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Bioactivity of some plant extracts against larvae of *Spodoptera litura* (Fab.) and *Athalia proxima lugens* (Klug.) under laboratory conditions

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Abstract
The crude aqueous extracts from the leaves of five plants *viz*., *Ageratum conyzoides* L., *Parthenium hysterophorus* L., *Lantana camera* L., *Solanum nigrum* L. and *Cannabis sativa* L. were tested for their insecticidal property against larvae of *Spodoptera litura* (F.) and *Athalia proxima lugens* (Klug.). The results revealed that the highest mortality (93.33%) of *Spodoptera litura* was obtained in 5 per cent concentration and at 96 hours exposure in the treatments of *Cannabis sativa* and *Solanum nigrum*. The larvae of *Athalia proxima lugens* was found somewhat susceptible compared to the larvae of *Spodoptera litura* and highest mortality of 93.33% was obtained in 5 per cent concentration and at 72 hours exposure in the treatments of *ageratum conyzoides* and *Solanum nigrum*. The mortality was directly related to concentration and exposure period. These five plants can be used as botanical insecticide to manage the insect problems.

Keywords: *Spodoptera litura*, *Athalia proxima lugens*, plant extracts, botanicals, bioassay

1. Introduction
Defoliating insects cause damage to the plants by eating leaves and reduce photosynthetic area results in poor growth and maintenance [1]. Defoliation also results in increased susceptibility of plants for other insects and pathogens, reduces growth and may cause plant death under severe infestation. They can cause significant damage to plant by chewing the leaves [2]. The tobacco caterpillar, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae), is a cosmopolitan insect and distributed throughout Asia, Australia and pacific islands [3]. It is an important polyphagous pest infesting about 40 species of plants in India and causing heavy yield loss [4]. It is a major pest on cotton, tobacco, groundnut, chilly, jute, castor, maize, cabbage, cauliflower, potato, lucerne and pulses [5, 6]. It may cause an economic loss ranged from 25.8 - 100% [7]. Synthetic insecticides are important and effective tools to reduce losses but it has been reported that this pest has developed resistance against almost all insecticide groups [8] resulting in failure of effective controls and hence, it is difficult to manage this pest with synthetic insecticides. To overcome this pest problem, large quantities of insecticides have been used on crops which exert adverse effect on environment and people.
Another important defoliator is mustard sawfly, *Athalia proxima lugens*. In India, it is a severe pest on cruciferous plants including rapeseed-mustard, cabbage, cauliflower, knol-khol, radish, turnip *etc*. [9] causing severe defoliation (65-80%) [10].
Because of cumulative problems generated by the usage of insecticides, more emphasis is being laid on botanical control of pests. Plants are rich sources of natural substances and have great potential to be formulated as botanical pesticides that can be utilized in the development of environmentally safe alternative methods for insect control in the place of synthetic insecticides [11]. Plants contain secondary metabolites that are deleterious to insect and other herbivores in diverse ways; through acute toxicity, enzyme inhibition and interference with the consumption and/or utilization of food [11]. In India, several plant products have been screened and tested against these pests [12, 13, 14, 15]. However, screening of plant extracts is still continuing throughout the world to find out different kinds of effects of botanicals and to obtain an eco-friendly biopesticide. Therefore, the present study focuses on the insecticidal activity of some plant extracts against *Spodoptera litura* (Fab.) and *Athalia proxima lugens* (Klug.).

2. Material and Methods

The present study was conducted in Department of Entomology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar during September, 2016 for *Spodoptera litura* and December, 2016 for *Athalia proxima lugens*.

2.1 Collection of plant material

Different plant species from different families were collected from different locations in Pantnagar region to study their bioactivity against the larvae of *Spodoptera litura* (Fab.) and *Athalia proxima lugens* (Klug.).

