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Comparative potency of different insecticides against *Tuta absoluta* (Gelechiidae) on tomato varieties in agriculture zone, Sariab, Quetta (Baluchistan) Pakistan

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Abstract

A study was carried out to manage tomato leaf miner (*T. absulata*) on exotic (Super-man) and local (Shalkot) varieties of host plant in a field plot at vegetable and seed farm, Sariab, Quetta. Chemical pesticides (Chlorfenapyr, Propenofos, Chlorpyrifos) were used and their relative efficacy against *T. absulata was* evaluated. The research was done in a randomized complete block design (RCBD) by performing three treatments. Two sprays of each pesticide were applied on tomato varieties. Larvae of the pest were observed before starting the treatments and mortality rate of larval forms were monitored at intervals of 1, 4, and 8 days after each spray. Results revealed that all the three pesticides showed significant control of leaf miner infestation. However, chlorfenapyr has shown best control after 1st spray after 1 and 4 days ($P<0.0001$) and after 8 days ($P<0.001$) intervals than propenofos and chlorpyrifos. Similarly, after 1 and 8 days significance level was observed to be $P<0.001$, and after 4 days it was $P<0.0001$ for shalkot variety severally. But after 2nd spray applications on both varieties significance level was noted to be higher $P< 0.0001$ at all intervals. It was also observed that the efficacy of all tested pesticides was below the pest injury level. It is concluded that chemical use remain the most effective control methods available to reduce *T. absoluta* threat levels. However, the need for alternative control methods is fortified by the presence of resistant populations as well as by the side effects of pesticides on beneficial arthropods. Even, to optimize such effective control strategies, it is necessary to understand the relationships take place between the leaf miner and its host plants.and propose recommendations for further research.

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Introduction

Tomato (*Solanum lycopersicum* L.) is considered one of the most delicious vegetable-fruits worldwide. It belongs to the family Solanaceae which include some other important vegetables like potatoes (*Solanum tuberosum* L.), brinjals (*Solanum melongena* L.), black nightshade (*Solanum nigrum* L.) and capsicums (*Capsicum annuum* L.). The tomato plant is adapted to a wide range of climatic conditions and the optimum temperature required for growth and development for most varieties lies between 21 and 24 °C (Naika *et al.*, 2005) and fairly tolerant to a wide range of pH. Tomato in our daily life is used as salad and cooked in numerous ways due to its flavor and also in processed forms like ketchup and paste (Saeed *et al.*, 2007; Akhtar *et al.*, 2010).

It has rich nutrients like vitamins (ascorbic acid), minerals, and antioxidants like carotenoids (β-carotene) which boost up immunity against diseases(Clinton, 1998; Rao and Agarwal, 1999; Moco *et al.*, 2006; Borguini *et al.*, 2009;Kotikova *et al.*, 2009, 2011; Vallverdu-Queralt *et al.*, 2011; Saidov *et al.*, 2018). Tomato is grown all over the world even in cold areas through greenhouse cultivation (Wachira *et al.*, 2014) production reached 37.1 million metric tons during the year 2018 assessed by World processing tomato council (Gacemi *et al.*, 2016; Ahmad *et al.*, 2018) and Tomato crop production in Central Asia, was on 126,600 hectares (FAo and UNICEF, 2017) while in Pakistan, the total tomato grown in the year 2016 was 575923 tons documented by Ahmad *et al.* (2018).

The tomato leaf-miner (*T. absoluta)* is a native micro-lepidopteron of South America (Torres *et al.*, 2001) and taken the status of major tomato pest since its discovery in Mediterranean basin (Guenaoui, 2008). Globally, there are numerous pests targeting tomato shrubs and fruits across the world including Europe, Asia, and sub-Saharan Africa but harm posed by *Tuta absoluta* is note-able (Urbaneja *et al.*, 2009; Giorgini *et al.*, 2019). It was first recorded from Eastern Spain in late 2006 and then from Morocco, Algeria, France, Greece, Malta, Egypt and other countries (Roditakis *et al.*, 2010; Mohammed, 2010). The severe infestation of this insect causes severe loss to the extent of 80-100% in tomato, both in protected and open field cultivation (Korycinska and Moran, 2009).

In Pakistan, various factors are responsible for tomato low yield but the most dreadful are insect pests including *Tuta absoluta* (Lepidoptera), *Liriomyza trifolii* (Diptera) and *Helicoverpa* (*Heliothis*), *armigera* (Lepidoptera) and aphids i.e. *Aphis gossypii*, *Myzus persicae* (Hemiptera), etc. *T. absoluta* is a recognized pest of tomato, the larval form feed all parts of tomato even green and ripened fruits as well.

