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Bioefficacy of *Caesalpinia bonducella* extracts against tobacco cutworm, *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae)

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ABSTRACT

Objective: To evaluate the antifeedant, oviposition deterrent, ovicidal and larvicidal activities of benzene, dichloromethane, diethylether, ethyl acetate and methanol extracts of Indian medicinal plant, *Caesalpinia bonducella* (*C. bonducella*) at different concentrations against Lepidopteran agricultural field pest *Helicoverpa armigera* (Lepidoptera: Noctuidae).

Methods: Antifeedant activities of the selected plant extract were studied using leaf disc no-choice method and oviposition deterrent, ovicidal and larvicidal activities were also assessed by adapting the standard protocols.

Results: The antifeedant activity of *C. bonducella* showed significant antifeedant activity in methanol extract. Oviposition deterrency is higher in methanol extract than the other solvent extracts. Similarly, maximum egg mortality was observed in methanol leaf extract of *C. bonducella* Lethal concentration, LC_{50} value of benzene, diethylether, dichloromethane, ethyl acetate and methanol extract of *C. bonducella* were 470.02, 469.00, 465.47, 460.52 and 443.87 mg/L respectively. The *Chi*-square values are significant at $P< 0.05$ level. Among five solvent extracts, the methanol extract was responsible for strong lethal activity observed against selected pest species.

Conclusions: Results of this study show that the selected Indian medicinal plant *C. bonducella* could be a potent source of natural antifeedant, oviposition deterrent, ovicidal and larvicidal agent against the field pest *Helicoverpa armigera*.

1. Introduction

The development of integrated pest control programs in controlling the economically important pest, *Helicoverpa armigera* (Hub) (*H. armigera*) has gained increased attention in many parts of the world. *H. armigera* is highly polyphagous pest, infest more than 500 plant species and is a serious pest in India. The greatest damage is caused to cotton, tomatoes, maize, chick peas, alfalfa and tobacco, *etc*. The economic threshold of harmfulness in central Asia is three to five larvae per hundred plants of long-staple cotton and eight to twelve larvae per hundred plants on medium-staple cotton. In cotton crops, blooms that have been attacked may open prematurely and stay fruitless. When the bolls are damaged, some will fall off and others will fail to produce lint or produce lint of an inferior quality. Secondary infections by fungi and bacteria are common and may lead to rotting of fruits. Injury to the growing tips of plants may disturb their development, and maturity may be delayed and the fruits may be dropped. This pest is reflected in the wide taxonomic range of wild and cultivated plants acceptable for oviposition by adults and feeding by larvae. This notorious pest initially feeds on

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vegetative parts and subsequently on immature pods and ultimately causes severe loss of production. However, many chemicals available for treatment of insect pest are also toxic to natural enemies and gradually the pest will develop resistance to it[1–9].

Nowadays, synthetic insecticides have been widely used for controlling this pest on different crops, but undesirable side effects of synthetic insecticides, including development of resistance, have necessitated a shift to more eco-friendly approaches for controlling this pest. In recent years, the use of synthetic organic insecticides in crop insect pest management programmes around the world has resulted in damage to the environment, pest resurgence, pest resistance to insecticides and lethal effects on non-target organisms. Due to these impacts of chemical insecticides prompted search for alternate techniques for insect pest management arises[10,11]. One possible way to reduce the high consumption of synthetic insecticides is through the application of botanical insecticides, generally considered to be environmentally and medically safe[12]. Plant derivatives are highly toxic to many insect species and more than 2 000 plant species are known to possess some insecticidal properties[13]. Biopesticides provide an alternative to synthetic pesticides because of their generally low environmental pollution, low toxicity to humans and other advantages. Essential oils and their constituents have been reported to be an effective source of botanical pesticides[14–16]. The growing awareness of the hazards of excessive use of pesticides globally has led researchers to search for safer and more environment friendly alternative methods for insect pest control. Therefore, extensive studies are carried out to screen plants as insect growth control agents.

