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Research Article

Efficacy Ofcertain Botanicals Against Melon Fruit Fly (*Bactrocera cucurbitae*) (Diptera: Tephritidae)

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Abstract Bactrocera cucurbitae (Coquillett) commonly known as the melon fruit fly, is a polyphagous pest of a variety of economically important agricultural crops. This dipteran fly is a serious pest of cucurbits. Laboratory experiment was carried out to evaluate the bio-efficacy of neem oil, cedar oil and pongamia oil against melon fruit fly. After surface coating pumpkin pieces with three concentrations viz, 1000 ppm, 5000 ppm and 10,000 ppm of these botanicals,oviposition deterrence against melon fruit fly was evaluated. The lowest number of ovipositional marks were observed in pumpkins treated with cedar oil followed by pongamia oil and neem oil after 24 hours of treatment. A decrease in egg hatching was observed withincrease in concentration of botanicals. Further, percent pupation and emergence varied significantly from control for all tested botanicals with nil pupation in case ofpongamia oil and cedar oil and 1.19% pupation and emergence in case of neem oil 72 HAT. The male-female ratio of flies so emerged also varied significantly from control with more number of males as compared to females. It is recapitulated that the concentrations of botanicals as well as time periodhave significant effects on oviposition, development, and sex ratio of the melon fruit fly.The mortality of flies increases

Keywords: B.cucurbitae, pumpkin, oviposition, survival, mortality, pupation, emergence, HAT, male-female ratio.

Introduction

More than 125 species of fruits and vegetablesbelongingto the family Cucurbitaceae and Solanaceae have been recorded as the hosts of B. cucurbitae. The extent of loss varies between 30% to 100% depending on the cucurbit species and the season (Sapkota et al., 2010). This pest causes yield loss in both ways; quantitatively as well as qualitatively. The larvae of this fly feed on economically most important parts of fruits and vegetables that completely deter its quality(Ansari et al., 2019).The adult female lays its egg below the hard covering of fruits and vegetables by penetrating its protruding ovipositor. The eggs hatch into larvae which feed upon fruit flesh thus rendering them unfit for consumption whereas adults feedson sugary contents like resins released from fruit and plant parts. Due to thehighly destructive nature of this fly, it has been considered as afederal quarantine pest in India and in many other countries (Mir et al., 2014). Meanwhile, this pestalso leads to decrease the trade value and export due to strict regulations by importing countries (Chen et al., 2007).

Once egg laying has taken place, chemical eradication becomes difficult. Therefore, flies can only be controlled either at the adult stage when they start hovering over the vegetation or just before pupation; when third-instar larvae come out of the infested fruit and about to enter insoil for pupation (Agarwal et al., 1987).The main aspect of the fruitfly control program is based on the use of chemical insecticides. Several researchers have worked on the effectiveness of different insecticides for the control of B. cucurbitae (Babu et al., 2002). However, chemical control measures such as the use of chemical insecticide causedisadvantages like pest resistance, residues in food, environmental contamination, outbreaks of secondary pests, reduction in the population of beneficial insects, and the inability of insecticides to penetrate inside the infested fruits to kill larvae. Plant extracts are one of several non-chemical control alternatives that inspired great interest due to their easy availability, reduced human and mammalian toxicity, and friendliness to the environment (Aquilet al., 2010).Neem oil is one of the most promising substances in the current approach to pest control. It possesses a variety of insecticidal properties such as repellency (Bina et al., 2017),antifeedency, toxicity, and growth disruption against numerous pest species (Saxena., 1989).The physiological and biochemical effects of neem oil against more than 30 lepidopteran pests has been acknowledged(Senthil, 2013). Neem oil is basically the contact insecticide, butsystematic activity has also been documented (Osman, 1990). Apart from neem oil, pongamia oil and cedar oil also possess insecticidal properties. Pongamia oil, is extracted from theseeds of wide-spread tropical and sub-tropical tree,Pongamia pinnata(L.) Pierre (Parmar and Gulati., 1969) whereas cedar oil is extracted from Cedrus deodara plants commonly known as Deodar. Both of them show repellency against insect pests (Buneriet al., 2017) but pongamia oil, in addition, acts as insecticide, antifeedant, and growth regulator (Kumar et al., 2006) and even oviposition deterrent (Pavela and Herda., 2007).

Therefore, present study was undertaken to assess the bioefficacy of above botanicals against the fruit fly aiming to develop an ecofriendly and sustainable management system of the pest species.

