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Biology and Management of Pomegranate Fruit Borer, Virachola Isocrates (Lycsenidae: Lepidoptera) Through Chemicals and Botanical Extracts

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Abstract

A research study was conducted for investigating the biology, infestation level and chemical control of pomegranate fruit borer under field and lab conditions at ARI, Mingora Swat during summer, 2018. The experiment comprised of twenty four trees of Kandahari anar selected from the orchard and eight different treatments were assigned in Randomized Complete Block (RCB) Design having three replications. Treatments including cypermethrin @ 3ml/lit, indoxacarb @ 0.5 ml/lit, bifenthrin @ 2.5 ml/lit, lamda-cyhalothrin @ 1.5-2 ml/lit, Azadirachta indica @ 5%, Persicaria hydropiper @ 5%, Eucalyptus globulus @ 5% and control (tap water) were applied four times during the entire experiment at 10 days interval. Influence of different synthetic chemicals and botanical extracts on mean infestation of V. isocrates revealed that lamda-cyhalothrin resulted in lowest mean infestation (3.740.36) followed by bifenthrin (3.950.32), indoaxarb (4.350.28) and cypermethrin (4.550.28). Botanical extracts i.e., Azadirachta indica (8.000.50), Persicaria hydropiper (7.56 0.27) and Eucalyptus globulus (7.040.70) also performed better than control and reduce the mean infestation of V. Isocrates as compared to maximum yield (16.000.49 ha^{-1}) was obtained from lamda-cyhalothrin treated plots while minimum (7.170.43 ha^{-1}) was recorded in control. Developmental period of V. Isocrates completed in 34-55 days. Eggs period lasted for 7-10 days with average of 8.84, larval period for 18-46 with an average of 32.22 and pupal period for 8-32 days with an average of 17.60 days. Adult longevity ranges 6-8 days with average of 6.58 days to complete. Highest 100% mortality was caused by lamda-cyhalothrin and cypermethrin after 72 hrs followed by neem seed extract (81.00) and Persicaria hydropiper (78.80) when tested under laboratory conditions. Based on the current studies, further studies on the side effect of these botanical extracts are recommended.