Over the last two to three decades, greater attention has been focused on the bioactivity of phytochemical for their potential as pesticides against phytophagous insects[17]. Research on natural products that could be alternatives to synthetic pesticides and fungicides, for example, plant extracts and essential oils, has greatly increased during recent years[18]. The neonate larvae initially attacking the foliage of the plants and the later stage feed on developing seeds in the pod. This pest is considered as the serious pests of various economically important crops such as, cotton, groundnut, chilly, tobacco, castor and tomato as well as some legumes, tea, *etc.*, and also they have developed resistance in almost all commercially available chemical pesticides. *Caesalpinia bonducella* (*C. bonducella*) has been used as a medicinal plant since antiquity. In siddha medicine it is considered as a tonic and analgesic and is believed to help heal broken bones. It is said to have antibacterial, antifungal, antioxidant, anthelmintic, antihemorrhoidal and analgesic activities. It has been found to contain a rich source of carotenoids, triterpenoids and ascorbic acid. Several species are used in African or Indian herbal medicine. Furthermore, literatures pertaining to the control of this pest using phytopesticides are scanty. Hence, in the present study the bioefficacy of *C. bonducella* were evaluated against *H. armigera* for its antifeedant activity, oviposition deterrent activity, ovicidal activity and larvicidal activity.

2. Materials and methods

2.1. Plant material

The selected plants leaves was collected from in and around Yercaud hill station (11.77940° N 78.20340° E) Salem Districts of the Tamilnadu India. The leaves were collected from the August 2013 to September 2013 and brought to the laboratory where they were washed thoroughly with tap water and kept in sunlight for 45 min for the complete evaporation of water and then shade dried on blotting paper spread at room temperature (28 ± 2) ˚C. The dried plant were ground to fine powder. At the time of collection, two pressed voucher herbarium specimens were prepared and identified with the help of plant taxonomist, Department of Botany, Govt. Arts College, Nandanam, Chennai, flowering or fruiting specimens were collected to facilitate taxonomic identification.

2.2. Extraction method

The dried leaves (100 g) were powdered mechanically using commercial electrical stainless steel blender and extracted sequentially with benzene, chloroform, hexane and methanol in a Soxhlet apparatus separately until exhaustion. The extract was concentrated under reduced pressure of 22-26 mmHg at 45 ˚C by Rotavapour and the residue obtained was stored at 4 ˚C in an amber vial. Then the vials were named and covered with silver foil and transported to the laboratory. Those vials were kept in cool and dark place at 4 ˚C until use.

2.3. Rearing of test organism

Tobacco cutworm, *H. armigera* (Hub) (Noctuidae: Lepidoptera) collected from nearby fields formed the initial source for continuous, disease free culture. The insect culture was maintained on cotton leaves and maintained in the laboratory. *H. armigera* were cultured in plastic vials individually to avoid cannibalistic activity and leaves under standard conditions of temperature (27 ± 2) ˚C and relative humidity (70 ± 5)% throughout the period of study. An insect culture was continuously refreshed with wild moths

captures by a light trap in the vicinity of the agricultural farm of Koothur Village, Sirkali Taluk, Nagapattinam District. Generally, hale, healthy and uniform sized fourth instar larvae, eggs and newly emerged adult moths of cultured species were used for the experiments.

2.4. Antifeedant assay

Antifeedant activities of the selected plants extract were studied using leaf disc no-choice method as described by Isman *et al.* with slight modifications[19]. Selected plant extracts prepared different concentrations *viz.*, 100-500 mg/L were treated individually on the fresh leaf discs. One treatment with acetone alone was used as positive control and one treatment without solvent was considered as negative control (0 mg/L). In each Petri discs (1.5 cm × 9 cm) wet filler paper was placed to avoid early drying of the leaf disc, single fourth instar larva of *H. armigera* was introduced individually. Five replicates were maintained for each concentration and the progressive consumption of leaf area by the larvae after 24 h was recorded in control and treated discs using leaf area.

2.5. Oviposition deterrent activity

For oviposition deterrent activity 100-500 mg/L concentration of individual extract was sprayed on respective fresh host plant and similar controls as mentioned above were also used here. The petioles of the treated leaves were inserted into a conical flask (cotton plugged) containing dechlorinated water to avoid early drying and placed inside the cage (60 cm × 45 cm × 45 cm). Ten pairs of (adult moths) *H. armigera* were introduced in individual cage. Then 10% (w/v) sucrose solution with multivitamin drops was provided for adult feeding to increasing fecundity, five replicates were maintained for control and treatments. After 48 h, the numbers of eggs (*H. armigera*) laid on treated and control leaves were recorded and the percentage of oviposition deterrence was calculated[20].