Materials and Methods

Insect Culture and Rearing

The melon fruitflies were procured from the infested fruits collected from the vegetable fields of Khalsa College, Amritsar,kitchen gardens and vegetable market of Amritsar city. After collection they wereidentified according to the taxonomic characters given by Kapoor (1993). The laboratory rearing of fruit flies was done in the same way reported by Gupta et al. (1978)under controlled temperature (25±2ºC), relative humidity (70-80%), and photophase (10L:14D).

Tested Botanicals and Concentrations

Neem oil, cedar oil, and pongamia oil selectedfor the present study were tested at three concentrations viz, 1000 ppm, 5000 ppm and 10,000 ppm. Control was also maintained for comparison and the whole experiment was replicated thrice.

Oviposition Preference Test

Pieces of pumpkin (Cucurbita moschata) were used as oviposition medium. B. cucurbitaelaid eggs in itand the larvae left inside. Larvae feed on the fruit pulp and deter the quality of fruit. It is difficult to count the number of larvae inside the food medium, therefore, the oviposition preference was calculated by counting the number of pupae formed. Oviposition preference of the melon fruit fly, B.cucurbitae were tested against the non- choice test.

Non-Choice Test

A wholeuninfested pumpkin was collected from the local market and cut into pieces weighing 100 g. Total number of 18 pieces were prepared at a time. After that,each piece of pumpkin was placed on the small petri dish, then coated with different concentrations of biopesticides along with untreated fruit and placed into the cages. After 24 hours of egg deposition, the pieces were collected for checking oviposition marks. Thenthese fruits were placed into the battery jars that contained sterilized moist sand and covered with muslin clothes and secured with rubber bands. Same process was repeated at 48 hours and 72 hours after treatment. After pupation, the pupae were collected by sieving the sawdust.

Oviposition Marks

The fruits were individually exposed to equal no. of mature males and females of 15 days in the bottom of the cage (L45 x B45 x H50) for 24, 48, and 72hrs. After this exposure period, charged fruits were collected and oviposition punctures were marked.Then the marked fruits were kept into battery jars for further biological observations.

Percentage (%) Pupation

The percent pupation was calculatedbased onthe number of pupae obtained from treated larvae with respect to a total number of pupae formed in the control. The following formula was used to obtain the percent pupation.

$$\% \text{ Pupation} \quad \frac{\text{No.of pupae formed in treated fruit}}{\text{Pupation from control fruit}} \quad 100$$

Percentage (%) Emergence

Percent emergence was calculated as per the total number of flies that emerged from treated fruit (oviposition medium) with respect to the total number of flies that emerged from untreated control.

$$\% \text{ Emergence} \quad \frac{\text{Flies emerged from the treated fruit}}{\text{Emergence from control diet fruit}} \quad 100$$

Male/Female Ratio

It was determined by counting the total number of males and females emerged from treated fruits.

Statistical Analyses

The data obtained was subjected to statistical analyses using ICAR wasp 2.0 forone-way ANOVA to find out the significant difference in the observations from the present study.Chi-square methodwas used to analyze the male-female ratio of flies.

Results and Discussion

Effect of Botanicals on the Oviposition Behavior of B. *cucurbitae*

Effect of Neem Oil Onoviposition Marks

Total number of oviposition marks decreases withthe increase in concentration, and varied significantly from control, in all treatments at all time intervals.Minimum oviposition marks (1.00) were observed at the highest tested concentrationafter 24 hours of treatment (Table 1). Akhtar et al. (2004) also reported reduced settling of Bactrocera zonata adults on fruits treated with neem extract. Decrease in ovipositional marks might occur due to the repellent action of neem oil. Ovipositional repellence of Mexican fruit fly against neem oil was reported by Botinet al. (2004). Further, an increase in ovipositional marks was observed 48 HAT and 72 HAT which might have occurred due to the reduced repellent effect of neem oil over time. Jilani et al.(1988) recorded persistence effect of neem oil more thansweetflag and turmeric oil for red flour beetle.

Effect of Cedar Oil on Oviposition Marks

Total number of oviposition marks decreases with increase in concentration and varied significantly from control, in all treatments at tested concentrations after 24 hours of treatments (Table 1). The minimum number of infestation spots were recorded at 5000 ppm and 10,000 ppm concentrations of Cedrus deodara. At the highest concentration of 10,000 ppm, 0.33 oviposition marks were observed at 24 hours of treatment, 0.66 after 48 hours and 1 was recorded after 72 hours of treatment. Increase in ovipositional marks might occur due to its reduced repellent properties over time period.

Makhaiket al. (2005) also used essential oil of C. deodara against mosquito species, Aedes aegypti and C. quinquefasciatus after one hour of exposure and found comparable results.

