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Prospects of the Application of Garlic, *Allium sativum* (Lamiaceae) and *Annona reticulata* (Annonaceae), Extracts for Plant Protection against Bihar hairy caterpillar, *Spilarctia obliqua* Walk. (Lepidoptera: Arctiidae)

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Abstract

Protection of plants against herbivorous pests is an important aspect that guarantees agricultural efficiency, i.e., food provision to populations. Environmental, water and foodstuff pollution by toxic pesticides, along with climate changes, highlight the necessity to achieve intensive development of ecologically safe methods of insect-pest control. A laboratory experiment was conducted to evaluate the prospects of insecticidal bio efficacy in extracts of Garlic, *Allium sativum* (Lamiaceae) and sareefa, *Annona reticulata* (Annonaceae) against Bihar hairy caterpillar, *Spilarctia obliqua* Walk. (Lepidoptera: Arctiidae). Bualbs of Garlic, *Allium sativum* and unripe fruts of *Annona reticulate* were collected from Kanpur and extracted them through soxhlet apparatus using alcohol as solvent. From stock solution different concentrations (0.5, 1.0 and 2.0 per cent) are prepared and tested under ambient condition against 3rd intars caterpillar of Bihar hairy caterpillars, *Spilarctia obliqua* Linn. *A. sativum* Linn. Extract showed the highest toxicological compatibility followed by *C. domesticus* Vol. and *C. monophylla* Linn. Gave 64.16 per cent caterpillar mortality whereas in untreated control gave only 12.26% mortality to the larvae only and taken as unit.

Keywords: Garlic, custard apple, Bihar hairy caterpillars, mustard, insecticidal

1. Introduction

The tests insect Bihar hairy caterpillar, *Spilarctia obliqua* Walk. (Lepidoptera: Arctiidae) is a serious pests, causing enormous qualitative and quantitative losses to various Cruciferous crops and vegetables. The Bihar hairy caterpillar, *Spilarctia obliqua* (Walker) is considered as a dominant polyphagous pest of various crops including soybean, pulses, oilseeds, legumes etc. Agricultural crop about 40 per cent is lost every year due to herbivory attacks, diseases, weeds and grain infestation (Tapondjou *et al.*2002) [1].

Insect pests are known not only to decrease plant growth and development, causing crop death in extreme cases, but also to act as vectors of pathogens Abass *et al.* 2014 [2]. These facts result not only in great economic losses but also stimulate insecticide production, thus increasing the pollution of the environment, water and food products with toxic compounds (Kumar and Kalita 2017) [3]. At present, worldwide insecticide production reaches more than 3 million tons per year. Russian statistics reveal that, during 2016–2020, the production of these compounds increased by 1.8 times and reached 131 thousand tons (Singh and Singh, 2020) [4].

The insect activity is directly affected by abiotic factor like temperature as they are cold blooded organisms, a temperature increase will induce increased herbivory occurrence in agricultural crops in the near future, a phenomenon connected with the increase in reproduction, survival and geographical expansion (Hamann *et al.* 2021) [5]. These facts highlight the urgent necessity to revise the existing methods of pest control, abandon the utilization of chemical insecticides and develop new, safe and highly efficient methods of plant protection against herbivory (Skendžić *et al.* 2020) [6]. In this respect, the utilization of environmentally friendly pesticides, such as essential oils, plant extracts, special microelements demonstrating growth stimulation effects and inert powders, may become the main method of herbivory control (Skendžić *et al.* 2021) [7].

So that natural plant defence should be encouraged, in order to develop ecologically safe and highly efficient methods of crop protection against herbivorous insect-pests. Apart from these facts into consideration, we have chosen three topics to develop naturally occurring indigenous plant extract as herbal insecticides which was first described many years ago, whereas the utilization of their constituents should be considered as one of the latest extremely promising approaches to solving this problem, thus far, such ecofriendly and highly efficient supplements, which also show growth stimulation effects and the ability to protect plants against other biotic and abiotic stresses, may herald a new era of modern agriculture.

Therefore in the present paper as alternative of synthetic insecticides certain indigenous plant extracts applied as ecofriendly non-hazardous, cheap, easily available method for insect- pest management against Bihar hairy caterpillar, *Spilactia obliqua* Walk. (Lepidoptera: Arctiidae) under laboratory conditions.

2. Materials and Methods

2.1: 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.