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Key Words

Population dynamics of aphids, wheat in charsadda, harvesting

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INTRODUCTION

Pomegranate, Punica granatum L belongs to family Lythraceae. An attractive shrub or small tree, with average height of 6-9 meters, much-branched, more or less spiny and extremely long-lived. The leaves are evergreen or deciduous, showy flowers are singly or 5 in cluster[1]. Pomegranate grow best on deep, heavy loams, but are adapted to many soil types from pure sand to heavy clay. Growth on alkaline soil is poor. Optimum growth is associated with deep fairly heavy and moist soil of pH 5.5-7.0[2]. It is widely cultivated throughout the Middle East and Caucasus region, North Africa and Tropical Africa, the Indian subcontinent, Central Asia and the drier parts of Southeast Asia. In recent years, it has become more common in the commercial markets of Europe and the Western Hemisphere[1]. Worldwide it is cultivated on an area of 0.3 million hectares with annual production 3.0 million tones (Sharma *et al.*, 2014). In Pakistan, the annual production of pomegranate was 42641 tones obtained from an area of 9434 hectares[3]. In Khyber Pakhtunkhwa, pomegranate was cultivated on an area of 254 hectares which gave production of 2656 tons[3]. Pomegranate cultivation in swat is in initial phases: Though growers are now taking interest in the commercial production of pomegranate due to its economic value[4]. Pomegranate has high nutritional value as it contains high amount of protein 1.7%, fats 6%, carbohydrates 14%, minerals and vitamins[5]. The pomegranate fruit also have functional and medicinal effects. Pomegranate can act as antioxidant[6] as anti-tumoral[7] or anti-hepatotoxic[8] agent and improve cardiovascular health[9]. Pomegranate has been seen to have antimicrobial, anti-inflammatory, antiviral, antidiabetic properties[10-12] and it is also useful for diseases such as those of mouth[13] and skin[14]. It helps prevent Brain diseases[15] and helps in the development and nourishment of sperm[16] and erectile dysfunction in male patients[17]. Various types of insect pests (fruit borer, thrips, stem borer and bark eating caterpillar) and diseases (bacterial blight, pomegranate wilt, 44fruit cracking, sun scald, internal breakdown and arial discoloration) attack pomegranate. Among the insect pests, the most destructive pest is Pomegranate fruit borer, Virachola Isocrates (Lycaenidae: Lepidoptera) which attack pomegranate at flowering stage. This pest is one of the major constraints faced by pomegranate growers in Swat, Khyber Pakhtunkhwa[4]. Studies on pomegranate fruit borer, Virachola Isocrates have shown that the insect increases primarily on pomegranate fruit under orchard agro ecosystem. It has been noticed that extreme damage occurs in 30-50 days old fruits. Most of the eggs are layed singly on newly blooming out leaves, buds and flowers. The grown up larvae are brownish in color, having standing hair and the body consisting white patches and measures about 16-20 mm long. Maximum damage is caused by fourth and fifth instar larvae[18]. Pomegranate fruit borer is the most widespread, polyphagous and destructive pest with a wide range of host plants viz., wood apple, pomegranate, citrus, guava, litchi, apple, ber, loquat, mulberry, peach, pear, plum, sapota and tamarind[19,20]. The pest is distributed all over India that decrease the yield of pomegranate upto 50 percent[21]. Peak incidence of the pest is during August in monsoon and also more during November and December in winter crop. It attacks the developing fruits and causes heavy losses for growers. The incidence of fruit borer has been reported throughout the year with varying degrees of intensity in Maharashtra and Karnataka[22,20]. Reported 100 per cent damage to pomegranate under severe endemic conditions in Karnataka. However, average losses of 40-90 per cent have been reported in India (Nair, 1978)[23]. Stated that V. isocrates is widely distributed all over India and is found wherever pomegranates are grown. Different types of management practices i.e, cultural, physical, biological and chemical are mainly used for Pomegranate fruit borer. Among these control measure the most efficient way is the use of synthetic insecticides. The use of chemical or synthetic insecticides is most common for the management of the borers but it has some limitations which include pest resistance and negative effect of the chemicals on the environment[24]. Alternate control measures can be applied for the management of the borer which include the use of botanical insecticides. Natural plant pesticides are safe to environment, natural enemies, other animals and humans. Botanical pesticides have also low and moderate mammalian toxicity[25]. Many researchers reported botanical extracts having pesticidal properties and thus having potential to be used against many pests[26]. Efficacy of these or other botanical extracts (neem leaf extracts, pungam oil, lluppai oil, neem seed kernel extract against V. isocreates have been used which successfully reduce the infestation caused by this borer[27]. Similarly, Neem products, neem oil (3%) and neem Seed Kernel Extract were found moderately effective against V. isocrates by[28]. In Swat, cypermethrin, lamda cyhalothrin, bifenthrin and Methomyl has been tested against this pest in which lamda chylothrin decrease the infestation comparatively more from other tested treatment[4]. In Pakistan, these extracts are obtained from many plants including neem seed and leaves, eucalyptus globulus leaves, turmeric, henge, datura stramonium, nicotiana tabacum, garlic and marsh pepper etc. These bio-insecticides have been reported as successful by many researchers and are used for management of several insect pests[29]. Keeping in view the economic importance of the pomegranate fruit borer, the

present research was conducted with the following specific objectives.

Objectives:

- To determine the infestation level of pomegranate fruit borer.
- To study the biology of pomegranate fruit borer under laboratory conditions.
- To compare the efficacy of different insecticides and botanical extracts against pomegranate fruit borer under field conditions.
- To compare efficacy of different insecticides and botanical extracts against pomegranate fruit borer under laboratory condition (bioassay).

MATERIALS AND METHODS

A research study was conducted for determining the efficacy of different chemicals and botanical extracts for the management of pomegranate fruit borer at Agriculture Research Institute (ARI) North, Mingora, Swat during summer, 2018. ARI is located 30°-35° N latitude and 72°-74° 6' E Longitude and an altitude of 984 meters (3,228 ft).

Field Experiment: Effect of chemical insecticides and botanical extract on pomegranate fruit borer.