Effect of Pongamia Oil on Oviposition Marks

In Pongamia oil treatment significantly reduced ovipositions marks with increase in concentration were found over control after 24 hours of treatment. Pongamia oil when tested at highest concentration i.e., 10,000ppm under laboratory conditions resulted in degradation of host tissue within 48 hours of treatment (Table 1). The flies rejected the degraded tissues for oviposition as very few egg laying was recorded in the tissue. Similar results were observed by Harrewijnet al. (2001) when they detected repellent and anti-oviposition effects with different types of choice tests. Same results were revealed by Thakur and Gupta (2016),they tested pongamia oil at the concentration of 1.0%, 2.0% and 3.0% under laboratory conditions which was resulted in degradation of host tissue and reduced oviposition marks.

Efficacy of Botanicals on Pupation of B. *cucurbitae*

A significant decrease in pupation in comparison with control was observed at all tested concentrations at all time intervals in all the botanicals (Table 2). Minimum pupation (1.19%) was observed at highest tested concentration after 72 hrs of treatment in neem oil. In pongamia oil, significantly less number of pupae were recoverd from all the selected concentrations. At highest concentration nil pupation was found. Our results are in agreement with those of Almeida et al, (2007) where they found reduced number of pupae and adults after reduced oviposition of Ceratitis capitata on fruits treated with pongamia oil.Our results are in agreement with those of Akhtar et al. (2004) where they found reduced number of pupae and adults after reduced oviposition of Bactrocera zonata on fruits treated with neem extarcts.

Efficacy of Botanicals on Emergence of *Bactrocera cucurbitae* (Table 3)

Effect of Neem Oil on Emergence

Like pupation, emergence was also significantly reduced as compared to control at all concentrations and time periods. Maximum emergence observed in all treatments, was lower than 50% and minimum emergence was observed at 10ml after 72 hrs of treatment. According to Khattak et al., (2009) Neem oil and neem seed water extract at concentration of 1%, 2% and 3% reduced the percent infestation of fruit fly; as the pupae recovered in each treatment was significantly not so much as compared to that in control. Significantly lower pupae as well as emerged flies were recovered in all tested concentrations than in their respective controls. Other research workers also obtained identical results with the same compounds and other botanical insecticides against fruit flies as well as other insect pests.

The findings has similarity to the result of Mahufuzaet al. (2007) they reported that the neem blocks ovarian development and can be used as safe alternative of insecticides for the control of Bactrocera species.

Effect of Cedar Oil on Emergence

From the above findings it was revealed that the lowest emergence (0.00%) was recorded at 10,000ppm (highest concentration) after 72hrs of treatment. Significant variations were observed among all the selected concentrations. With the increase in concentration the rate of emergence decreases, Cedar oil totally affects the biology of melon fruit fly.

Effect of Pongamia Oil on Emergence

Less number of pupae were resulted into emerged flies. At high concentration 14.44%, 10.99% and 0% number of flies were emerged at 24, 48 and 72 HAT.

Effect of Botanicals on Male Female Ratio

Neem oil significantly represents variedmale-female ratio with less number of males and females over control at all selected concentrations (Table 4).Also, with the increase in time interval and rate of concentrations, the ratio of male and female get decreased.It was noticed that cedar oil shows significant variations among male-female ratio at only highest (10,000 ppm) concentration after the treatment of 24, 48 and 72 hours.With the increase in time interval and rate of concentrations the ratio of male and female decreases. Lastly Pongamia oil also reduced male and female ratio significantly at 10,000ppm in 24, 48 as well after 72 hrs of treatment. The least ratio was found at 1000ppm in all time intervals.

Conclusion

Our findings have provided evidence that each oil has a range of repellent effect against melon fruit fly. with maximum effect byneem oil followed bycedar oil and pongamia oil. All the treatments showed significant reduction of melon fruit fly population and fruit damage in comparison with control. However, there was no difference among different botanicals.The relationship appears between repellent effect and biology of fruit fly as measured by different parameters. Cedar oil ,pongamia oil and neem oil proved effective against target pest and can be incorporated in the module for integrated pest management. Cedar oil and pongamia oil needs to be further evaluation by using commercial formulations which has better adherence to surface and hence may prove better.