A study conducted by Desenex *et al.* (2010, 2016) in Egypt reported that third & fourth larval instars cause the highest damages by reducing the amount of chlorophyll in leaves and young buds and also pave way for the entry of secondary pathogens, cause yield losses between 50 and 100% (Ghoneim, 2014) Tomato leaf miner is cosmopolitan, originated in South America spread to Africa, Asia thereafter it recorded in Spain in 2006, it has prevailed in Middle-east countries, Mediterranean, Europe & South Asia (Desneux *et al.*, 2010, 2011) ustified the presence of this insect in northern Africa, Tunisia, north of the Sahel, western Africa, Sudan, and Ethiopia.

Reports on the existence of this pest from Pakistan and Tajikistan are also mentioned by (Campos *et al.*, 2017). *T.absoluta* was recorded for substantial crop loss in Pakistan for both open fields and glasshouses tomato crop (Mirza, 2007). Bajwaand Kogan (2004) highlighted the control approaches for tomato pests in Pakistan include cultural, chemical, biological and physical methods. No research work had been conducted till yet on 'Comparative Potency of different insecticides against *Tuta absoluta* on Tomato varieties' in Pakistan and Balochistan province of the country. To fill this gap a study was conducted with main objectives to evaluate the effectiveness of three commonly used insecticides and to assess tomato varieties resistance against *T. absoluta* in the tomato crop fields.

Material and methods

Study area

The present study was conducted during 2018-2019 in a field plot of tomato crop at vegetable seed farm located nearly 10 kilometers in the west of Metropolitan city, Quetta. Three insecticides used to evaluate their toxicity against tomato leaf miner, *T. absoluta,* through field evaluation.

Field experiments

Experiments were carried out in Rabi season during the period from 5th February till 30th August 2019 in the Agricultural Vegetable and Seed Farm at Sariab, Quetta (Baluchistan), Pakistan. The experiment was laid out in a randomized complete block design (RCBD) with an arrangement of split-plot divided into eight parts, each with 4320 feet. The seeds of two tomato varieties, the American Super-Man and local Shalkot were collected with ecological characteristics given in Table 1, from Directorate of Agriculture and Seed Farm Sariab, Quetta, were grown separately.

Eight replicates were selected including two untreated (control). Recommended agronomic practices were observed during the study. Experiments were conducted to evaluate the tested insecticides, as the propenofos, chlorfenapyr, and chlorpyrifos against leaf miner insect in the tomato field during 2019 on both tomato varieties (Table 2). These insecticides were applied two times at recommended dozes (0.4,1 and 1ml/L of water respectively). The first spray was applied on 15 of July 2019 while the second spray on 12 August 2019. Hand fitted Knapsack-sprayer with one nozzle was used for spraying insecticides. The control plots were treated with water only and kept protected from the treated ones avoiding any contamination.

Management of T. absoluta in tomato leaves

10 plants were selected from each plot for the evaluation of insecticides efficiency on leaf miner, before and after treatment. A total of 400 tomato leaves from 10 plants of each replicate were cut and assessed for the presence of live and dead larvae after each treatment. The leaf miner infestation was calculated before and 1,4 and 8 days after spraying in all experimental plots and compared with the control plots. The efficacy (larval mortality) of insecticides was calculated using the formula of (Zereabruk, Wakgari, & Ayalew, 2019) from the mean of dead larvae inside their made, leaf-tunnels after treatment with the help of 15x magnifying glass and compound light Microscope.

$$\text{Mortality Rate} = \frac{(\text{control mean} - \text{treatment mean})}{\text{Mean of control}} \times 100$$

Statistical analysis

Data were statistically analyzed using GraphPad Prism (version 7). The results were presented in mean ±S.D. Two-way ANOVA followed by Tukey's post hoc test was done. Differences were considered significant at P-Value Less than 0.05.

Results and discussion

The latest finding on the benefits of tomato carotenoids, including lycopene, suggests that they may play a role in lung and vision function in healthy people and fight against cancer, and cure breathing ailments as well (DLeite *et al.*, 2001; Leite, *et al.*, 2001; Lietti *et al.*, 2005; *Salim et al.*, 2017).

Table 1. Ecological characteristics of the experimented varieties.