Table 1: Details of plant species evaluated

S.NO	Common name, Vernacular name (V)	Botanical name (Order: Family)	Plant part used
1	Goat weed, Mahku	*Ageratum conyzoides* L. (Asterales: Asteraceae)	Leaves
2	Wild carrot weed	*Parthenium hysterophorus* L. (Asterales: Asteraceae)	Leaves
3	Lantana	*Lantana camera* L. (Verbenales: Verbenaceae)	Leaves
4	Solanum Makoi	*Solanum nigrum* Linn. (solanales: solanaceae)	Leaves
5	Bhang	*Cannabis sativa* Linn. (Rosales: Cannabaceae)	Leaves

2.2 Preparation of plant extracts

For the preparation of plant extracts, leaves of the different plants were collected from nearby areas. The plant leaves were washed to remove the dust and placed on blotting paper for overnight to remove the excess water content. About 250 gm of plant leaves were added in the 500 ml of water and allowed to boil up to half of the original volume, and then it was cooled. The material was filtered through muslin cloth and filled in the glass bottle and stored in the cool and dry place. For conducting experiment, different concentrations (1%, 3% and 5%) were prepared by adding water.

2.3 Bioassay

To conduct bioassay, third instar larvae of *Spodoptera litura* and *Athalia proxima lugens* were used and fed them with the treated leaves of castor and mustard, respectively. Ten larvae per extract were used and experiment was carried out in three replications. Leaves were first washed with distilled water and dried for about one hour, then dipped in the test solution of various extracts for about 10 seconds. One leaf was kept in one petri plate and larvae were released in each petri plate. Leaves treated with distilled water served as control. Mortality was recorded after 24, 48, 72 and 96 hours of release and moribund insects were counted as dead.

2.4 Statistical analysis

The data were subjected to one-way analysis of variance (ANOVA) using completely randomized design (CRD) programme. The data on per cent mortality were transformed to angular transformation.

3. Results

Highest per cent larval mortality of *Spodoptera litura* was obtained in 5 per cent concentration and at exposure of 96 hours (Table 2). The mortality was found to be increased with an increase in concentration and exposure period. In case of 1% solution, at 24 hours exposure, *Solanum nigrum* gave the highest per cent mortality (53.33%) while minimum per cent mortality was 26.67% in *parthenium hysterophorus* and *Lantana camera*. The mortality was found to be increased continuously up to 96 hours and reached at 86.67% in *Cannabis sativa*. In case of 3% solution, the per cent mortality was found to be increased as compared to 1% solution. The same trend of mortality from short exposure to long exposure was obtained and maximum per cent mortality of 86.67% was recorded at 96 hours in the treatment of *Solanum nigrum*. In case of 5% solution, the per cent mortality was again increased and same trend of mortality was found in different exposure periods. At 96 hours exposure, up to 93.33% mortality was obtained in *Cannabis sativa* and *Solanum nigrum*.

In case of *Athali aproxima lugens*, the larvae were more susceptible, so that the data at 96 hours exposure are not given in Table 3 because of 100 per cent mortality in all the three concentrations. Similar to Spodoptera litura, per cent larval mortality of *Athali aproxima lugens* was found to be increased with an increase in concentration and exposure period *i.e*. highest mortality was obtained in 5 per cent concentration and at exposure of 72 hours. In case of 1% solution, at 72 hours exposure, up to 86.67% mortality was reached in the treatments of *ageratum conyzoides*, *Lantana camera* and *Solanum nigrum*. It was again increased in 3% solution and reached up to 93.33% at 72 hours exposure in the treatment of *Solanum nigrum*. In 5% solution, highest mortality of 93.33% was obtained at 72 hours exposure in the treatments of *ageratum conyzoides* and *Solanum nigrum*.

Table 2: Effect of plant extracts on the larval mortality of *Spodoptera litura* (Fab.)