2.6. Ovicidal activity

For ovicidal activity, the eggs of *H. armigera* were carefully removed using fine camel brush. A total of 500 eggs from three selected lepidopteran was separated into five lots each having 100 eggs and dipped in 100-500 mg/L concentrations of plant different solvent extracts. Number of eggs hatched in control and treatments were recorded and the percentage of ovicidal activity was calculated using Abbott's formula[21]. For each experiment, five replicates and the hatch rate was assessed 120 h post treatment.

2.7. Larvicidal assay

For the evaluation of larvicidal activity, the selected plant extracts tested is based on the wide range and narrow range tests. It was tested at 100-500 mg/L and they were tested against the freshly moulted (0-6 h) fourth instar larvae of important agricultural field pest *H. armigera*. Petioles of the leaves were tied with wet cotton plug to avoid early drying and placed in plastic trough (29 cm × 8 cm) 20 pre-starved fourth instar larvae of test organisms were introduced individually and covered with muslin cloth. Five replicates were maintained and the number of larvae dead after 24 h was recorded and the percentage of larval mortality was calculated using Abbott's formula[21]. All moribund pest larvae were considered as dead.

2.8. Determination of lethal concentrations

Lethal concentration (LC_{50} and LC_{90}) represents the concentration of the test material that caused 50% mortality of the test (target and non-target) organisms within the specified period of exposure, and it was determined by exposing various developmental stages of the mosquitoes to different concentrations of the extract. Based on the mortality of the test organisms recorded in these bioassays, LC_{50} and $LC_{90}$was calculated along with their fiducial limits at 95% confidence level by probit analysis using SPSS software package 12.0 (Statistical Package of Social Sciences) software. Results with $P < 0.05$ were considered to be statistically significant.

3. Results

3.1. Feeding deterrent activity of different solvent extracts of *C. bonducella*

Methanol extract of *C. bonducella* showed (19.67 ± 1.93)% feeding deterrency against the fourth instar larvae of *H. armigera* at 100 mg/L concentration, whereas, (29.37 ± 1.53)% and (78.52 ± 2.86)% of antifeedant activity were recorded in methanol extract of *C. bonducella* at 200 and 300 mg/L respectively. Similarly, at higher concentrations such as 400 and 500 mg/L (86.87 ± 2.82)% and (96.73 ± 2.36)% antifeedant activity were recorded respectively (Table 1). In general, the antifeedant activity is directly proportional to the increase in the concentration and also among the various extracts tested, methanol extract was found to have significant activity than the other solvent extracts.

Table 1
Antifeedant activity of *C. bonducella* extracts against the 4th instar larvae of *H. armigera* at different concentration.

Solvent tested	Antifeedant activity %				
	100 mg/L	200 mg/L	300 mg/L	400 mg/L	500 mg/L
Benzene	8.39 ± 1.23^{b}	15.54 ± 1.17^{b}	65.74 ± 2.37^{b}	75.75 ± 2.42^{b}	84.24 ± 2.26^{b}
Diechloromethane	13.23 ± 1.24^{d}	24.82 ± 1.36^{d}	72.79 ± 1.66^{d}	80.39 ± 2.37^{d}	91.23 ± 2.44^{d}
Diethylether	10.45 ± 1.68^{c}	18.85 ± 1.64^{c}	67.84 ± 2.39^{c}	77.27 ± 2.29^{c}	88.44 ± 2.27^{c}
Ethyl acetate	15.79 ± 1.86^{e}	27.68 ± 1.28^{e}	75.38 ± 2.14^{e}	83.38 ± 2.43^{e}	93.52 ± 2.53^{e}
Methanol	19.67 ± 1.93^{f}	29.37 ± 1.53^{f}	78.52 ± 2.86^{f}	86.87 ± 2.82^{f}	96.73 ± 2.36^{f}
Control	1.78 ± 0.35^{a}	1.78 ± 0.35^{a}	1.78 ± 0.35^{a}	1.78 ± 0.35^{a}	1.78 ± 0.35^{a}

Values represent mean ± SD of five replications. Different alphabets in the column are statistically significant at $P < 0.05$. (MANOVA; LSD -Tukey's test). Control groups were fed with tender host leaf disc with no phytochemicals.

