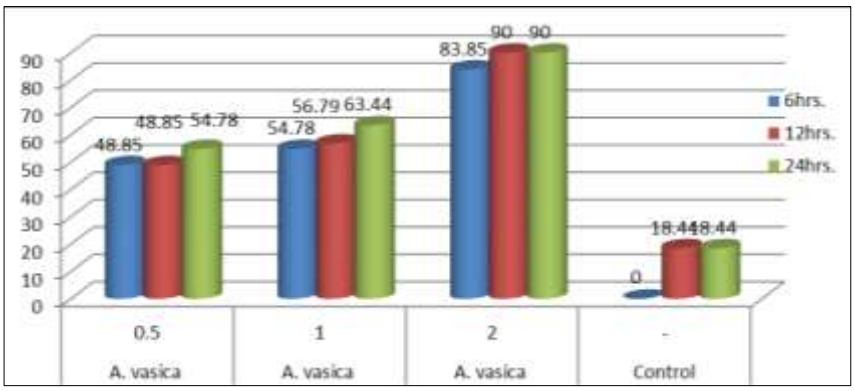

Fig 1: Mean mortality % of *S. obliqua* larvae on the exposure of different conc. of *A. vasica Nees.*

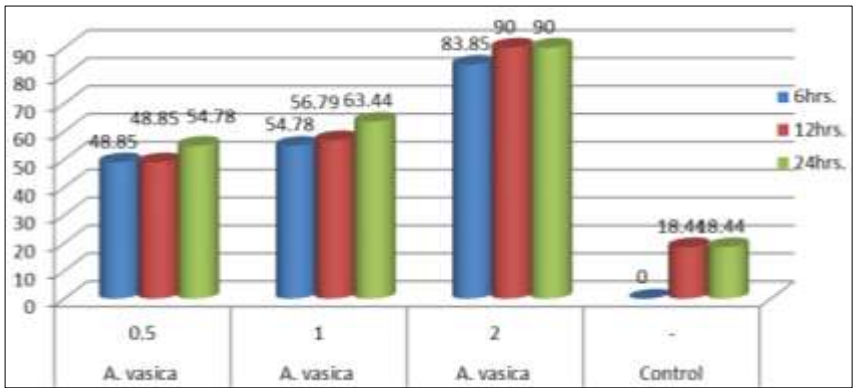

Fig 2: Mean mortality % of *S. obliqua* larvae on the exposure of different conc. *of C. domesticus*

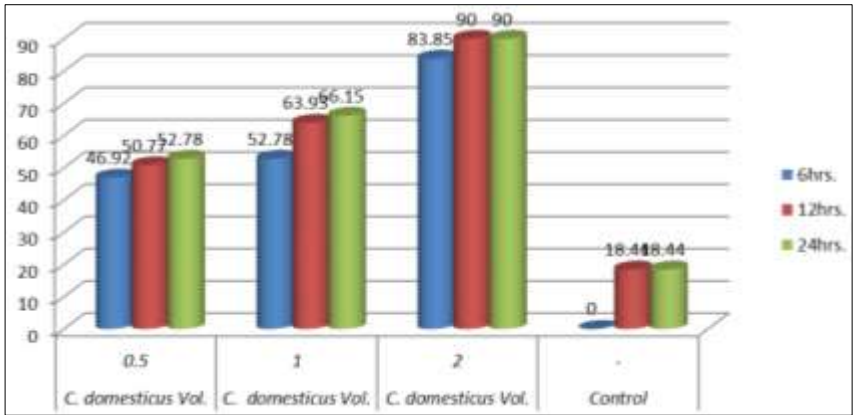

Fig 3: Mean mortality % of *S. obliqua* larvae on the exposure of different conc. *of C. monophylla*

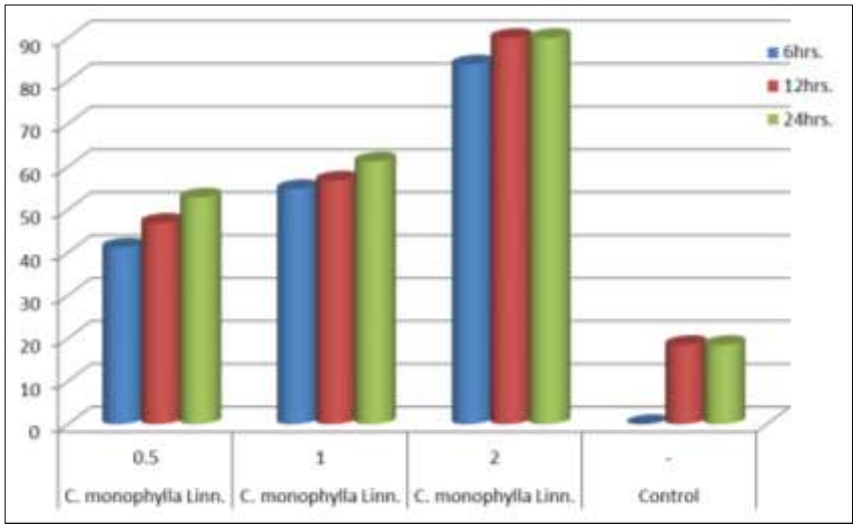

Fig 4: Mean mortality % of *S. obliqua* larvae in exposure different exposure periods

