International Journal of Advanced Academic Studies 2020; 2(3): 98-103

E-ISSN: 2706-8927
P-ISSN: 2706-8919
IJAAS 2020; 2(3): 98-103
Received: 11-05-2020
Accepted: 13-06-2020

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An assessment of ecofriendly insecticidal toxicity of *Ocimum sanctum*, *Croton tiglium* and *Zingiber officinale* extractives against Bihar hairy caterpillar, *Spilarctia obliqua* Walker (Lepidoptera: Arctiidae)

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Abstract
The Bihar hairy caterpillar, *Diacrisia* (*Spilarctia*) *obliqua* Walker are sporadic in nature has been in regular occurrence in northern Indo-Gangatic reigion, causing considerable damage to cruciferous crops and vegetables in our country. An experiment was conducted to test the insecticidal efficacy of six naturally occurring plant extracts against third instar larvae of *Diacrisia* (*Spilarctia*) *obliqua* Walker under the laboratory conditions. The bio-efficacy of six plant materials *viz*., *Croton tiglium* Linn., *Datura alba* Linn, *Ocimum santum* Linn, *Spilanthes acmella* Murr, *Thavetia nerfolia* Linn. and *Zingiber officinale* Linn. were prepared with the help of the soxhlet apparatus under the laboratory conditions and one untreated control used for detail study. The laboratory trial was done in three glass petridishes (10cm diameter and replicated thrice by using each selected extracts per petridish. To record the mortality of ten larvae of *Spilarctia obliqua* were released inside each pair of petridishes and allow them to remain for 24 hours. These petridishes were kept as such under control conditions and mortality count was taken after 6, 12, 24 hours of exposure. The result observed that *O. santum* registered highest mortality (65.61%) to the 3rd instars larvae of *Spilarctia obliqua* Walk. when compared to other plant extracts as; *C. tiglium* (57.39) >*Z. officinale* (55.84) >*S. Acmella* (51.70) >*T. Nerfolia* (51.56) >*D. Alba* (37.93), respectively. The aforesaid results have focused on natural plant products as alternatives for insect-pest control.

Keywords: *Spilarctia obliqua, Ocimum santum, Croton tiglium* and caterpillars

Introduction
Provision of food has always been a challenging when hungriness facing mankind. A major cornerstone in this challenge is the competition from insects which claim to be responsible for destroying one-fifth of the world's total crop production annually (Wyckhuys *et al.* 2013) [1]. India is basically an agro-based country and more than 80% of Indian population still depends by agricultural production. It is unanimously agreed that insect-pests are the main factors causing damage to crops adversely affects agricultural production. The monetary loss due to feeding by larvae and adult insects alone contributes to billion dollars per annum (Nelson *et al.* 2016) [2].
The Bihar hairy caterpillars, *Diacrisia obliqua* (Walk.) are sporadic in nature has been in regular occurrence in northern India, causing considerable damage to cruciferous crops and vegetables in our country (Chandel *et al.* 2004 and Tandon *et al*. 2004) [3, 4]. The pest is distractive in its larval stages. The damaged plant shows stunty growth and results in deterioration of yield. Indiscriminate use of synthetic insecticides has led to problems has been raised about the ill effects to human health and affecting environment and increase the casts of insect control (Chandel *et al.* 2018) [5].
In the quest of recent approaches to insect-pests control viz., discovery of cheap, biodegradable, least adverse effective and ecofriendly effective pesticides, the insecticides suit well as far as Indian conditions are concerned, where the mass of farmers lack resources and technical knowledge. It is required that production of insecticides of plants origin should be encouraged in our country (Chaudhay and Dadheech, 1989, Konar and Rai, 1990, Schmidt and Streloke, 1994, Tripathi *et al.* 2000, Dubey *et al.* 2004, Isman, 2006, Bajpai and Chandel, 2009, Dang *et al.* 2010; Kim *et al.*, 2011 and Valsalan and Gokuldas, 2015 [6, 7, 8, 9, 10, 11, 12, 13, 14, 15]. Majority of Indians are vegetarian and vegetables play an important role in

human diet, supplying some of nutrients, which are important source of mineral elements and vitamins. Family cruciferae provides some valuable vegetable and oil yielding crop like mustard, *Brassica campestris*, *Brassica napus*, *Brassica junsia*, raddish, *Ravenous sativus*, cabbage, *Brassica oleracea* var. *capitata* etc. particularly in all places. A large number of insect-pests as, cabbage butterfly, *Pieries brassicae* Linn., tobacco caterpillar, *Spodoptera litura* Fabr., Bihar hairy caterpillar, *Spilarctia obliqua* Walk., cabbage borer, *Hellula undalis* Fabr., mustard sawfly, *Athalia proxima* Klug., cabbage semilooper, *Trichoplusia ni* Hub. and cabbage leaf webber *Crocidolomia binotalis* Zell. Are limiting factors of crops (Bharti and Chandel, 1017) [16].

