Pure Appl. Biol., 7(3): 1014-1020, September, 2018
http://dx.doi.org/10.19045/bspab.2018.700120

Research Article

Comparative efficacy of indigenous plant extracts and a synthetic insecticide for the management of tomato fruit worm (*Helicoverpa armigera* Hub.) and their effect on natural enemies in tomato crop

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Citation
Amjad Usman, Mian Imad Ali, Maqsood Shah, Fazal e Amin and Jawad Sarwar. Comparative efficacy of indigenous plant extracts and a synthetic insecticide for the management of tomato fruit worm (*Helicoverpa armigera* Hub.) and their effect on natural enemies in tomato crop. Pure and Applied Biology. Vol. 7, Issue 3, pp1014-1020. http://dx.doi.org/10.19045/bspab.2018.700120

Received: 17/04/2018 Revised: 09/07/2018 Accepted: 20/07/2018 Online First: 23/07/2018

Abstract

Efficacy of five botanical extracts (eucalyptus, bakayan, chilli, thyme and onion extract) and synthetic insecticide (Steward 150 EC) was evaluated against *H. armigera* and its associated natural enemies under field conditions during 2014, followed Randomize Complete Block Design with three replications. Results revealed that all the tested botanicals and insecticide were found effective in controlling the tomato fruit worm infestation as compared to control. Among all the tested spray materials, Steward 150 EC was found the most effective in reducing *H. armigera* larval infestation (61.01%) followed by bakayan extract (44.49%). However, the steward 150 EC was comparatively more toxic to the natural enemies than botanicals. Fruit infestation was minimum in Steward tested plots and maximum in control on weight basis and on number basis 10.53% and 10.29% and 30.88% and 29.11% respectively. Similarly, Steward treated plot yielded the highest (9564 kg ha^{-1}) and control yielded the lowest (5487 kg ha^{-1}). It was concluded that Steward 150 EC was the most effective in managing fruit worm infestation and hence resulting the minimum fruit damage and consequently enhanced the yield of tomato. However, the synthetic insecticide was extremely toxic to the natural enemies. Furthermore, eucalyptus, chilli, onion and thyme extract also showed better results than control in term of pest reduction and were comparatively safe to the natural enemies, Hence these botanicals should be included in IPM program for the suitable management of *H. armigera* associated with tomato crop.

Keywords: Botanical extracts; *Helicoverpa armigera* infestation; Natural enemies; Percent reduction; Synthetic insecticide

Introduction

Tomato fruit worm (*H. armigera* Hub.) is one of the devastating pest of tomato resulting in considerable yield losses i.e. 32-53 % annually **[1]**. Initially pest starts feeding on leaves, flowers and finally bore into tomato fruits, making them unfit for human consumption and also reduce its market value **[2]**. Being a polyphagous pest, annual loss of approximately 5 billion US

dollars has been attributed to *H. armigera* worldwide [3]. To deal with this potential and notorious pest, 85% of the word insecticide is used to manage this pest [4]. This incredible use of synthetic insecticide has led to the problem of pest resurgence, insecticidal resistance in insects, environmental pollution, health problems, decimation of useful fauna and the increased cost of pest controls as well [5]. In order to address all these issues, it has become imperative to explore the substitutes of these toxic insecticides to keep the *H. armigera* population below injury level and have no harmful effect on biocontrol agents [6].

One such alternate is the use of plant extracts. The use of plant extracts has been given major emphasis in IPM Programme. Compared to other commonly used synthetic insecticides, plant extracts are safe for both the pesticide user and consumer of the treated crop as well as to non-target animals and humans.

Mostly the farmers rely on conventional synthetic chemicals to control insect pest and little attention has been made to explore the indigenous fauna having insecticidal properties that is ecofriendly and safe for nature enemies. The concept of botanicals extracts is not particularly new and some important practical progress has been made in other crops/ insects. Hence, an attempt has made to evaluate the efficacy of indigenous plant extracts i-e. *Melia azedarach, Thymus volgaris, Eucalyptus tereticornis, Allium cepa* and *Capsicum annum* on *H. armigera* and its associated natural enemies as alternative to synthetic insecticide for the sustainable management of tomato fruit.

Materials and methods

The current experiment was carried out at New Developmental Farm (NDF) of The University of Agriculture, Peshawar during spring 2014, to evaluate the efficacy of various indigenous plant against tomato fruit worm (*H. armigera*) and its associated natural enemies in tomato crop.

Field layout and experimental design

Seedlings of tomato variety (Riogrande) were transplanted in 2nd week of March followed randomized complete block design (RCBD) with three replications. Plot size was 1.5 x 3 square meter. Plant to plant and row to row distance was maintained 45 cm and 90 cm respectively. Standard agronomic and cultural practices were applied uniformly to all experimental plots.