Experimental Procedure and Layout: In this experiment a total of twenty four trees of variety (Kandahari Anar) were selected from the orchard at above mentioned research institute. Row to row distance was kept 20 feet and plant to plant distance was 15 feet with an average tree height of 10-15 feet. Eight different treatments were assigned in Randomized Complete Block (RCB) design with three replications. Different insecticides and botanical extracts along with their recommended doses are given below.

Table 1: Different Insecticides and Botanical Extract and their Recommended Doses

Treatments	Trade Name	Chemical /scientific Name Active-ingredient	Recommended Dose
T1	Arrive 10Ec	Cypermethrin	3 ml/lit
T2	Steward 150 Ec	Indoxacarb	0.5ml/lit
T3	Talstar 10Ec	Bifenthrin	2.5ml/lit
T4	Karate 2.5 Ec	Lamda-cyhalothrin	1.5-2ml/lit
T5	Neem Seed Extract	Azadirachta indica/ Azadirchitin	5%.
T6	Water Pepper Leaf Extract	Persicaria hydropiper	5%.
T7	Eucalyptus Leaf Extract	Eucalyptus globulus/ Eucalyptol	5%.
T8	Control	----------	----------

Chemical Insecticide Preparation: The chemical insecticides were brought from local market and spray solutions were prepared for foliar application according to their recommended doses with the help of electric balance and graduated cylinder.

Preparation of Plant Extracts: Neem seeds were brought from local market and dried. The seed covers were removed for further processing. Leaves of water pepper and eucalyptus were collected from local fields and shade dried at the laboratory. Then, all the three plant products were milled and each plant extract was prepared by mixing 50g powder in water in a conical flask to make the final volume of 1 L. Solution for field application (5% concentration) was prepared from the stock solution [30-32]. During the entire experiment, a total of 4 sprays were applied at an interval of 10 days using a knapsack sprayed. Control plots were sprayed with tap water. The spray machine and other tools were thoroughly cleaned for each treatment preparation/ application.

Data Collection

- **Fruit Damage (%):** Post treatment infestation data were recorded by observing the infested fruits and their means were calculated with the help of the following formula[4].

$$\textbf{Fruit Damage (\%)}: = \frac{\text{No. of damage fruits}}{\text{Total no. of fruits}} \times 100$$

Yield Data: The fruit yield data were recorded at the time of fruit harvest by picking healthy and mature fruits that were weighed for each of the treatments applied. Further, treatment yield was compared with the control plots. The obtained yield was converted into kg/ha (Kumar, 2014).

Laboratory Experiment:

Study of the Biology of Virachola Isocrates: Study on the biology of V. isocrates was carried out at entomology laboratory, ARI Mingora (Swat). Larvae and pupae (ten each) were collected from the infested fruits and were kept in rearing chambers with two fruits per chamber. The emerging male and female insects was differentiated based on their morphological characters. A single pair of newly emerging adults were kept in a glass cage of 500ml, water and 10% honey solution were supplied to them (as food) in cotton swabs and were covered with mesh cloth. The total eggs laid by the adult (females) were counted and the duration of egg, larval, pupal and adult stages was noted. The mean temperature and relative humidity during the period of study were maintained at 25±2°C and 65±5% respectively (Kumar *et al.*, 2017).

Bioassay Experiment: A bioassay experiment was carried out at entomology laboratory ARI, Mingora, Swat. The laboratory condition was maintained at 25 ±2°C Temperature, 65±5% (RH) and 8 hour photoperiod. For this experiment, chemical solution of lamda-cyhalothrin, cypermethrin and botanical extracts of Azadirachta indica, Persicaria hydropiper was prepared at recommended dose as mentioned in

(Table 1). Total of two pomegranate fruits were dipped in the prepared solution for 1 minute and on each treatment 6 larvae of Viorachola isocrates (same size) were exposed to that chemically treated pomegranate fruit in a plastic container having diameter of 15cm and depth of 10cm. The process was repeated 10 times. Larval mortality data was recorded after 24, 48 and 74 hours[33].

Data Analysis: The received data was analyzed using computer statistics software Statistic. 8.1 version. Means were separated at alpha level=5% after applying LSD test[34].