Therefore, the present investigation was aimed to understand the differential bioefficacy of the certain indigenous plant extract against polyphagous insect, Bihar hairy caterpillar, *Spilarctia obliqua* as this information will help to develop a sowed insect pest management programmed.

2. Materials and Method

2.1 Plant collection and Preparation of Powder: The plant materials of selected plants were collected in November 2008 from the cultivated field of farmers and wild areas in the vicinity of Kanpur region of Uttar Pradesh, India. The plant species was authenticated. and plant parts were dried under shade and then powdered using a mechanical grinder into a coarse powder. The selected plant materials were collected from the vicinity of Kanpur region during spring season. The identification of these collected leaves was confirmed by the plant taxonomist of Department of Botany D.B.S. College, affiliated to C.S.J.M. University, Kanpur.

2.2 Preparation of Extract and their Formulations: The powdered plant material was extracted with 80% methanol using Soxhlet extraction apparatus. The solvent was removed completely under reduced pressure and a semisolid mass was obtained. The extracts were stored in a vacuum desiccator for further use (Schmutterer, 1988) [17].

2.3 Rearing of Insect: Adult male and female of the Bihar hairy caterpillar *Diacrisia obliqua* (Walk.) were used for the present investigation. They were housed in a clean polypropylene cage and maintained under standard laboratory conditions (temperature 25±2 °C). They were fed natural diet. All experimental procedures described by Nagarkatii and Prakash, 1974 and Chandel and Sengar, 2017 [18, 19]

3. Experimental Protocol

Insecticidal test was carried out under laboratory condition against 3rd instars larvae of *Diacrisia obliqua***.** The mustard leaves were used as food for the larvae of *Diacrisia obliqua***.** Mustard leaves were treated with different concentrations (0.25, 0.5, 1.0, 1.5 and 2.0 percent) for two minutes. The treated leaves were left under electric fan for about half an hour, to make a dry film of the extracts on the leaves for each set of extract and one control. The treated foods were kept in jar (23cm x 10cm) on moist filter paper. The untreated leaves were dipped in Benzene +emulsified water only. Ten starved larvae of *Diacrisia obliqua* were released in each jar along with control. Three replicates per treatments were maintained. Number of larvae of *Diacrisia obliqua* died or moribund in all treatments and replications were recorded.

4. Statistical Analysis

The experimental results were expressed as mean ± standard error of mean (SEM). Statistical significance was analyzed by analysis of variance and P values of <0.001 were considered to be statistically significant (Abbott, 1926) [20].

Table 1: *In vitro* effect of the different extractives for their mean mortality against *D. obliqua* irrespective of concentration and periods

Treatment (Plant extracts)	Con. (%)	Mean Mortality Percent After					
		6hrs.		12hrs.		24hrs.	
		T_1	T.B.V.$_1$	T_2	T.B.V.$_2$	T_3	T.B.V.$_3$
Croton tiglium Linn.	0.5	0.5	37.14	36.5	53.07	63.9	67.84
Croton tiglium Linn.	1.0	43.07	46.6	59.00	73.5	72.78	91.2
Croton tiglium Linn.	2.0	48.93	56.8	61.92	77.8	72.78	91.2
Datura alba Linn	0.5	26.64	21.4	32.08	28.2	38.59	38.9
Datura alba Linn	0.1	32.20	28.4	37.35	36.8	37.75	54.1
Datura alba Linn	2.0	36.87	36.0	39.35	40.2	50.07	50.8
Ocimum santum Linn.	0.5	48.93	56.8	57.00	70.3	63.93	80.7
Ocimum santum Linn.	1.0	54.78	66.7	61.92	77.8	75.00	93.3
Ocimum santum Linn.	2.0	61.92	77.8	81.14	97.6	83.84	98.9
Spilanthes acmella Murr.	0.5	35.00	32.9	46.92	53.4	50.85	60.1
Spilanthes acmella Murr.	1.0	46.92	53.4	52.77	63.4	59.21	73.8
Spilanthes acmella Murr.	2.0	39.14	39,94	45.00	50.0	50.85	60.1
Thavetia nerfolia Linn.	0.5	0.5	39.14	39.9	45.00	50.0	50.85
Thavetia nerfolia Linn.	1.0	45.00	50.0	48.93	56.8	59.00	70.5
Thavetia nerfolia Linn.	2.0	48.93	56.8	44.78	66.7	72.29	90.8
Zingiber officinale Linn.	0.5	45.00	50.0	52.77	63.4	54.78	66.7
Zingiber officinale Linn.	1.0	52.77	63.4	64.07	64.9	61.92	77.8
Zingiber officinale Linn.	2.0	54.78	66.7	59.00	73.5	70.07	88.4
Control	0.00	0.00	00.0	0.00	00.0	21.14	7.04