Plant name	Per cent larval mortality of *Spodoptera litura*											
	1%				3%				5%			
	24 hrs	48 hrs	72 hrs	96 hrs	24 hrs	48 hrs	72 hrs	96 hrs	24 hrs	48 hrs	72 hrs	96 hrs
parthenium hysterophorus	26.67 (30.78)*	46.67 (43.07)	60.00 (51.14)	73.33 (59.21)	53.33 (46.92)	60.00 (50.76)	73.33 (59.21)	73.33 (59.21)	53.33 (46.92)	66.67 (59.99)	80.00 (73.07)	80.00 (68.06)
Cannabis sativa	26.67 (30.78)	60.00 (51.14)	73.33 (59.21)	86.67 (72.28)	53.33 (46.92)	60.00 (51.14)	76.67 (65.85)	83.33 (66.14)	60.00 (51.14)	73.33 (59.21)	86.67 (72.28)	93.33 (81.14)
ageratum conyzoides	46.67 (43.07)	60.00 (51.14)	66.67 (54.99)	80.00 (68.06)	60.00 (51.14)	66.67 (54.99)	63.33 (52.77)	83.33 (66.14)	66.67 (54.99)	80.00 (68.06)	80.00 (68.06)	86.67 (72.28)
Lantana camera	26.67 (30.78)	46.67 (43.07)	60.00 (51.14)	73.33 (59.21)	46.67 (43.07)	66.67 (54.99)	73.33 (59.21)	73.33 (59.21)	60.00 (51.14)	73.33 (59.21)	73.33 (59.21)	86.67 (72.28)
Solanum nigrum	53.33 (46.92)	66.67 (55.36)	60.00 (50.93)	80.00 (63.43)	53.33 (46.92)	66.67 (54.99)	80.00 (63.43)	86.67 (72.28)	60.00 (51.14)	73.33 (64.22)	86.67 (76.92)	93.33 (81.14)
control	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.0)	00.00 (00.0)	00.00 (00.0)	00.00 (00.0)	00.00 (00.0)	00.00 (00.0)
Sem	6.67	10.32	9.54	7.30	10.74	7.30	6.99	5.57	9.88	12.99	12.64	7.88

	(4.07)	(6.20)	(5.78)	(7.03)	(6.48)	(4.52)	(6.13)	(5.07)	(5.98)	(11.13)	(11.72)	(9.45)
Cd at 5%	21.00 (12.83)	32.53 (19.53)	30.06 (18.23)	23.00 (22.17)	33.86 (20.42)	23.00 (14.25)	22.02 (19.34)	17.57 (15.98)	31.14 (18.85)	40.93 (35.08)	39.84 (36.93)	24.84 (29.79)
cv	32.07 (19.35)	31.94 (22.03)	25.83 (18.74)	16.07 (18.91)	34.91 (23.89)	19.76 (14.68)	16.51 (17.69)	12.07 (13.60)	28.54 (20.30)	30.69 (31.04)	26.93 (29.04)	15.52 (21.84)
F value	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

*Figures in parenthesis are angular transformation

Table 3: Effect of plant extracts on the larval mortality of *Athali aproxima lugens* (Klug.)