RESULTS AND DISCUSSIONS

Influence of Different Synthetic Chemicals and Botanical Extracts on % Infestation of Virachola Isocrates on Pomegranate Fruit at Agriculture Research Institute Mingora Swat, During Summer, 2018: The data (Table 2) showed that there was statistically non-significant difference in pre-spray data at p<0.05. However, the percent infestation ranges from 16.8-18.56. The data showed statistical significant difference at p<0.05 in all the treatments after the application of 1st spray. All the tested treatment reduced the percent infestation of V. Isocrates. The minimum (4.26 0.44) percent infestation was recorded in plots treated with lamda-cyhalothrin followed by bifenthrin (4.63 0.37), Indoxacarb (4.93 0.37) and cypermethrin (5.330.41), cypermethrin, indoxacarb, bifenthrin and lamda-cyhalothrin were not significantly different from each other but these were significantly different from Azadirachta indica, Persicaria hydropiper and Eucalyptus globulus with (8.930.26), (8.530.28) and (8.160.31) mean percent infestation, respectively. The maximum 17.86 mean percent infestation was recorded in control plots. After the 2nd spray application, a significant difference was recorded among different insecticides and botanical extracts at p<0.05. Lowest (3.8 0.36) mean percent infestation was recorded in Lamda-cyhalothrin, which was not significantly different from cypermethrin, indoxacarb and bifenthrin with (4.86) (4.56 0.31) and (4.16 0.46) mean percent infestation, respectively. Followed by E. globulus (7.10.80), P. hydropiper (7.630.27) and A. indica with (8.16 0.52b) mean percent infestation. The highest 16.561.48 mean percent infestation was recorded from control plots.

After the 3rd spray, significant difference was recorded among different treatments at p<0.05. The lowest 3.630.37 mean infestation was recorded from the plot treated with Lamda-cyhalothrin followed by Bifenthrin (3.80.36) indoxacarb (4.160.23) and cypermethrin (4.430.32) which was not significantly different from each other. But were significantly different from A. indica, P. hydropiper and E. globulus with (7.860.57), (7.140.29) and (6.64 0.86) mean percent infestation, respectively. From the control plot, the highest (14.761.20) mean percent infestation was recorded. After the 4th spray application, a significant difference at p<0.05 among the chemical and botanical extracts was observed. The minimum mean percent infestation was recorded same for bifenthrin and lamda-cyhalothrin (3.230.12) followed by indoxacarb (3.760.24), cypermethrin (3.560.17) E. globulus (6.260.86) P. hydropiper (6.6 0.29) and A. indica with (7.030.75) mean percent infestation. While, the maximum mean percent infestation was recorded from control (13.1 1.15). The overall mean percent infestation showed statistically significant difference at p<0.05. All the applied treatments reduced the V. isocrates infestation as compared to the control plot. Data revealed that minimum (3.740.36) mean infestation were recorded from lamda-cyhalothrin followed by bifenthrin (3.950.32), indoaxarb (4.350.28), cypermethrin (4.550.28), E. globulus (7.040.70), P. hydropiper (7.56 0.27) and A. indica with (8.000.50) mean percent infestations. The maximum (15.57 1.24) mean percent infestation was recorded from the control plots. The synthetic chemical applications were not significantly different from each other but were significantly different from botanical extracts and control. Similarly, the botanical extracts were not significantly different from each other but were significantly better as compared to control.

Table 2: Influence of Different Synthetic Chemicals and Botanical Extracts on Mean Infestation of Virachola Isocrates on Pomegranate Fruit at Agriculture Research Institute Mingora Swat, During Summer 2018

Treatments	Pre-spray	1st spray	2nd spray	3rd spray	4th spray	Mean
Cypermethrin	17.3 0.67	5.33 0.41 c	4.86 c	4.43 0.32 c	3.56 0.17 c	4.55 0.28 c
Indoaxarb	18.13 0.52	4.93 0.37c	4.56 0.31 c	4.16 0.23 c	3.76 0.24 c	4.35 0.28 c
Bifenthrin	17.73 1.23	4.63 0.37 c	4.16 0.46 c	3.8 0.36 c	3.23 0.12 c	3.95 0.32 c
Lamda-cyhalothrin	17.65 1.34	4.26 0.44 c	3.8 0.36 c	3.63 0.37 c	3.23 0.26 c	3.74 0.36 c
Azadirachta-indica	17.96 1.14	8.93 0.26 b	8.16 0.52 b	7.86 0.57 b	7.03 0.75 b	8.00 0.50 b
Persicaria hydropiper	18.33 1.28	8.53 0.28 b	7.63 0.27 b	7.14 0.29 b	6.6 0.29 b	7.56 0.27 b
Eucalyptus globulus	18.56 0. 18	8.16 0.31 b	7.10.80 b	6.64 0.86 b	6.26 0.86 b	7.04 0.70 b
Control	16.8 0.15	17.86 1.20 a	16.561.48 a	14.76 1.20 a	13.1 1.15 a	15.57 1.24a
LSD		2.39	2.20	1.94	1.76	2.02