Table 1. Effect of botanicals on oviposition marks of *B. cucurbitae*

Botanicals	Time Period	Concentrations				F Value
		Control	1000 ppm	5000 ppm	10,000 ppm	
Neem oil	24 HAT	11.33a±3.21	2.66b±0.57	2.00b±0.57	1.00b±1.00	21.25*
	48 HAT	12.00a±1.00	4.00b±0.57	2.33bc±0.57	1.00c±0.00	41.71*
	72 HAT	10.00a±1.00	4.00b±0.57	2.66bc±0.57	1.33c±0.00	49.37*
Cedar oil	24 HAT	8.33a±1.52	2.33b±0.57	2.00b±1.00	0.33b±0.57	29.40*
	48 HAT	9.00a±1.00	3.33b±0.57	3.33b±0.57	0.66c±1.00	45.89*
	72 HAT	6.33a±1.15	4.66ab±0.57	3.33b±1.00	1.00c±0.00	11.66*
Pongamia oil	24 HAT	6.00a±1.00	2.66b±0.57	2.33b±0.57	0.66c±0.57	31.70*
	48 HAT	9.00a±5.19	3.33b±1.52	1.66b±0.57	0.33c±0.57	8.22*
	72 HAT	6.00a±1.73	3.66ab±3.51	1.00b±1.15	1.33b±1.00	6.21*

Table 2. Effect of botanicals on percentage pupation of *B. cucurbitae*

Botanicals	Time Period	Concentrations				F Value
		Control	1ml	5ml	10ml	
Neem oil	24 HAT	100a±0.00	58.16b±0.04	38.73c±0.14	11.78d±0.06	79.76*
	48 HAT	100a±0.00	39.26b±0.06	34.70b±0.08	9.29b±0.02	81.68*
	72 HAT	100a±0.00	36.72b±0.00	22.88c±0.01	1.19d±0.02	2640.2*
Cedar oil	24 HAT	100a±0.00	46.90b±0.05	35.94b±0.01	12c±0.10	146.88*
	48 HAT	100a±0.00	40.00a±0.18	24.85b±0.19	10.31c±0.09	35.50*
	72 HAT	100a±0.00	35.66b±0.00	20.33b±0.01	0.00c±0.02	113.08*
Pongamia oil	24 HAT	100a±0.00	60.75b±0.16	45.51c±0.08	16.37d±0.10	66.97*
	48 HAT	100a±0.00	50.53b±0.05	35.40c±0.09	12.99d±0.10	93.28*
	72 HAT	100a±0.00	45.20b±0.10	30.96c±0.10	0.00d±0.00	71.47*

Table 3. Effect of botanicals on percentage emergence of *B. cucurbitae*

Botanicals	Time Period	Concentrations				F Value
		Control	1000 ppm	5000 ppm	10,000 ppm	
Neem oil	24 HAT	100a±0.00	30.80b±0.09	28.09b±0.06	13.86c±0.07	204.41*
	48 HAT	100a±0.00	26.26b±0.11	24.87b±0.22	15.90c±0.08	16.12*
	72 HAT	100a±0.00	15.05b±0.16	9.62b±0.17	1.19c±0.02	44.37*
Cedar oil	24 HAT	100a±0.00	46.90b±0.04	38.90b±0.05	12.37c±0.10	96.45*
	48 HAT	100a±0.00	38.40b ±0.18	20.85b±0.19	8.31c±0.10	35.50*
	72 HAT	100a±0.00	24.33b±0.14	18.16b±0.05	0.00c±0.00	87.70*
Pongamia oil	24 HAT	100a±0.00	50.46b±0.15	40.81b±0.08	14.44c±0.04	69.28*
	48 HAT	100a±0.00	39.53b±0.05	30.21b±0.09	10.99c±0.10	95.56*
	72 HAT	100a±0.00	27.20b±0.10	17.96b±0.10	0.00c±0.00	71.42*

Table 4. Effect of botanicals on male-female ratio of *B. cucurbitae*:

Botanicals	Time period	Concentrations			
		1000 ppm	5000 ppm	10,000 ppm	Control
Neem oil	24 HAT	(7.3:6)*	(2.66:3.66)*	(2:1.66)*	24:23
	48 HAT	(4:4)*	(4.3:4)*	(2.33:1.33)*	13:14
	72 HAT	(3.66:2.66)*	(2.3:3)*	(0.03:0)*	11:37
Cedar oil	24 HAT	(6.33:5.33)*	(6:6)*	(2:1.33)*	12:11
	48 HAT	(5.3:5)	(4:3)	(1:0.33)*	6.66:6.33
	72 HAT	(3.66:3.33)	(2.33:2.66)	(0:0)*	4.33:5
Pongamia oil	24 HAT	(3:2.33)*	(2.33:2.33)*	(1.66:1.33)*	10.33:10.33
	48 HAT	(3:2.3)*	(2.66:2.33)*	(0.33:0.33)*	6.66:5.66
	72 HAT	(4.7:4)	(3.33:3)*	(0:0)*	6:8.7

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