Plant name	Per cent larval mortality of *Athalia proxima lugens*								
	1%			3%			5%		
	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
parthenium hysterophorus	40.00 (38.85)*	53.33 (46.92)	66.67 (54.99)	40.00 (39.23)	66.67 (54.99)	80.00 (63.43)	53.33 (46.92)	73.33 (59.21)	86.67 (72.28)
Cannabis sativa	26.67 (30.78)	53.33 (47.29)	73.33 (59.21)	33.33 (29.99)	60.00 (51.14)	73.33 (59.21)	46.67 (43.07)	66.67 (54.99)	80.00 (68.06)
ageratum conyzoides	13.33 (13.07)	60.00 (51.14)	86.67 (72.28)	13.33 (13.07)	60.00 (50.76)	86.67 (72.28)	26.67 (30.78)	73.33 (63.84)	93.33 (81.14)
Lantana camera	26.67 (26.15)	66.67 (54.99)	86.67 (72.28)	40.00 (39.23)	73.33 (59.21)	86.67 (72.28)	40.00 (38.85)	86.67 (72.28)	86.67 (72.28)
Solanum nigrum	26.67 (26.15)	53.33 (46.92)	86.67 (72.28)	40.00 (34.22)	66.67 (54.99)	93.33 (81.14)	66.67 (55.36)	80.00 (68.06)	93.33 (81.14)
control	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
Sem	11.92 (10.76)	9.42 (5.68)	6.67 (7.36)	14.29 (12.23)	7.30 (4.52)	5.96 (7.11)	11.92 (7.25)	9.42 (9.15)	7.88 (9.45)
Cd at 5%	37.56 (33.91)	29.69 (17.89)	21.00 (23.18)	45.04 (38.54)	23.00 (14.25)	18.78 (22.41)	37.56 (22.86)	29.69 (28.82)	24.84 (29.79)
cv	77.45 (69.06)	28.48 (19.89)	14.43 (19.25)	74.29 (68.03)	19.36 (14.45)	12.29 (17.68)	44.26 (29.24)	21.48 (24.88)	15.52 (21.84)
F value	ns	ns	ns	ns	ns	ns	ns	ns	ns

*Figures in parenthesis are angular transformation

4. Discussion

Plant-based products have potential to develop as organic pesticides that are effective against insects for protecting crops, inexpensive, safer and more environmentally friendly [16]. They possess a number of advantages like rapid degradation, no persistence and bioaccumulation in the environment. Plant derived insecticides are compatible with IPM, biological control and also with some conventional pesticides. They exert less effect on beneficial insects comparative to conventional insecticides, because of their capacities of biodegradable nature and innate low mammal toxicity [17]. Many plant extracts have been tested for their antifeedant, repellent and toxic effects against insect pests of field crops, storage and mites [18, 19, 20].

Ageratum conyzoides shows antifeedant, repellent and toxic activity against lepidopteran insects [21]. It interferes in the synthesis of juvenile hormone (JH) and causes maximum of biological and morphogenesis effects results in deformation in larval and pre-pupation stages of *Spodoptera litura* [22]. At concentration of 20% it can cause 100% mortality in *Spodoptera litura* with the period of mortality 26-60 minutes [23]. *A. conyzoides* reduces total head protein of *Spodoptera litura* and can be used in pest control programme as botanical insecticide [24]. It is also very effective against coleopteran insects and can cause 100 per cent larval mortality in brinjal hadda beetle, *Epilachna 28 punctata* (Fabr.) at 1.0% solution [25].

Parthenium hysterophorus contains several important chemical constituents mainly histamine, saponin, glucosides and triterpene (sesquiterpene) and can be of use for the purpose of biocontrol of various pathogens [26]. It possesses antifeedant, larvicidal and growth inhibiting activity against *Spodoptera* spp. [27]. However, [28] reported that it is moderately antifeedant against sixth-instar larvae of *Spodoptera litura*.

Lantana camera shows antifeedant, oviposition deterrent, developmental and morphogenetic variations, toxic effects and ovicidal activity against larvae of *Spodoptera litura* [29, 12, 13, 30, 31]. It is also effective against stored grain pest of Lepidoptera [32]. However, it had antagonistic effect when used in combination with Btk [33]. [34] tested eight plant species including *Lantana camera* L., *Cannabis sativa* Linn. and *Solanum nigrum* Linn. that show larvicidal activity against *Spodoptera litura* (Fab.) and *Pieris brassicae* (Linn.).

5. Conclusion

From the present study it can be concluded that all the five plants can be used as biopesticide and further studies are necessary to recognize the active compounds present in the plant extracts for developing plant - based biopesticide which is safer to human beings and beneficial organisms and has minimum risk to environment.

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