(T_1, T_2, T_3 = Treatments and TBV.$_1$, TBV.$_2$, TBV.$_3$ = Transformed Back Values)

C.D. for the treatment combination means = 0.147

i) C.D. for control vs. treated = 5.0499

ii) C.D. for insecticide means = 4.3879

iii) C.D. for concentration means = 2.0973
iv) C.D. for period means = 2.0903
v) C.D. for insecticide and concentration means at the same period = 7.1368

The analysis of variance in table 1 shows that the main effect of insecticides, concentration, and periods as well as 'control versus treated' in first order and periods, concentrations in second order interactions are more highly significant except the first order interaction "Insecticides X concentrations" and the second order which is non-significant. The effect of "Control versus treatment" is also significant at 0.5% level of significance.

Table 2a: Mean mortality percentage of *Diacrisia obliqua* in case of different combination under laboratory conditions

Treatment (Plant extracts)	Con. (%)	Mean Mortality percent After					
		6 hrs.		12 hrs.		24 hrs.	
		T_1	T.B.V.$_1$	T_2	T.B.V.$_2$	T_3	T.B.V.$_3$
Croton tiglium Linn.	0.5	37.14	36.5	53.07	63.9	67.84	85.8
Datura alba Linn	0.5	26.64	21.4	32.08	28.2	38.59	38.9
Ocimum santum Linn.	0.5	48.93	56.8	57.00	70.3	63.93	80.7
Spilanthes acmella Murr.	0.5	35.00	32.9	46.92	53.4	50.85	60.1
Thavetia nerfolia Linn..	0.5	39.14	39.9	45.00	50.0	50.85	60.1
Zingiber officinale Linn.	0.5	45.00	50.0	52.77	63.4	54.78	66.7
Control	0.00	0.00	00.0	0.00	00.0	21.14	7.04

(T_1, T_2, T_3 = Treatments and TBV.$_1$, TBV.$_2$, TBV.$_3$= Transformed Back Values)

Table 2b: Mean mortality percentage of *Diacrisia obliqua* in case of different combination under laboratory conditions

Treatment (Plant extracts)	Con. (%)	Mean Mortality percent After					
		6hrs.		12hrs.		24hrs.	
		T_1	T.B.V.$_1$	T_2	T.B.V.$_2$	T_3	T.B.V.$_3$
Croton tiglium Linn.	1.0	43.07	46.6	59.00	73.5	72.78	91.2
Datura alba Linn	1.0	32.20	28.4	37.35	36.8	37.75	54.1
Ocimum santum Linn.	1.0	54.78	66.7	61.92	77.8	75.00	93.3
Spilanthes acmella Murr.	1.0	46.92	53.4	52.77	63.4	59.21	73.8
Thavetia nerfolia Linn..	1.0	45.00	50.0	48.93	56.8	59.00	70.5
Zingiber officinale Linn.	1.0	52.77	63.4	64.07	64.9	61.92	77.8
Control	0.00	0.00	00.0	0.00	00.0	21.14	7.04

(T_1, T_2, T_3 = Treatments and TBV.$_1$, TBV.$_2$, TBV.$_3$= Transformed Back Values)

Table 2c: Mean mortality percentage of *Diacrisia obliqua* in case of different combination under laboratory conditions