Means followed by different letter (s) are significantly different from one another at (P=0.05), using LSD test.

Influence of Different Chemicals and Botanical Extracts on Pomegranate Yield (t ha-1) at Agriculture Research Institute Mingora Swat, During Summer, 2018: Yield data recorded in tones ha^{-1} from different chemicals and botanical extracts treated plots of pomegranate orchard (Table 3) showed significant difference at P<0.05. The maximum yield (16.000.49 t ha^{-1}) was recorded from plots treated with lamda-cyhalothrin followed by bifenthrin (15.330.29), cypermethrin (15.10.58), indoaxarb (14.860.58), A. indica (12.270.27), P. hydropiper (11.970.29) and E. globulus with (11.340.66 t ha^{-1}). While the minimum (7.170.43 t ha^{-1}) yield was recorded from control plots. Plots treated with synthetic pesticides did not differ significantly from each other, however these were significantly better as compared to the botanical extracts and control plots.

Table 3: Influence of Different Chemicals and Botanical Extracts on Pomegranate Yield (t ha-1) at Agriculture Research Institute Mingora Swat, During Summer, 2018

S. No	Treatments	Yield tones ha^{-1}
1	Cypermethrin	15.16 0.58 a
2	Indoaxarab	14.86 0.58 a
3	Bifenthrin	15.33 0.29 a
4	Lamda-cyhalothrin	16.00 0.49 a
5	Azadirachta indica seed	12.27 0.27 b
6	Persicaria hydropiper leaf	11.97 0.29 b
7	Eucalyptus globulus leaf	11.34 0.66 b
8	Control	7.17 0.43 c
	LSD	1.2369

Means followed by different letter (s) are significantly different from one another at (P≤0.05), using LSD test.

Developmental Period (Days) and Adult longevity of Pomegranate Fruit Borer Virachola isocrates record on Kandahari Anar Variety Under laboratory Conditions: The data (Table 4) showed that reared V. isocrates layed out their eggs singly on tender leaves and stems during the experiment at lab condition. The data further revealed that eggs period lasts 7-10 days with an average of 8.84 days. The recorded larval period was 18-46 days with mean duration of 32.2 days. Pupation occurs in soil and its pupal period lasts for 8-32 days with mean duration of 17.6 days. Life cycle was completed within 34-55 days with average duration of 45.3 days. Adult longevity ranges from 4-7 days with average of 6.58 days.

Table 4: Developmental Period (Days) and Adult Longevity of Pomegranate fruit borer Virachola isocrates grown on Kandahari Anar Variety Under Laboratory Conditions

	Duration (Days)	
Developmental stages	Range	Mean ±SE
Eggs period	7-10	8.84±0.95
Larval period	18-46	32.22±7.08
Pupal period	8-32	17.60±4.99
Adult	6-8	6.58±0.85
Total life cycle	34-55	45.36±3.8

Means followed by different letter (s) are significantly different from one another at (P≤0.05), using LSD test.

Influence of Different Synthetic Insecticides and Botanical Extracts on Mortality (%) of the 4th Instar Larvae of Virachola Isocrates Under Laboratory Conditions: Results (Table 5) showed a significant difference at (P≤0.05) in mean percent mortality of larvae after 24, 48 and 72 hours after the exposure to different synthetic insecticides and botanical extracts. After 24hr, non-significant differences were recorded between lamda-cyhalothrin and cypermethrin but these were found significantly different from Azadirachta indica seed extracts and Persicaria hydropiper leaves in percent mortality of the larvae. The maximum mortality (54.50) was caused in larvae exposed to lamda-cyhalothrin followed by cypermethrin (52.52), A. indica seed extract (26.80) and P. hydropiper (23.80). While lowest (0.00) mean percent mortality were recorded from control. The mean percent mortality increased after 48hr in all the treatments (except control). Maximum mean percent mortality was 83.78 recorded from lamda-cyhalothrin which is statistically similar to cypermethrin (82.12), followed by A. indica seed extract and P. hydropiper leaves (57.60 and 53.40) respectively and minimussm mortality were recorded in control plot (0.00). After 72 hrs, the highest mean percent mortality was not significantly different for lamda-cyhalothrin and cypermethrin (100.00) followed by A. indica extract (81.00), P. hydropiper leaves (78.80) and lowest from control (0.00).