Treatments and its application

All the plant extracts and insecticide (steward) were sprayed twice by Knap Sack sprayer at 15 days interval. At the time of spray, polythene sheet was hanged around each plot to protect the adjacent plots from the drift effect of spray application (Table 1).

Table 1. Detail of different botanical extracts and a synthetic insecticide used in the experiment

Treatments	Treatments (common name)	Technical Name	Concentration / dose
1	Eucalyptus	*Eucalyptus tereticornis*	5%
2	Bakayan	*Melia azedarach*	5%
3	Chilli	*Capsicum annum*	5%
4	Thyme	*Thymus volgaris*	5%
5	Onion	*Allium cepa*	5%
6	Steward 150 EC	Indoxicarb	250 ml ha^{-1}
7	Control	-	-

Extract preparation

The above mentioned tested botanicals were collected from the local area, washed and dried under shade for 7 days. The dried material of each plant parts was grinded into fine powder separately. Ten percent (10%) stock solution of each plant extract was prepared by mixing 100 g powder in 1 liter of water in a conical flask. The mixture was thoroughly shaken, left for 24 h and

filtered through muslin cloth to remove the impurities. 5% concentration for field application was prepared from the stock solution.

Data collection

***H. armigera* larvae plant^{-1}**

Data on *H. armigera* larval population were recorded on randomly selected 5 plants in each plot, 24 hours before spray application and then after 24 hours, 48 hours, 72 hours and 7 days of spray application. The data were then converted into percent larval reduction using [7] formula as under:

$$\text{Per cent reduction in population} = \left[1-\frac{T_a \times C_b}{T_b \times C_a}\right] \times 100$$

Where,

Ta= insects population after spray application

Tb= insects population before spray application

Ca= insects population in control plot after spray application

Cb= insects population in control plot after spray application

Natural enemies population plant^{-1}

Predators (green lace wing and lady bird beetle) were also counted on randomly selected 5 plants in each plot, 24 hours before spray application and then after 24 hours, 48 hours, 72 hours and 7 days of spray application. The data were then converted into percent reduction in predators population using [7] formula as mentioned earlier

Percent fruit damage (weight and number basis)

Fruits damaged by *H. armigera* larvae on weight and number basis were recorded at each picking by counting and weighting sound and infested fruit. Percent fruit damage was calculated using following formula as suggested by [8].

$$\%\text{ damaged fruits (weight basis)} = \frac{\text{Weight of damaged fruits}}{\text{Total weight of tomato}} \times 100$$

$$\%\text{ damaged fruits (number basis)} = \frac{\text{Number of damaged fruits}}{\text{Total number of tomato}} \times 100$$

Yield

Yield in different treatments was recorded at each picking from net plot area. Total yield was calculated by adding the yield from all picking for each treatment and then converted in to yield per hectares with the following formula:

$$\text{Yield (kg ha}^{-1}) = \frac{\text{Yield plot}^{-1}}{\text{Plot size}} \times 10000$$

Statistical analysis

All the above parameters were subjected to the analysis of variance and means were separated using LSD test at 5% level of significance.

Results and discussion

***H. armigera* larval infestation**

Results on efficacy of different botanicals and a synthetic insecticide against *H. armigera* larval infestation showed that all the tested treatments were significantly superior in reducing the larval population (Table 2). However, two sprays application of Steward was found to be the most effective after 24 hr, 48 hr, 48 hr and 7 days with maximum mean reduction (61.01%) in the larval population of *H. armigera* followed by Bakayan extract with a total larval reduction of 44.49%. Our current results are previously endorsed by [9] who found 73.25-76.65% reduction in larval population under field conditions after first and second spray of indoxacarb at recommended dose respectively. Similar finding has also been reported by [10] who stated that synthetic insecticide was more effective than botanicals. [11] also reported that steward was much effective when applied against early instars larvae of *H. armigera* and hence maximum mortality of the targeted pest was recorded in 24-48 hours after spray application. Similarly [12] found that steward remain effective against different instars of *H. armigera* and 24–48 hours are sufficient enough to kill early stages of *H. armigera*. However, present findings (Table 2) showed that maximum mortality was recorded after 72 hours of spray application, might be due to variation in the dose and experimental condition. It can be seen that spray application of

euclyptus, onion, chilli and thyme extract were equally effective and efficiently reduce the pest population with mean larval reduction of 32.50%, 32.05%, 31.63 and 30.29% respectively. The present finding is in accordance with the findings of [13, 14]. Onion extracts produces a pungent alliaceous which probably is responsible for its pest repellent attribute. Similarly [15] also assumed the anti-feeding effect of garlic and onion reduced the ability of the insects or cutworms to feed. [16] reported that Azadirachtin-based compounds have insecticidal, feeding deterrent, repellent, antioviposition, and physiological properties such as are survival, longevity, molting and reproduction. Similarly thyme contained high amounts of thymol, a monoterpene phenol that binds to post-synaptic GABA receptors associated with chloride channels in insects [17].