2.2. Test Insects and Host Plant

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

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

2.3. 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 under side 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.

2.4 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/antifeeding/repellent/insecticide against the insects. Thirteen plant materials were used for their biological efficacy against Bihar hairy caterpillar, *Spilarctia obliqua* Walk.

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

A laboratory 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 and their details.

Scientific Name	Vernacular Name	Part Used	Faimly
Allium sativum Linn.	Garlic	Bulb	Lamiaceae
Annona reticulata Linn.	Custard apple	Unripe frute	Annonaceae

2.5 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.

2.6. The Insecticidal Formulations

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.

2.7. 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).

2.8. Preparation of Various 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:

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)
0.50	5.00	20.00	475.00	500.00
1.00	10.00	15.00	475.00	00.00
2.00	20.00	5.00	475.00	500.00

3. Experimental Protocol

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 (10 cm 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 peach 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 % of *S. obliqua* larvae against different botanicals

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. sativum Linn.	0.5	59.01	73.5	63.44	80.0	83.85	98.9
A. sativum Linn.	1.0	71.56	90.0	90.00	100.0	90.00	100.0
A. sativum Linn.	2.0	90.00	100.0	90.00	100.0	90.00	100.0
A. reticulata Linn.	0.5	43.08	46.6	46.92	53.4	50.77	60.0
A. reticulata Linn.	1.0	66.15	83.6	68.85	87.0	71.56	90.0
A. reticulata Linn.	2.0	83.85	98.9	90.00	100.0	90.00	100.0

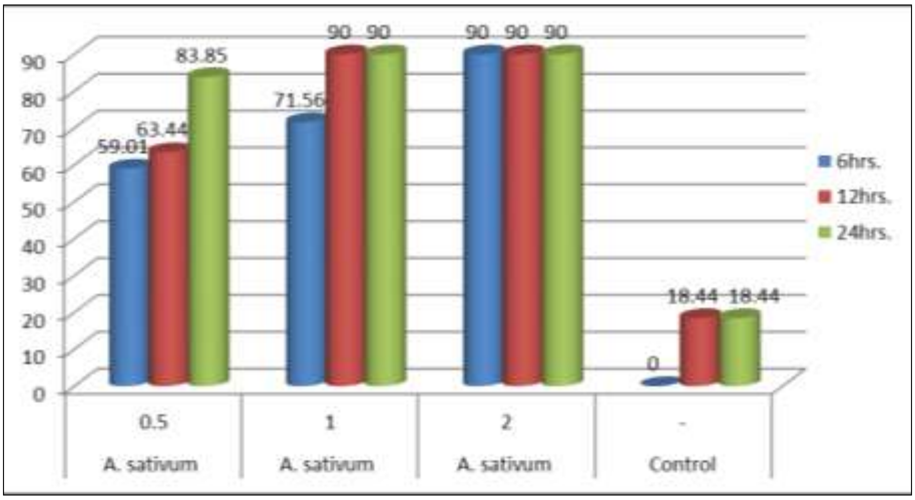

Fig 1: Mean mortality % of *S. obliqua* larvae on the exposure of different conc. *of* A. sativum

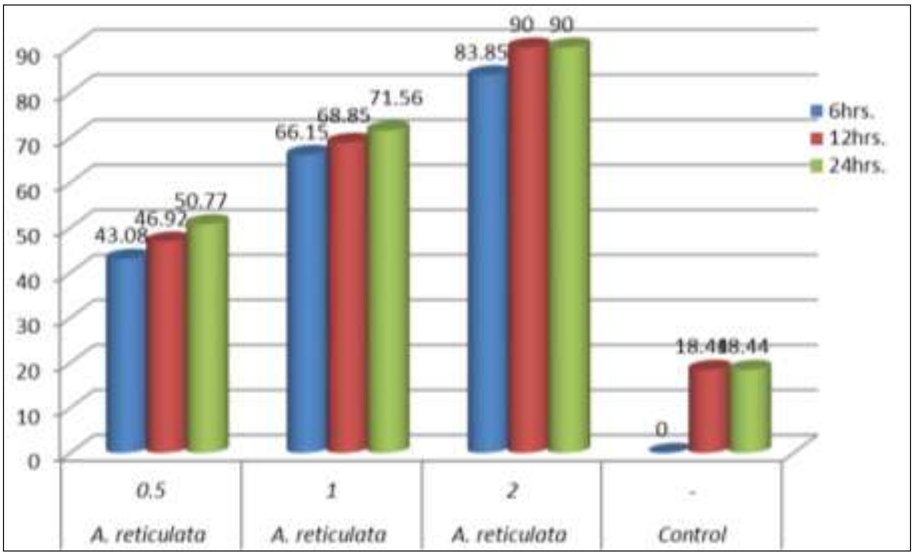

Fig 2: Mean mortality % of *S. obliqua* larvae on the exposure of different conc. *of A. reticulata* Linn