Table 5: Influence of Different Synthetic Insecticides and Botanical Extracts on Mortality (%) of the 4th Instar Larvae of Virachola Isocrates Under Laboratory Conditions

Treatments	Doses	Mean % Mortality after		
		24 Hrs	48Hrs	72Hrs
Lamda-cyhalothrin	1.5-2ml/lit	54.50 a	83.78 a	100.00 a
Cypermethrin	3 ml/lit	52.52 a	82.12 a	100.00 a
Azadirachta indica seed	5%	26.80 b	57.60 b	81.00 b
Persicaria hydropiper leaf	5%	23.80 b	53.40 b	78.80 b
Control	Water	0.00 c	0.00 c	0.00 c
LSD		3.9075	4.4884	3.1566

Means followed by different letter (s) are significantly different from one another at (P≤0.05), using LSD test.

Pomegranate fruit borer (Virachola Isocrates Fab.) is one of the main constraints in production of pomegranate fruit for local and international market[35]. Over 50% of yield loss is caused by pomegranate fruit borer[21]. Virachola Isocrates has been effectively managed and its infestation has been reduced through synthetic chemical and botanical extracts in various research programmers (Kulkarni *et al.,* 2009). The effectiveness of the synthetic insecticides (Deltamethrin, Quinalphos and Cypermethrin) for the management of pomegranate fruit borer has been reported by[36] from Himachal Pradesh, India. Cypermethrin is a synthetic pyrethroid having stomach and contact mode of entry. It is fast-acting and especially effective against chewing insects and absorbed by the insect pest when it walks over the dry residues[37]. In the present study, different synthetic insecticides (lamda- cyhalothrin, bifenthrin, indoxacarb and cypermethrin) and botanical extracts (E. globulus, P. hydropiper and A. indica) were tested against V. Isocrates under field conditions. While, under laboratory conditions the biology of V. isocrates was studied and synthetic insecticides and botanical extracts were tested for percent mortality of V. isocrates (Larvae). The results of the field study showed statistically significant difference in percent infestation of V. isocrates in all applied treatments. All the treatments reduced the V. isocrates infestation as compared to control. Data revealed that minimum (3.740.36) mean percent infestation was recorded from lamda-cyhalothrin followed by bifenthrin (3.950.32), indoaxarb (4.350.28), cypermethrin (4.550.28), E. globulus (7.040.70), P. hydropiper (7.56 0.27) and A. indica with (8.000.50) mean percent infestations. The maximum (15.57 1.24) mean percent infestation was recorded from the control plots. The synthetic chemical applications were not significantly different from each other however, lamda-cyhalothrin