3.2. Oviposition deterrent activity of different solvent extracts of C. bonducella

Methanol extract of *C. bonducella* showed (22.85 ± 1.62)% oviposition deterrency against the gravid moths of *H. armigera* at 100 mg/L concentration, whereas, (35.92 ± 1.53)% and (79.84 ± 2.72)% of oviposition deterrent were recorded in methanol extract of C. bonducella at 200 and 300 mg/L respectively. Similarly, at higher concentrations such as 400 and 500 mg/L (88.68 ± 2.85)% and (98.54 ± 2.42)% oviposition deterrency were recorded respectively against the above said concentrations (Table 2). In general, the oviposition deterrency is directly proportional to the increase in the concentration and also among the various extracts tested, methanol extract was found to have significant activity than the other solvent extracts.

Table 2
Oviposition deterrent activity of *C. bonducella* against the gravid moths of *H. armigera*.

Solvent tested	Oviposition deterrent activity %				
	100 mg/L	200 mg/L	300 mg/L	400 mg/L	500 mg/L
Benzene	9.32 ± 1.58^{b}	21.59 ± 1.59^{b}	61.35 ± 2.84^{b}	72.44 ± 2.25^{b}	83.24 ± 1.88^{b}
Diechloromethane	17.76 ± 1.43^{d}	31.34 ± 1.49^{d}	70.55 ± 2.35^{d}	84.55 ± 2.54^{d}	92.54 ± 1.82^{d}
Diethylether	13.96 ± 1.84^{c}	28.67 ± 1.28^{c}	64.58 ± 2.49^{c}	75.62 ± 2.76^{c}	84.55 ± 2.55^{c}
Ethyl acetate	19.75 ± 1.76^{e}	33.62 ± 1.34^{e}	76.82 ± 2.82^{e}	86.72 ± 2.36^{e}	94.33 ± 2.68^{e}
Methanol	22.85 ± 1.62^{f}	35.92 ± 1.53^{f}	79.84 ± 2.72^{f}	88.68 ± 2.85^{f}	98.54 ± 2.42^{f}
Control	1.39 ± 0.84^{a}	1.39 ± 0.84^{a}	1.39 ± 0.84^{a}	1.39 ± 0.84^{a}	1.39 ± 0.84^{a}

Values represent mean ± SD of five replications. Different alphabets in the column are statistically significant at $P < 0.05$. (MANOVA; LSD-Tukey's Test). Control groups were allowed to lay eggs on host plant sprayed with no phytochemicals.

3.3. Ovicidal activity of different solvent extracts of C. bonducella

Methanol extract of *C. bonducella* showed (21.86 ± 1.74)% ovicidal activity against the eggs (0-6 h) of *H. armigera* at 100 mg/L concentration, whereas, (34.75 ± 1.26)% and (58.93 ± 2.67)% of ovicidal activity were recorded in methanol extract of C. bonducella at 200 and 300 mg/L respectively. Similarly, at higher concentrations such as 400 and 500 mg/L, (75.83 ± 2.90)% and (95.55 ± 4.26)% ovicidal activity were recorded respectively (Table 3). In general, the ovicidal activity is directly proportional to the increase in the concentration and also among the various extracts tested, methanol extract was found to have significant activity than the other solvent extracts.

Table 3
Ovicidal activity of *C. bonducella* against the eggs (0-6 h) of *H. armigera*.

Solvent tested	Ovicidal activity %				
	100 mg/L	200 mg/L	300 mg/L	400 mg/L	500 mg/L
Benzene	8.58 ± 1.43^{b}	22.44 ± 1.69^{b}	32.25 ± 1.25^{b}	56.33 ± 2.22^{b}	80.33 ± 2.87^{b}
Diechloromethane	15.54 ± 1.62^{d}	28.32 ± 1.75^{d}	53.56 ± 2.39^{d}	76.84 ± 2.67^{d}	88.51 ± 3.44^{d}
Diethylether	12.63 ± 1.52^{c}	23.64 ± 1.83^{c}	42.68 ± 2.84^{c}	69.16 ± 2.74^{c}	83.66 ± 4.64^{c}
Ethyl acetate	18.60 ± 1.22^{e}	31.69 ± 1.48^{e}	54.84 ± 2.95^{e}	71.72 ± 2.24^{e}	92.87 ± 2.47^{e}
Methanol	21.86 ± 1.74^{f}	34.75 ± 1.26^{f}	58.93 ± 2.67^{f}	75.83 ± 2.90^{f}	95.55 ± 4.26^{f}
Control	1.88 ± 0.64^{a}	1.88 ± 0.64^{a}	1.88 ± 0.64^{a}	1.88 ± 0.64^{a}	1.88 ± 0.64^{a}