Treatment (Plant extracts)	Con. (%)	Mean Mortality percent After					
		6 hrs.		12 hrs.		24 hrs.	
		T_1	T.B.V.$_1$	T_2	T.B.V.$_2$	T_3	T.B.V.$_3$
Croton tiglium Linn.	2.0	48.93	56.8	61.92	77.8	72.78	91.2
Datura alba Linn	2.0	36.87	36.0	39.35	40.2	50.07	50.8
Ocimum santum Linn.	2.0	61.92	77.8	81.14	97.6	83.84	98.9
Spilanthes acmella Murr.	2.0	39.14	39,94	45.00	50.0	50.85	60.1
Thavetia nerfolia Linn..	2.0	48.93	56.8	44.78	66.7	72.29	90.8
Zingiber officinale Linn.	2.0	54.78	66.7	59.00	73.5	70.07	88.4
Control	0.00	0.00	00.0	0.00	00.0	21.14	7.04

(T_1, T_2, T_3 = Treatments and TBV.$_1$, TBV.$_2$, TBV.$_3$= Transformed Back Values)

Table 3: Mean mortality % of *D. obliqua* larvae in different periods irrespective of treatment

Treatments	6hrs	TBV-1	12 hrs	TBV-2	72 hrs	TBV-3	GT	TBV-G
C. tiglium	43.04	46.6	57.99	71.9	71.14	89.6	57.39	71.0
D. alba	32.08	28.2	36.27	35.0	4340	50.8	37.93	38.0
O. santum	55.21	67.5	66.68	84.5	74.00	92.5	65.31	82.5
S. acmella	44.89	49.8	52.23	62.5	57.99	71.9	51.70	61.6
T. nerfolia	44.89	48.9	49.97	58.6	60.38	75.6	51.56	61.4
Z. officinale	50.85	60.1	54.44	67.0	62.25	78.3	55.84	68.9
Control	0.00	0.00	00.0	0.00	21.14	7.04	7.04	1.5

(Figures in parenthesis represent mean percentage transformed back values.)
C.D. for period means at the same insecticide = 5.0497
C.D. for insecticide means at the same period = 5.1452

The table 3 and Figure 3, 3a and 3b reveals that the insecticide, *Ocimum santum* Linn leaves extract gave the best results when compared to other plant extracted insecticides. It killed 63.31 per cent of larvae followed by *Croton tiglium Linn. (*57.39 per cent), *Zingiber officinale* Linn. (55.84 per cent), *Spilanthus acmella* Murr. (51.70 percent), *Thavetia nerfolia* Linn. *(*51.56 per cent*)* and Datura *Alba Linn. (37.93* per cent), respectively. The insecticide *Ocimum sanctum* differs significantly from the remaining ones except *Croton tiglium* from which it does not differ significantly to one another. *Datura Alba proved least toxic giving only 37.73* percent mortality of *Dicricia obliqua* Walker larvae.

Table 4: Mean mortality % of D. *obliqua* in concentrations irrespective of periods under the laboratory condition

Treatments extractivess	Mean mortality percent after						Mean % Mortality	
	6 hrs.		12 hrs.		24 hrs.			
	T_1	TBV_1	T_2	TBV_2	T_3	TBV_3	G.T.	TBV
0.5	41.08	43.2	46.38	52.4	57.63	71.3	48.36	55.9
1.0	47.65	54.6	55.67	68.2	66.49	84.1	56.60	69.7
2.0	57.63	47.3	62.52	78.7	76.45	94.5	66.53	82.8
Control	0.00	0.00	00.0	0.00	21.14	7.04	7.04	1.5

(T_1, T_2, T_3 = Treatments and T.B.V.$_1$, T.B.V.$_2$, T.B.V.$_5$= Transformed Back Values)

Table 4 and figure indicate 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. It is observe that the difference in the percentage larvae of Dicricia *obliqua* kill in concentration 2.0 percent and 1.0 per cent is greater than the difference in concentration to kill the grub and adults in 1.0 per cent and 0.5 per cent in all the three periods. Similarly, the difference in percentage mortality of larvae of *Dicricia obliqua* Walker.

Table 5: Mean mortality % of D. *obliqua* in control irrespective of treatments.