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

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. sativum Linn.	73.52	91.2	81.14	97.1	87.95	99.8	80.87	97.5
A. reticulate Linn.	64.35	81.3	68.59	86.7	70.77	89.2	67.90	85.9
Control	0.00	0.00	18.44	10.00	18.44	10.00	12.26	4.25

(Figure TBV 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

The table 4 reveals that the plant extract of *A. satuvum* gave the maximum mortality. It killed 80.87 per cent caterpillar of *S. obliqua* followed by *A. reticulate* Linn (67.90 per cent) in mean larval mortality after 24 hrs. In 6hrs of exposures it gave only 73.52percent larval mortality followed by 64.35 percent mortality whereas in 12 hrs of exposure periods it showed only 81.14 per cent followed by 68.59 per cent larval mortality, respectively. In control it gave 12.26 mean mortality after 24 hrs exposure period.

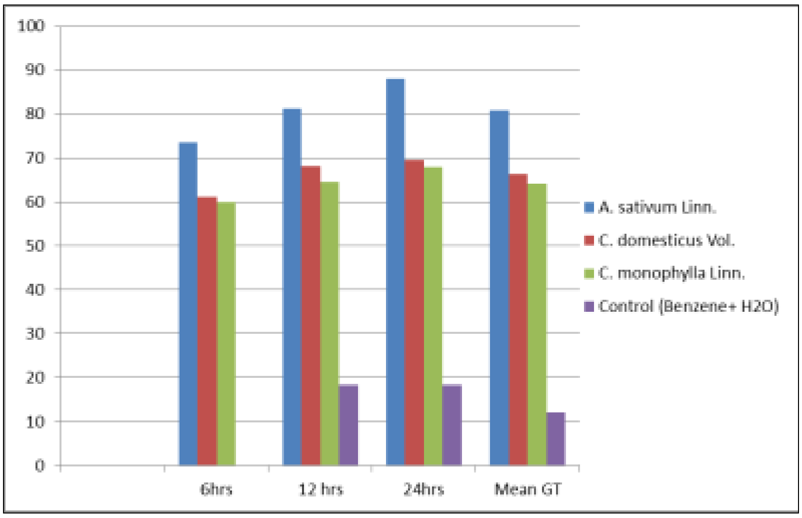

Fig 3: Mean mortality % of *S. obliqua* larvae in exposure periods and their TBV

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

Concentrations		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

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 caterpillar of *S. obliqua* (81.54 per cent)..

It is also observed that the difference in the percentage kill of caterpillars in concentration 2.0 per cent and 1.0 per cent is greater than the difference in concentration to kill the grubs in 1.0 per cent and 0.5 per cent in all the three periods. Similarly the difference in percentage mortality of the caterpillars in 48 hours and 12 hours is greater than the difference in percentage mortality in the period of 12 hours and 6 hours.

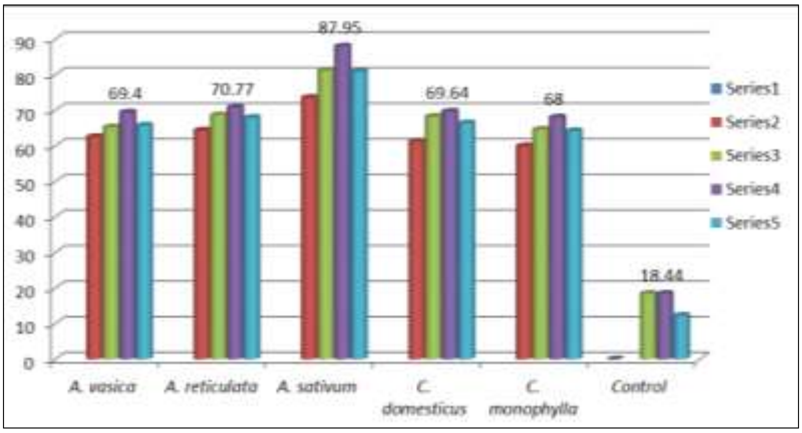

Fig 4: Mean mortality percentage of *Spilosoma obliqua* larvae in different concentration irrespective of treatments under In-vitro.