Table 2. Effect of plant extract and synthetic insecticide on *H. armigera* larvae infesting tomato crop during 2014

Treatments	% reduction in larval population after spray application								
	1st Spray				2nd Spray				
	24 hours	48 hours	72 hours	7 days	24 hours	48 hours	72 hours	7 days	Mean
Eucalyptus extract	22.58 cd	20.22 c	43.53 c	37.66 b	27.46 c	43.98 bc	55.43 c	9.15 d	32.50 c
Bakayan extract	31.36 b	37.16 b	53.39 b	40.33 b	34.29 b	46.52 b	80.03 a	32.72 b	44.49 b
Chilli extract	26.77 bc	22.39 c	42.72 c	28.66 c	22.11 d	39.95 cd	44.51 d	26.02 c	31.63 c
Thyme extract	19.97 d	27.41 bc	44.03 c	30.76 c	20.87 d	34.12 de	58.14 c	6.95 d	30.29 c
Onion extract	25.44 c	26.18 bc	46.23 c	29.66 c	24.09cd	32.65 e	46.58 d	25.45 c	32.05 c
Steward	51.20 a	62.40 a	76.70 a	62.00 a	53.10 a	69.45 a	72.33 b	40.91 a	61.01 a
LSD 0.05	**5.304**	**11.578**	**4.406**	**4.6873**	**4.350**	**5.913**	**5.528**	**3.743**	**2.880**

Means in columns with different letters are significantly different at p = 0.05 using LSD Test

Natural enemies population

In the present study, two natural enemies (Green lacewing and ladybird beetle) were found to be associated with tomato crop. The presences of these natural enemies in the field play an important role in the population fluctuation of the pest. Previous studies showed that steward is safe and selective insecticides [18]. However, table 3 clearly indicated that both natural enemies were significantly affected by the tested treatment applications. In both spray application, insecticide steward found more toxic to both the natural enemies (ladybird beetle and green lacewing) with mean percent reduction of 58.87% and 44.61% respectively. Similar finding has also been reported by [19, 20] that Steward found from slight to moderate toxic against the green lacewing (*Chrysoperla carnea*) (68.8-84.8% mortality). Similarly, [21, 22] revealed that Steward significantly reduced number of predators in field and is slightly toxic to the egg parasitoid *Trichogramma chilonis* as well. However, all the tested botanicals were comparatively least toxic and found statistically at par with each other. However, based on mean percent reduction, Chilli extract found relatively safer than other tested botanicals with minimum reduction of 16.64% and 20.33% in ladybird beetle and green lace wing population respectively. Present finding showed that steward was very effective and gave maximum mortality of the target pest (Table 2). However, it was slightly toxic to the natural enemies as presented in (Table 3). The present study indicated that two spray application of insecticide steward significantly reduced both the predators' population in tomato crop as compared with botanicals. It is clear from this study that botanical extract reduce insect pest infestation and is comparatively safe to the natural enemies. The present findings are in agreement with [23] who found that botanicals (neem) significantly reduced insect pest infestation. Similarly, in the present study predators population was significantly higher in botanicals treated plots as compared to synthetic insecticide, indicating that neem insecticide was

comparatively less harmful to predators. Similarly, [24] evaluated a formulation of neem against two Coccinelid predators i.e. *M. sexmaculta* and *V. vincta* on okra and found all formulations relatively safer than synthetic insecticide.

Table 3. Effect of plant extracts and synthetic insecticide on predators population post spray application during 2014

Treatments	Mean % reduction in predators population after spray application					
	Ladybird beetle			Green lacewing		
	1st spray	2nd spray	Mean	1st spray	2nd spray	Mean
Eucalyptus extract	12.61 b	24.26 bc	18.44 c	28.76 b	21.05 bc	24.90 b
Bakayan extract	34.70 b	31.27 b	32.98 b	26.24 b	23.85 bc	25.05 b
Chilli extract	18.70 b	14.57 c	16.64 c	21.43 b	19.23 c	20.33 b
Thyme extract	34.79 b	25.05 bc	30.09 bc	25.65 b	22.64 bc	24.15 b
Onion extract	29.03 b	25.05 bc	27.04 bc	16.66 b	29.33 b	23.00 b
Steward 150 EC	59.56 a	58.16 a	58.87 a	46.06 a	43.16 a	44.615 a
LSD 0.05	**22.243**	**14.142**	**14.000**	**16.121**	**9.435**	**9.725**

Means in columns with different letters are significantly different at p = 0.05 using LSD Test