was found most effective in minimizing the percent infestation. Similar results reported by[4] who tested Bifenthrin, Cypermethrin, Methomyl and Lambda -Cyhalothrin in pomegranate orchard against V. isocrates and concluded that lamda-cyhalothrin is most effective. The results are in line with Obeidat and Mazen (2002) who used four synthetic parathyroid (lamda-cyhalothrin, methomyl, diflubenzuron and chloropyrifos) on the pomegranate butterfly (Virachola livia) and they reported that lambda-cyhalothrin gave 97% clean fruits. The botanical extracts was more effective than control but its efficacy was less than synthetic insecticides. Corresponding results are stated by[38] where they used synthetic insecticides and bio pesticides and found botanical extracts as less effective than synthetic insecticides[38]. Neem oil (3%), neem Seed Kernel Extract (5%) and Neem Cake Extract (5%) were found moderately effective against pomegranate fruit borer by[28] which is similar to our results. The efficacy of A. indica against Virachola isocrates is also reported by[39]. In the present study, yield (tones ha^{-1}) obtained from different treated plots were significantly different from each other. The maximum yield (16.000.49 t ha^{-1}) was recorded from plots treated with lamda-cyhalothrin followed by bifenthrin (15.330.29), cypermethrin (15.10.58), indoaxarb (14.860.58), A-indica (12.270.27), P. hydropiper (11.970.29) and E. globulus with (11.340.66 t ha^{-1}). While the minimum (7.170.43 t ha^{-1}) yield was recorded from control plots. Corresponding finding were reported by Ramachandra[40] who obtained significantly higher pomegranate yield from plots treated with insecticides as compared to other treatment (5% neem seed kernel extract). Yield of plots treated with botanical extracts was significantly higher than control plots. In this experiment, biology of the Virachola isocrates was studied under laboratory conditions and the observation revealed that V. isocrates lay their eggs singly on tender leaves and stems during the experiment at laboratory conditions. The eggs period was 7-10 days with an average of 8.84 days. The recorded larval period was 18-46 days with mean duration of 32.2 days. Pupation occurs in soil/fruit and its pupal period lasts for 8-32 days with mean duration of 17.6 days. Adult longevity ranges from 4-7 days with average of 6.58 days and total life cycle was completed within 34-55 days with average duration of 45.3 days. The outcome of our research work was in contrast with findings of Khan[41] by study the biology of V. isocrates on guava and their results showed that incubation period, larval period, pupal period of this borer ranged from 8-10, 17-46, 7-33 days, respectively and total life cycle was completed within 30-60 days. Adult longevity ranged from 4-7 days. The current results are also agreed with[27] where pomegranate fruit borer mean larval period was recorded 32.9±2.38 days, pupation period 10.25±0.10 days, total developmental period 63.92±2.87 days, adult female longevity 10.28±0.20 days and male longevity period 8.26±0.14 days on pomegranate. Similarly the biology of V. isocrates was examined by[42] on pomegranate and concluded that total developmental period last for 67.00±8.67 days. The larval period of pomegranate fruit borer varies from 24-38 days (33.2±1.10) days on Citrus [43,44]. Reported that larval duration of pomegranate fruit borer ranged from 33-38 days with mean of 35.3±1.88 days and pupal period mean was 14.5±2.7 (10-18) days on Emblica officinalis. Furthermore, larvae of V. isocrates were exposed to insecticides and botanical extracts treated fruits for finding the effectiveness of the treatments and percent mortality of the borer. Results showed significant difference in the percent mortality of V. isocreates. After 24hr, non-significant differences were recorded between lamda-cyhalothrin and cypermethrin but these were found significantly different from Azardirachta indica seed extract and Persicaria hydropiper leaves in percent mortality of the larvae. The mean percent mortality increased after 48hrs in all the treatments (except control). After 72hrs, the highest mean percent mortality was the same (100%) for lamda-cyhalothrin and cypermethrin followed by A. indica seed extract (81.00), P. hydropiper (78.80) and lowest for control (0.00). These results are agree with Yilang[45] who reported that lamda cyhalothrin was most effective against 3rd and 4th generation of H. armigera (Hub.) in Shandong, China. The effectiveness of cypermethrin against H. armigera was reported by[46]. The findings are in line with[4] who used cypermethrin, lamda cyhalothrin, bifenthrin and methomyl in pomegranate field and against V. isocrates and concluded that lamda cyhalothrin was most effective in reducing infestation caused by V. isocrates. The results regarding the efficacy of botanical extracts are in line with[47] who used A. indica, E. globulus and N. tabacum reported that A. indica was most effective among the tested botanical extracts. Similarly, the efficacy of botanical extracts (Neem, Datura and also bitter apple) against chrysoperla carnea larvae and is reported by[48]. In overall both experiments (lab and field) the synthetic insecticides decreased the percent infestation and caused high mortality as compared to the botanical extracts. The botanical extracts showed sufficient response in decreasing the percent infestation as compared to control but less effective than synthetic chemicals. The highest yield in (tones ha^{-1}) were obtained from insecticides treated plots.