Variety	Characters	Description	Variety	Characters	Description
Super-Man	Color	Red	Shalkot	Color	Red
	Size	90-94 mm		Size	80-90 mm
	Area	Uplands and Plains		Area	Uplands
	Time of Nursery Raising	February		Time of Nursery Raising	February
	Time of Transplantation	March		Time of Transplantation	March
	Harvesting	July-Aug		Harvesting	July-August
	Seed Type	Exotic variety		Seed Type	Vernacular variety
	Days to Maturity	90 days		Days to Maturity	110 days
	Irrigation	Weekly		Irrigation	weekly
	Shelf Life	Up to 5-6 days at room temperature.		Shelf Life	Up to 7 days at room temperature.

In the current study, a uniform distribution of leaf miner was observed a day before initiation of spray application. In this regard, three insecticides were tested to check the efficacy against the leaf miner (*T. absoluta*) on two varieties of tomato (exotic super-man and local variety shalkot).

The pretreatment observations were recorded at 24 hours before spray, while, the post-treatment observations were taken after 1, 4, and 8 days of all the three treatments. The data regarding the mortality rate of different insecticides on the leaves of tomato crop at different intervals given in Table 3, 4. Differences between treated and untreated plots were noted. All the insecticides showed significant differences over control and a significant difference was also recorded among the efficacy of all the treated groups (Propenofos 31 EC, Chlorpyrifos 40 EC, and Chlorfenapyr 36 SC).

Table 2. The insecticides sprayed for the control of leaf miner insect in experimental fields with their various rates/ml.

S.No	Common name	Trade name	Formulation type	Conc.	Rate (ml/L)	Family
1	Chlorfenapyr	Drone fighter	SC	36%	0.4	Chlorinated pyrrole
2	Propenofos	Curacron	EC	31.03%	1	Organophosphate
3	Chlorpyrifos	chlorpyrifos	EC	40 %	0.25	Organophosphate

The results showed that Chlorfenapyr was the most effective insecticides against *T. absulata* with a high mortality rate of pest. Significant difference P<0.0001 was noted in one and four days on super-man and four, eight days on shalkot variety after 1st spray, and for all intervals of both varieties after 2nd spray, P<0.001 for one day of shalkot and eight-day on super-man after 1st spray. Followed by propenofos with significant P<0.05 at day one and eight, P<0. 0001 on 4th day after 1st spray and P<0.0001 for all the intervals after 2nd spray on super-man and P<0.001 for all the intervals in case of shalkot after 1st and 2nd spray. However, in the case of chlorpyrifos P<0.05 at one and eight-day and P<0.001 at 4th day after 1st spray; P<0.001 at day 1 and 8; P<0.0001 at 4h day after 2nd spray on super-man.

Table 3. Effectiveness of various insecticides against tomato leaf miner *T. absoluta* infestation on tomato plants before and after the treatment of 1st spray.

			Post-treatment observations			Mortality % age		
Variety	Treatment	control	1 Day	4 Days	8 Days	1 DPT	4 DPT	8 DPT
Superman	Propenofos	4.90±2.20	2.35±1.14	1.61±1.41	2.25±1.45	52	67	54
Superman	Chlorpyrifos	5.10±2.13	2.55±1.69	2.21±1.81	2.45±1.83	50	56	51
Superman	Chlorfenapyr	5.80±2.17	0.68±1.10	0.30±0.48	2.86±1.89	88	94	50
Shalkot	Propenofos	5.00±2.33	2.15±1.41	1.01±1.09	2.45±1.41	57	79	51
Shalkot	Chlorpyrifos	4.70±2.09	1.88±1.35	1.76±1.34	2.08±1.70	60	62	56
Shalkot	Chlorfenapyr	4.90±2.05	2.01±1.63	0.66±0.98	2.03±1.70	59	86	58

Data were represented in mean ± std, * show P <0.5, ** show P<0.001, *** show P<0.0001 and DPT mean days post-treatment.