Values represent mean ± SD of five replications. Different alphabets in the column are statistically significant at $P < 0.05$. (MANOVA; LSD-Tukey's Test). Eggs in control groups were sprayed with no phytochemicals.

3.4. Larvicidal activity of different solvent extracts of C. bonducella

Maximum larvicidal activity was observed in the methanol extract of *C. bonducella* followed by dichloromethane, diethylether, benzene and ethyl acetate. Among five solvents tested the methanol extract was found to be most significant solvent which brings the significant larvicidal activity against the 4th instar larvae of *H. armigera* which is represented in Figure 1. It is noteworthy to observe that as the concentration increased the larval mortality is also increased. The maximum larvicidal activity was recorded from the highest concentration of methanol extract at 1 000 mg/L and the least larvicidal activity was recorded from the 125 mg/L concentration of ethyl acetate extract. Furthermore, the larval mortality of the methanol extract at the concentration of 250, 500, 750 and 1 000 mg/L were (29.6 ± 1.69)%, (57.4 ± 1.94)%, (81.2 ± 1.48)% and (98.4 ± 1.55)% respectively. These results obtained from the present experiment have been proved significant statistically, and they are all on par with the control groups. In a nut shell, the experimental larvae subjected to 1 000 mg/L were found more susceptible to the plant extracts tested since the lethality of the larvae were found to be maximum among the test concentrations.

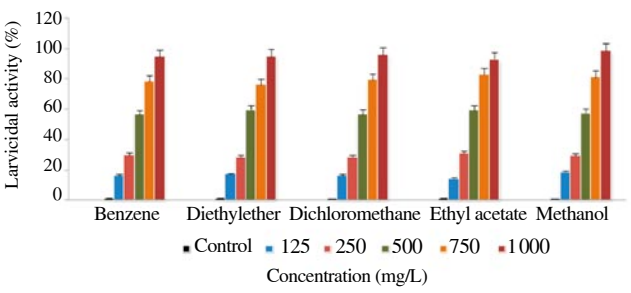

Figure 1. Larvicidal activity of *C. bonducella* extracts against freshly moulted 4th instar larvae of *H. armigera*.

3.5. Lethal concentraction of different solvent extracts of C. bonducella

Lethal concentration observed against 4th instar larvae of *H. armigera* with various solvent extracts are shown in Figure 2. The LC_{50} value of benzene, diethylether, dichloromethane, ethyl acetate and methanol extract of *C. bonducella* were 470.02, 469.00, 465.47, 460.52 and 443.87 mg/L, respectively. The *Chi*-square values are significant at $P \leqslant 0.05$ level. The *Chi*-square values in the bioassays indicated probably the heterogeneity of the test population. Among five solvent extracts, the methanol extract was responsible for strong lethal activity against selected pest species.

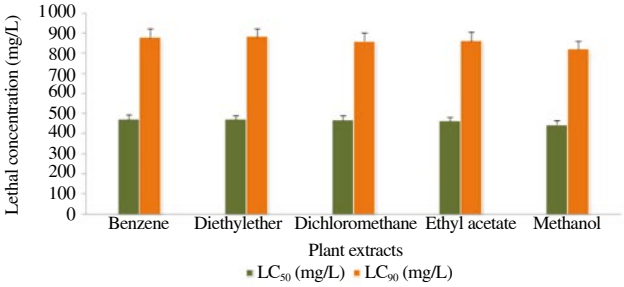

Figure 2. Lethal concentration of *C. bonducella* extracts against freshly moulted 4th instar larvae of *H. armigera*.