Summary: An experiment was conducted for determining the mean percent infestation of pomegranate fruit borer under field and lab conditions at ARI, Mingora Swat during summer, 2018. In the field, different synthetic insecticide (lamda-cyhalothrin, bifenthrin, indoxacarb and cypermethrin) and botanical extracts (E. globulus, P. hydropiper and A. indica) were tested against V. isocrates. While studies on the

biology and developmental period of V. isocrates and percent mortality of synthetic chemicals and botanical extracts on V. isocrates (Larvae) were carried out under lab conditions. Specific objectives were to determine the infestation level of pomegranate fruit borer, to study the biology of pomegranate fruit borer under laboratory conditions, to compare the efficacy of different insecticides and botanical extracts against pomegranate fruit borer under field conditions and to compare efficacy of different insecticides and botanical extracts against pomegranate fruit borer under laboratory condition (bioassay)[49-55]. The experiment was comprised of twenty four trees of a variety Kandahari anar selected from the orchard and eight different treatments were assigned in Randomized Complete Block (RCB) Design having three replications. Row to row and plant to plant to plant distance was kept 20 ft and 15 ft respectively. Treatments including cypermethrin @ 3ml/lit, indoxacarb @ 0.5 ml/lit, bifenthrin @ 2.5 ml/lit, lamda-Cyhalothrin @ 1.5-2 ml/lit, Azadirachta indica @ 5%, Persicaria hydropiper @ 5%, Eucalyptus globulus @ 5% and control (water treated) were applied four times during entire experiment at an interval of 10 days. Data was collected for percent fruit damage and mean yield in each treatment of every replication. In lab experiment studies on the biology of V[56-65]. isocrates and percent mortality of different treatment at 24, 48 and 72 hours interval were carried out. Results regarding influence of different synthetic chemicals and botanical extracts on mean infestation of V. isocrates revealed that lamda-cyhalothrin was found with the lowest mean infestation of (3.740.36) followed by bifenthrin (3.950.32), indoaxarb (4.350.28) and cypermethrin (4.550.28). Botanical extracts i.e., Azadirachta indica (8.000.50), Persicaria hydropiper (7.56 0.27) and Eucalyptus globulus (7.040.70) also performed better and reduce the mean infestation of V. isocrates as compared to control (15.57 1.24). Maximum yield in tones ha-1 was obtained from lamda-cyhalothrin treated plots (16.000.49) while minimum was in control (7.170.43). Results pertaining to developmental period of V. Isocrates realized that V. Isocrates completes its life cycle in 34-55 days with average of 45.36 days. Incubation period lasts for 7-10 days with average of 8.84, larval (18-46) with average of 32.22 and pupal period 8-32 days with average of 17.60. While adult longevity ranges 6-8 days with average of 6.58 days to complete. Effect of different synthetic chemicals and botanical extracts on percent mortality of 4th instar larvae of V[66-70]. Isocrates showed that 100 % mortality was caused by lamda-cyhalothrin and cypermethrin after 72 hours followed by Azadirachta indica seed extract (81.00) and Persicaria hydropiper (78.80) while 0% mortality was recorded in control. On the basis of current studies, it is concluded that synthetic insecticides decrease the percent infestation and caused highest mortality as compared to the botanical extracts in field and lab conditions. The botanical extracts showed sufficient response in decreasing the percent infestation and yield as compared to control but were less effective as compared synthetic chemicals.

CONCLUSION

- The synthetic chemicals performed better in reducing mean infestation of pomegranate fruit borer on pomegranate fruit.
- All the botanical extracts showed better performance in reduction of mean infestation of pomegranate fruit borer however, lowest mean infestation was recorded in Eucalyptus globulus leaf extract.
- Highest percent mortality was caused by synthetic chemicals as compared to the botanical extracts in lab condition.
- V. isocrates completes its whole life cycle within 34-55 days in which adult longevity ranges from 6-8 days.
- Maximum yield was obtained from plots treated with synthetic chemicals followed by botanical extracts. Minimum yield was recorded from untreated plot (control).

Recommendation:

- To avoid or minimize the use of synthetic insecticide, botanical insecticides should be incorporated in management programs because they have less or no impact on environment as well as on natural ecosystem.
- Based on the current studies, further studies on the side effect of these botanical extracts are recommended.
- The farmer should be informed through extension efforts for promoting these management techniques.

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