Treatments extractivess	Mean mortality percent after						Mean % Mortality	
	6 hrs.		12 hrs.		24 hrs.			
	T_1	TBV_1	T_2	TBV_2	T_3	TBV_3	G.T.	TBV
Control	0.00	0.00	00.0	0.00	21.14	7.04	7.04	1.5
Extractives	16.18	7.8	18.83	10.4	21.82	13.8	18.95	10.5
Mean %	0.09	0.00	9.41	2.7	21.48	13.4	12.39	4.6

5. Result and Discussion

In the present study, administration of *Dicricia obliqua* larvae infested on mustard and vegetables can be controlled by selected biorational products. The leves extract of Ocimum *santum* (Linn.) gave the best results when compared to other plant extracted insecticides. It killed 63.31 per cent of larvae followed by *Croton tiglium* Linn. (57.39 per cent), and *Zingiber officinale* Linn. (55.84 per cent), respectively. The insecticide *Ocimum santum* Linn. differs significantly from the remaining ones except *Croton tiglium* from which it does not differ significantly to one another. It is evident from the table A that the highest mortality of *D. obliqua* was observed 65.61 per cent treated with *Ocimum sanctum* concentration followed by *Croton tiglium* and *Zingiber officinale* giving 57.39 per cent and 55.84 percent mortality, within 24hrs. of treatment. Mortality percentage in all plant extracts treatment data were found highly significant as compared to control. The significance difference was observed in *Alpinia galanga* and *Zingiber officinale* treatment as compared to remaining plant extracts but no difference was observed. The higher mortality 65.61 per cent was recorded against third instars larvae of *D. obliqua* in case of *Ocimum sanctum* followed by *Croton tiglium* (57.39 per cent) and *Zingiber officinalis* (55, 84 per cent) as compared to control.

In the support of our findings many workers reported time to time that some plants protected themselves against injurious insects by producing their own biochemical defenses that are insecticidal bivalents (Bharti and Chandel,2017, Chandel and Singh, 2017) [21, 22]. The consideration for the use of extracts of plants origin is that they are easily biodegradable, effective on some pests and considered safe in pest control operations as they minimize pesticide residues, ensure safety of the consumers of the treated grains and the environment (Thara and Kingsly, 2001, Gowri *et al.* 2002, Tomova *et al.* 2005))[23, 24, 25].. Further, the production of organic extracts of plant origin for pest control may be easier and less expensive than the synthesis of some complex chemical (Zygadlo *et al*.1990, Olfa *et al*. 2009)) [26, 27], They possess many of the attributes of an ideal biological control agent, including broad host range, high virulence, host seeking capability, ease of mass production, recycling ability, non- hazardous to environment, etc. (Mahla *et al*. 2002, Sumathi *et al.* 2002, Panickar *et al.* 2003 and Ebrahimi *et al*.2005)) [28, 29, 30, 31]. Mansour *et al.* (2014) screened the toxicity of chicory, *Cichorium intybus* L. (Asteraceae), against larvae and adults of the mosquito (*Anopheles pharoensis*) and the housefly management. [32].

It can be concluded from above results that rhizome extracts of *Ocimum sanctum and Zingiber officinale were* most effective and gave highest mortality of third instars larvae of *Ocimum sanctum,* among all the selected plant extracts tested in the laboratory. Though, all the plant products were significantly better than control as regards the mortality of *S. obliqua* on mustard leaves are concerned after 6hrs, 12hrs. And 24hrs. Of treatments under laboratory conditions.

6. Conclusion

Conclusively, our findings reveal that the plant extract of *Ocimum sanctum* gave the maximum mortality. It killed 65.61 per cent larvae of *Spilarctia obliqua* followed by *Croton tiglium* (57.39 per cent) and *Z. officinale* (55.84 per cent) and control, respectively. The plant extract of *Ocimum sanctum* differed significantly from remaining once except *Croton tiglium* and *Z. officinale* from which it does not differs significantly to one another. Finally, it can be concluded on the basis of mean mortality percentage of six selected plant extracts against *S. obliqua* Linn. *D. Alba* is proved the least effective compare than all other plant extract. No physical injury was noticed on any part of the plant after spraying. During the spraying of the extract it was noticed that extracts gave a strong irritating and unpleasant odor. Use of these selected plant extractives can be used for insect pest management.

7. Acknowledgement
The authors thank the Principal D.B.S. College, Kanpur and Head, Department of Zoology, D.B.S. College, Kanpur, India, for providing the necessary facilities to perform the present study.. Prof. R.A. Tripathi, farmer, Head, Division of Entomology, C S Azad University of Agriculture and Technology, Kanpur for rendering their support and help for the completion of this work and manuscript.

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