The same pesticide showed significant reduction on day 4 (P<0.0001) after both 1st and 2nd spray in case of Shalkot tomato variety followed by P<0.05, P<0.001 at day 1 and 8. We found a significant reduction of leaf miner larvae after 4rth day of all the three treatments for both varieties of tomato. Our results presented in table 3 and 4 indicated that chlorfenapyr (organophosphate group) is an efficient insecticide showed significant reduction of leaf miner larvae than Chlorpyrifos and Propenofos. In a study

(Shalab *et al.*, 2012) fifteen insecticides against leaf miner was applied revealed that propenofos, cyfluthrin, lufenuron, chlorpyriphos-methyl, and indoxacarb were the most toxic compared to other chemicals, hence these results are apparently contrast with our results. In the present study, the efficacy of the tested insecticides reduced gradually after 8 days of spray in all treated plots which showed similarity with results documented by Santos *et al.*, (2011) who noted the reduced mortality percentage (96.1% to 91.4%) of pest after three days of chlorfenapyr application indicated the effectiveness of this chemical against *T. absulata*, but alter seven days of spray mortality was reached to 93.3%.and 93.6%.

Table 4. Effectiveness of various insecticides against tomato leaf miner *T. absoluta* infestation on tomato plants before and after the treatment of 2nd spray.

			Post-treatment observations			Mortality percentage		
Variety	Treatment	control	1 Day	4 Days	8 Days	1 DPT	4 DPT	8 DPT
Superman	Propenofos	5.88±1.99	2.46±1.82*	2.08±1.35***	2.71±2.13	58	65	54
Superman	Chlorpyrifos	6.30±1.86	3.18±1.92	1.88±1.86	3.10±1.80	50	70	50
Superman	Chlorfenapyr	6.60±1.70	2.80±2.36	2.10±2.46	2.90±2.08	57	68	56
Shalkot	Propenofos	5.20±1.82	1.85±1.83	1.05±1.58	2.01±1.63	64	79	47
Shalkot	Chlorpyrifos	5.30±2.14	2.05±2.28	0.45±0.69	1.90±2.12	61	91	64
Shalkot	Chlorfenapyr	6.10±1.96	0.26±0.48	0.15±0.36	0.58±0.78	95	97	90

Data were represented in mean ± std, * show P <0.5, ** show P<0.001, *** show P<0.0001 and DPT mean days post-treatment.

It was further observed that chlorfenapyr showed potency increasing till 3 days but falling after 4 days of application. Hence, all the three tested insecticides revealed variable insecticidal effect on *T. absoluta* which could be due to their variation in chemical nature, ecological factors as well as their targeted tissues in the body of insects and absorption permeability of pesticides by the host plant (Ahmed and Sajjad, 2015). Therefore, the efficacy of each insecticide is influenced independently by these mentioned factors against the same pest.

The efficacy of chlorfenapyr was highest comparatively on both varieties (Super-Man and Shalkot) of tomato against *T. absoluta* but in a slightly different ratio. These results are in agreement with findings of Giorgini *et al.* (2019), Gontijo *et al.* (2013), who also concluded that Chlorfenapyr is highly effective insecticide when applied against the larval forms of *T. absoluta* in field (Table 3).

The larval infestation in all treated and untreated plots was recorded higher in super-man variety cultivated plots than shalkot variety of the host plant (Table 4). Resultantly these results revealed the fact that the exotic Super-Man tomato variety was more susceptible to leaf miner than Local shalkot variety. The differential resistance against pests has also reported by (Lata *et al.*, 2010), that antibiosis was the main mechanism of exhibiting tolerance to insect pests (Leite *et al.*, 2001).

On the other hand they noted that relative resistance of tomato cultivars comes from the combination of different resistance mechanisms, i.e., morphological chemical as well as the physiological character of different cultivars. Ashfaq *et al.* (2012) also testified that various characteristics of tomato crops such as hair length and hair density on the lower leaf surface, as well as the thickness of leaf outer surface significantly interrelated with larval density and fruit infestation.

Applying multiple control tactics reduces the reliance on pesticides hence minimizing the need for chemical control (Ram, 2012). Botanicals and production of resistant tomato cultivar varieties as control strategies for protection from *T. absoluta* (Oliveira *et al.*, 2012). So, growing resistant tomato varieties is an essential part of the IPM method.

Conclusion

Chlorfenapyr (36 SC) gave the best results followed by propenofos, and chlorpyrifos applied after 4 days interval than all other mentioned intervals against the pest. Moreover, shalkot tomato variety was found to be more resistant against leaf miner than super-man variety, therefore, Chlorfenapyr 0.25 ml/L of water is recommended against leaf miner in district Quetta, Balochistan province, Pakistan. For the protection of tomato crops, leaf miner larvae should regularly be monitored if the population enhanced by 3 mines (larvae) per plant, the crop should be sprayed with recommended insecticide on the recommended dose. The spray application can be repeated if the leaf miner population exceeds this number.

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