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

Treatments	Lab.	mean	mortality	%	after		Mean	Mor-
	6	Hrs.	12	Hrs.	24	Hrs.	tality	(%)
	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

The table 6 reveals that the plant extract of *A. satuvum* gave the maximum mortality. It killed 80.87 per cent caterpillar of *S. obliqua* followed by *A. reticulata* Linn (67.90 per cent) in mean larval mortality after 24 hrs. In 6hrs of exposures it gave only 73.52percent larval mortality followed by 64.35 percent mortality whereas in 12 hrs of exposure periods it showed only 81.14 per cent followed by 68.59 per cent larval mortality, respectively. In control it gave 12.26 mean mortality after 24 hrs exposure period.

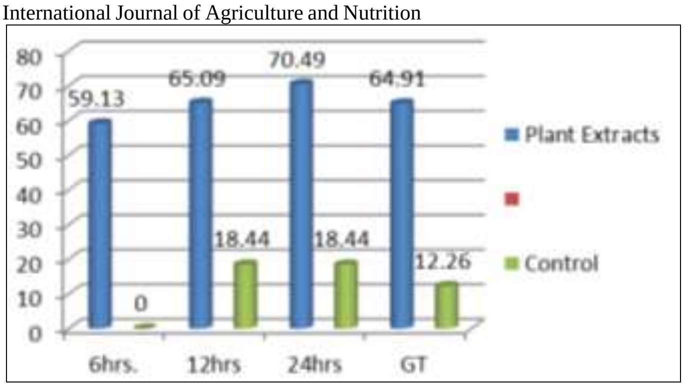

Fig 5: Mean mortality percentage of *Spilosoma obliqua* larvae in control irrespective of treatments under laboratory trials

In the conformity of above findings Park, *et al.* 2006 [7] conducted an experiment for insecticidal bioefficacy of three plant oils against *Lycoriella ingenua* (Diptera: *Sciaridae.* Among them, garlic (*Allium sativum*) oils exhibited potent fumigant activity to the test insect (Denloy, 2010) [8]. A numerous entomologist like Prowse *et al.* 2006, Hincapie *et al.* 2008, Douri *et al.* 2013 extract on their test insect pest and reported successful results [9, 10, 11].

The toxicicological bioefficacy of acute toxicity of essential oil of garlic (*Allium sativum*) against overwintering *Cacopsylla chinensis* and the maize weevil, *Sitophilus zeamais* (Motsch.) gave maximum protection to seeds (Zhao *et al.* 2013, Nwachukwu *et al.* 2014 and Alfthan, *et al.* 2015) [12, 13, 14].

Recently, Baidoo, and Mochiah,2016, Chaubey 2016, Rinaldii *et al*.2016, Stankovic *et al*.2016 and Hardiansyah *et al.*2020 described the practical auspect of naturally occurring botanicals like contact toxicity of *Allium stivum* against a number of insect pest of crop, stored grains and vegetables and recommended for pest management [15, 16, 17, 18, 19].

Similarly, González-Macedo *et al.* 2020 assessed the traditional applications of garlic (*Allium sativum*) and nettle (*Urtica dioica*) as botanical insecticides in the protection of mesquite (*Prosopis laevigata*) seeds against bruchins [20].

7. Conclusions

Global economic crisis and climate changes indicate the need for urgent decisions aimed to ecological equilibrium restoration, the utilization of highly efficient and safe methods of both mustard plant protection against *Spilosoma obliqua* Linn, without any harmful effect either on human health or on the environment, and plant growth stimulation. The present paper deals the management of Bihar hairy caterpillar, *Spilosoma obliqua* Linn on mustard agroecosystem and their practical application will promote sustainable agricultural development. Further investigations should be done to evaluate the pin point which are responsible for ecofrindly management of this insect-pest. However, the broad possibilities of garlic and custard apple extracts' application, both for plant protection against pests and growth stimulation, suggest the necessity for the commercial production of appropriate supplements to successfully convert the mentioned innovative approaches into agricultural practice.

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