4. Discussion

In present study, the results showed that *C. bonducella* plant extracts have significant antifeedant, oviposition deterrent, ovicidal and larvicidal activities against selected important agricultural lepidopteran field pest *H. armigera*. The results are comparable with an earlier report by Krishnappa *et al*. in which they have reported that *Tagetes patula* volatile oil contained 10 compounds and they were tested against the fourth instar larvae of *Spodoptera litura* (*S. litura*) for their antifeedant activity by leaf disc bioassay[13]. Among the compounds tested terpinolene was the most effective feeding deterrent agent against *S. litura*. Safia Zoubiri and Aoumeur Baaliouamer who observed that alternatives to conventional insecticides, essential oils extracted from aromatic plants have been widely investigated[22]. Their toxicities toward insects were of special interest during the last decade. Roman Pavela reported that the significant differences in antifeedant activity were found in the highest tested dose of 500 μg/cm^2, not only among individual extracts but also between both pest species tested[8]. *Spodoptera littoralis* (*S. littoralis*) larvae were less sensitive to the extracts, when 43 extracts showed antifeedant activity lower than 50%, and an effectiveness in the range of 50%-95% was found in 13 extracts. Out of all tested extracts, only the extracts obtained from the plants *Angelica archangelica, Imperatoria ostruthium, Psoralea bituminosa* and *Vincetoxicum hirundinaria* showed antifeedant activity higher than 95%, and their effective doses (ED_{50}) were estimated at 44, 34, 72 and 11 μg/cm^2, respectively. *Leptinotarsa decemlineata* larvae were very sensitive to all the tested extracts. Hamshou *et al*. 2010 reported that the effects of the *Rhizoctonia solani* lectin on the growth, development and survival of an economically important caterpillar in agriculture and horticulture, the cotton leafworm, *S. littoralis* were studied[23]. Evelyn Munoz *et al*. have been reported that the extracts from *Calceolaria talcana* exhibited strong bioinsecticidal effects against *Drosophila melanogaster* and *Spodoptera frugiperda*[24]. The most active extract was ethyl acetate and its majority compound verbascoside. The highest lethal concentration to the larvae of *Spodoptera frugiperda* and *Drosophila melanogaster* was 20.0 μg/mL of the ethyl acetate extract with 95.8% and 67.0% of mortality, respectively. Cespedes and Alarcon, demonstracted that the *Calceolaria talcana* showed insecticidal activity in a preliminary trial[25,26]. Based on this information and knowing that this plant has a high resistance to insect and pathogen attack we have carried out an insect grow regulatory study of the aqueous, ethyl acetate, methanol, and *n*-hexane extracts of aerial parts of this shrub. Milled sample from *Calceolaria talcana* was macerated with methanol and further partitioned with *n*-hexane, ethyl acetate and water, respectively.

Anandan *et al*. reported that efficacy of ethyl acetate, methanol and aqueous extracts of *Acrous calamus, Corchorus aestauaus, Cammelina bengalinsis, Emblica fisheri, Ficus religiosa* and *Lantena Camera* were tested at 1000 mg/L for their antifeedant activity against fourth instar larvae of *H. armigera* using leaf disc (no-choice) method[7]. The aqueous extract of *Cleistanthus collinus* was found to have maximum antifeedant activity followed by *Emblica fisheri, Ficus religiosa* and *Corchorus aestauaus*. Dalila Haouas *et al*. reported that the effect of the whole methanol extracts of five *Chrysanthemum* species on feeding and performance of *S. littoralis* (Boisduval) larvae has been investigated *in vitro*[27]. The extracts exhibited an antifeeding and phagostimulating activities against cotton leafworm larvae when applied either on leaf discs or incorporated into an artificial diet. Pavela[28], who reported that twenty essential oils applied by fumigation were highly toxic to the third instar of *S. littoralis* larvae. Two essential oils *Nepeta cataria* and *Thuja occidentalis* were highly toxic with LC_{50} 10.0 mL/m^3 (5.5 and 6.5 mL/m^3, respectively). Recently Zhang Bin *et al*. reported that the beet armyworm, *S. exigua* is an economically important pest of crops worldwide, and significant differences were found in development, fecundity and enzyme activity on different host plants[29]. Survival rate was the highest (42.8%) on asparagus lettuce (*Lactuca sativar* var. *asparagina*) and the lowest (17.0%) on sweet pepper (*Capsicum annuum*). Larval duration was the shortest on asparagus lettuce (12.0 d), and was 43.4% longer on sweet peppers (21.2 d). Elumalai *et al*.[5], they have been reported that maximum ovicidal activity was found in