Percent fruit infestation

Results on fruits infestation by *H. armigera* larvae showed significant variation in tomato (Table 4). Fruit damage was lowest (on weight as well as on number basis) in Steward treated plot 10.29 % and 10.53% respectively and highest in control with 30.88% and 29.11% respectively. Similarly among the botanicals, Bakayain extract was found the second best treatment with 14.58% fruit damage on weight basis and 15.38% on number basis followed eucalyptus and onion extract. While thyme extract proved least effective with high fruit damage as compared to the rest of botanicals. Steward was the most effective, resulting in significant decrease in fruit damage over control on weight basis (66.67%) and on number basis (63.82%) followed by Bakayan extract, while the thyme extract found to be the least effective in reducing the fruit damage 18.20% and 20.85 % on weight and number basis respectively (Table 4). Similar finding has also been reported by [10] that synthetic insecticide was found superior over botanicals when evaluated against tomato fruit worm. Present study also showed that plant with highest larval infestation had highest degree of fruit damage and vice versa. Our results are in agreement with [8] that high larval infestation resulting high fruit infestation. Similarly, [25] reported that fruit worm infestation could cause serious damage to tomato by boring into the fruits thereby reducing the fruit weight, yield and market value as a result of larval feeding within the fruit contents. Thus the reduction of *H. armigera* larval infestation subsequently led to a reduction in damaged fruit.

Yield (kg ha^{-1})

Table 5 shows that tomato yield was significantly affected by tested botanical extracts as well as synthetic insecticide. Highest (9564 kg ha^{-1}) tomato yield was recorded in case of steward treated plots with maximum (74.30%) increase in tomato yield over control plots. It was followed eucalyptus extract (8359 kg hac^{-1}), bakayain extract (8076 kg ha^{-1}), chilli extract (7512 kg ha^{-1}), onion extract (7102 kg ha^{-1}) and thyme extract (6410 kg ha^{-1}) with 52.34%, 47.18% ,36.90 and 29.42 % increase in yield over control respectively. Similarly, the lowest yield (5487 kg ha^{-1}) was recorded in control plots. This variation in yield may be due to the different level of larval infestation after the application of different spray application. It has also been observed that the pest initially fed on fresh tender leaves, flower and later on entered into tomato fruits which ultimately affected fruit yield. Results clearly indicate that plots with lowest pest larval population yielded better. While lowest yield was obtained in control plot because of the highest *H. armigera* larval

population. The present finding is also in agreement with those of [8] that profitable fruit yield was significantly greater in plots sprayed with selective insecticides compared to botanical extract and biocontrol agent.

Table 4. Effect of botanical extracts and synthetic insecticide on infestation level of tomato by *H. armigera* larva during 2014

Treatments	% fruit infestation (weight)	%decrease over control (weight)	% fruit infestation (number)	% decrease over control (number)
Eucalyptus extract	20.13 d	34.81	18.04 c	38.02
Bakayan extract	14.58 e	52.78	15.38 c	47.16
Chilli extract	23.63 bc	23.48	22.73 b	21.92
Thyme extract	25.26 b	18.20	23.04 b	20.85
Onion extract	21.68 cd	22.80	19.04 bc	34.60
Steward 150 EC	10.29 f	66.67	10.53 d	63.82
Control	30.88 a	0.00	29.11 a	0.00
LSD $_{0.05}$	**3.204**	**-**	**4.588**	**-**

Means in columns with different letters are significantly different at p = 0.05 using LSD Test

Table 5. Effect of different botanical extracts and synthetic insecticide on yield on tomato during 2014

Treatments	Yield (kg ha^{-1})	% increase over Control
Eucalyptus extract	8359 b	52.34
Bakayan extract	8076 b	47.18
Chilli extract	7512 c	36.90
Thyme extract	6410 d	16.82
Onion extract	7102 c	29.43
Steward 150 EC	9564 a	74.30
Control	5487 e	-
LSD $_{0.05}$	**417.89**	**-**

Means in columns with different letters are significantly different at p = 0.05 using LSD Test

Conclusion and recommendation

Based on current study, it was concluded that the new chemistry insecticide, Steward 150 EC proved the most effective in controlling the fruit worm infestation and consequently led to better fruit protection with significant increase in tomato production. However, it is more toxic to natural enemies. Hence, the use botanical extracts (bakayan, chilli and onion) is the better alternative to synthetic insecticide as they are cheap, easily available and relatively safe to the natural enemies and other non-target species. Therefore, it is recommended to use different plant based, indigenous botanical insecticides such as eucalyptus, chilli and onion etc. in IPM programs for the sustainable management of *H. armigera* in tomato and other crops.

Authors' contributions

Conceived and designed the experiments: A Usman, M Shah, Performed the experiments: MI Ali, Analyzed the data: F Amin, J Sarwar, Wrote the paper: A Usman.

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