The table 5 reveals that the plant extract of *C. domesticus* Vol. gave the maximum mortality. It killed 66.35 per cent caterpillar of *S. obliqua* followed by *A. vasica Nees.*. (65.70 per cent), and *C. monophylla* Linn (64.16 per cent) whereas untreated control showed only 12.26 per cent mean mortality to the caterpillar of *S. obliqua*. The plant extract of *C. domesticus* differed significantly from remaining once except *C. monophylla*, from which it does not differs significantly to one another.

Table 5: Mean mortality percentage of *Spilarctia obliqua* in different concentration irrespective of treatments under *In-vitro*.

Concen-trations		Lab.	Mean	Mortality	%	After	Mean	%
	6	Hrs.	12	Hrs.	24	Hrs.		
	T_1	TBV_1	T_2	TBV_2	T_3	TBV_3	G.T.	TBV
0.5	45.19	50.4	49.74	58.2	57.09	70.5	50.67	59.8
1.0	56.96	70.3	62.23	78.3	68.38	87.0	62.50	78.7
2.0	75.25	93.5	83.32	98.7	80.06	97.1	81.54	97.9

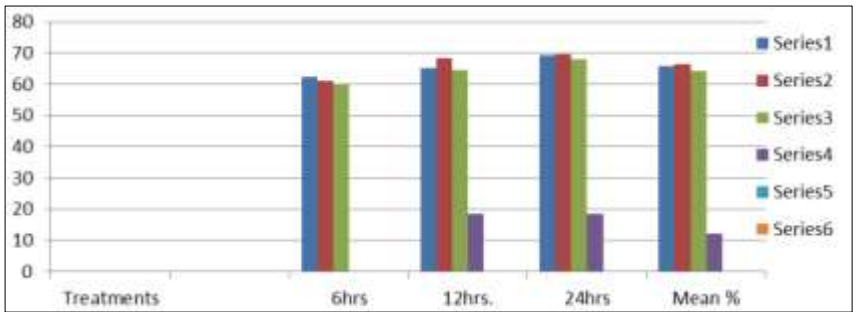

Fig 5: Mean mortality percentage of *S. obliqua* larvae in different concentration irrespective of treatments under *In-vitro*.
(Figure within parenthesis represent mean percentage transformed back value)
C.D. for treatment x period means = 0.080
C.D. for treatment means (plant extract) = 0.045
C.D. for treatment means (control) = 0.139

Table 5 indicates that all the three concentration differed significantly to one another. The concentration 2.0 per cent is superior to concentration 1.0 and 0.5 per cent. 2.0 per cent concentration killed grubs of *S. obliqua* (81.54 per cent). It is also observed that the difference in the percentage kill of grubs in concentration 2.0 per cent and 1.0 per cent (62.50%) is greater than the difference in concentration to kill the grubs in 1.0 per cent and 0.5 per cent (50.67%) in all the three periods

Table 6: Mean mortality percentage of *Spilarctia obliqua* in different exposure periods irrespective of treatments under *In vitro*.

Treatments	Lab. 6 Hrs.	Mean 12 Hrs.	Mortality %	After 24 Hrs.		Mean Tality	Mor- (%)
	T_1	TBV_1	T_2	TBV_2	T_3	TBV_3	G.T.	TBV
Plant Extracts	59.13	73.7	65.09	82.3	70.49	88.9	64.91	82.0
Control	00.00	0.00	18.44	10.00	18.44	10.00	12.26	4.25
Mean values	29.56	24.4	74.31	92.7	79.71	96.9	71.04	89.5