Ocimum basilicum and *Zingiber officinale*. *S. litura* eggs were 100% of mortality (no hatchability) recorded in 300 mg/L, respectively. Anandan *et al*.[6], they have been reported that crude extracts of *Hyptis suaveolens* and *Melochia chorcorifolia* against *S. litura*, four fractions obtained from *Hyptis suaveolens*, fraction III was found to inhibit the feeding ratio of the *S. litura* and it is apparent from the table. While in *Melochia corchorifolia* only three fractions have been obtained, among them fraction II was found to induced more feeding deterrent activity at 2000 mg/L concentration.

Wang *et al*.[30] reportd that the different host plants are known to be capable of affecting insect susceptibility to insecticides, as reflected in the change of some enzyme activities related to insecticide resistance. Earlier, Krishnappa and Elumalai[31], reported that the major chemical compositions in *Chloroxylon swietenia* leaves were α-pinene, limonene, geijerene, pregeijerene and germacrene D. The essential oil exhibited significant larvicidal activity, with 24 h LC_{50} 131.20 mg/L and LC_{90} 224.68 mg/L. The major chemical compositions larvicidal activity were also tested. The LC_{50} values of geijerene, limonene, germacrene D, pregeijerene and α-pinene were LC_{50} 18.31, 20.03, 24.83, 25.23 and 26.35 mg/L and LC_{90} 34.77, 38.31, 46.67, 47.27 and 49.78 mg/L, respectively. The essential oil produced (100% mortality) eggs no hatchability recorded in 200 mg/L, however, highest ovicidal activity found in geijerene 125 mg/L. This was closely followed by limonene and germacrene D 150 mg/L, Krishnappa *et al*. reported that the maximum antifeedant activity was noticed in *S. officinalis* (85.56 ± 9.44)% followed by *Ocimum basilicum* (80.55 ± 8.64)% at 1000 mg/L[32]. Similarly, larvicidal activity was recorded maximum in POF6 with (70.44 ± 3.43)% mortality followed by (67.55 ± 3.40)%; (65.41 ± 3.86)%; (64.24 ± 4.26)%; (60.33 ± 6.24)%; (55.22 ± 3.48)% mortality exhibited by POF4; POF5; POF3; POF1 and POF2 respectively.

Gokulakrishnan *et al*.[33] reported that the line of experiment was attempted with plant oil formulation, showed maximum percentage of ovipositional repellent activity against the gravid moths of *H. armigera* followed by *S. litura* and *Earias vitella* were 84.75, 79.90 and 76.55 respectively. Gokulakrishnan *et al*. reported that the most significant antifeedant activity was observed *Achaea janata* at 1000 mg/L concentration *Salvia officinalis* (85.56), *S. litura*, *Mentha spicata* (82.85), *H. armigera* and *Mentha spicata* (90.55), *Achaea janata*[9]. Thirugnanasampandan *et al*.[34] reported these phytochemical compounds do not cause any harmful effects on human or environment since these phytochemicals have shown effective antioxidant and DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging potential. Phytopesticides may be possible to produce botanical insecticides by phytopharming through genetic engineering of an existing field crop to produce high value natural products. We found in our research that even relatively short-term exposure of eggs, larvae, and adults to oil doses can markedly increase their mortality over time, and thus reduce the total number of viable larvae, eggs and moths leading to a possible significant reduction in the total population dynamics of pests.

The methanol extract of *C. bonducella* at higher concentration showed maximum antifeedant activity, oviposition deterrent activity, ovicidal activity and larvicidal activitiy against various life stages of selected important agricultural lepidopteran field pest *H. armigera*. Hence it is inferred that the methanol extract of *C. bonducella* can be used further for the isolation of active molecules and to develop a new botanical formulation for the management of *H. armigera*. This may serve as an effective phytopesticides to control tobacco cutworm compared to other toxins. Also it is a less expensive and more accessible one. We are continuing to develop phytopesticides as a biocide for agricultural field pest *H. armigera*.

Conflict of interest statement

We declare that we have no conflict of interest.

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