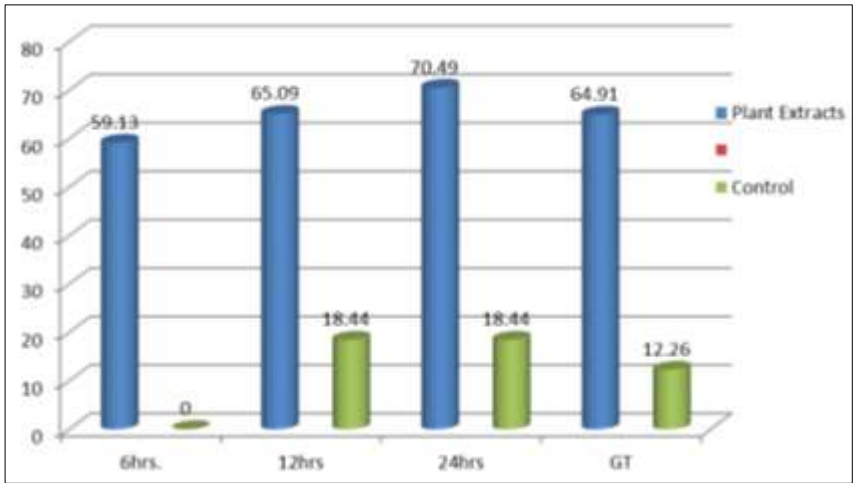

Fig 6: Mean mortality percentage of *Spilosoma obliqua* larvae in control irrespective of treatments under laboratory trials

It is obvious from table 6, the results the difference in percentage mortality of the grubs in 24 hours (79.71 per cent) and 12 hours (74.31 per cent) is greater than the difference in percentage mortality in the period of 12 hours (74.31 per cent) and 6 hours (29.56 per cent) mean mortality of *S. oblique* larvae.

4. Results and Discussion

The data depicted from the result the plant extract of *C. domesticus* Vol. gave the maximum mortality. It killed 66.35 per cent caterpillar of *S. obliqua* followed by *A. vasica Nees.*. (65.70 per cent), and *C. monophylla* Linn (64.16 per cent) whereas untreated control showed only 12.26 per cent mean mortality to the caterpillar of *S. obliqua*. The plant extract of *C. domesticus* differed significantly from remaining once except *C. monophylla*, from which it does not differs significantly to one another.

Similarly, all the three concentration differed significantly to one another. The concentration 2.0 per cent is superior to concentration 1.0 and 0.5 per cent. 2.0 per cent concentration killed grubs of *S. obliqua* (81.54 per cent). It is also observed that the difference in the percentage kill of grubs in concentration 2.0 per cent and 1.0 per cent (62.50%) is greater than the difference in concentration to kill the grubs in 1.0 per cent and 0.5 per cent (50.67%) in all the three periods.

Natural products recommended for organic agriculture tend to be safer alternatives to conventional insecticides () [xx] owing to their rapid degradation, lack of persistence and minimal adverse effects on humans, beneficial insects and environment () [xx]. Turmeric, *Curcuma longa* L. (Zingiberales: Zingiberaceae) (Synonym: *Curcuma domestica* Valeton), an herbaceous perennial plant (xxx)

[xx] with long lateral ramifications, originated from Southeast Asia, probably in the Indian subcontinent [15 16].

The *Curcuma longa* has well-known insecticidal effects on insect pests, but its impact on *Spilarctia obliqua* is unknown. In the support of the findings obtained reported potent insecticidal effect on their test insect-pest. (Chowdhury *et al*. 2000, Martins 2001, Lee 2001, Bambirra *et al*. 2002, Bansal 2002, Chane-Ming 2002, Kolev, 2005, Raina *et al*. 2005, Péret-Almeida 2005, Tayyem 2006, Qin 2007, Ajaiyeoba 2008 [1-11]. Turmeric, *Curcuma longa* L. (Zingiberales: Zingiberaceae) (synonym: *Curcuma domestica* Valeton), an herbaceous perennial plant have Insecticidal biopotency.

Turmeric, *Curcuma longa* L (synonym: *Curcuma domestica* Valeton) (Zingiberales: Zingiberaceae), an herbaceous perennial plant rhizomes exhibing insecticidal effect against a number of house hold insect-pest, cole crop, vegetables and stored grain pest like *Aedes aegypti* Linnaeus, *Rhipicephalus* (Boophilus) microplus, *Sitophilus zeamais* and *Spodoptera frugiperda*, *Trichoplusia ni* and *Myzus persicae* reported by Li 2010, Sukari 2010, Damalas,2011, Martinez-Velazquez,2011, Siddiqi 2011, Naz 2011, Xiao, 2011, Tavares,2013, Mourão2013 and Ribeiro2014), respectively [1, 2].

In this study, the concentration of in *C. domestica* Valeton rhizomes reduced larval weight on treated *Brassica oleracea* leaves in the laboratory and in experiments, compared with the untreated control. The extractives could be used as a low cost botanical insecticide for integrated management of Bihar hairy caterpillar in vegetable production.

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