RESEARCH ARTICLE

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Insecticidal Effects of Some *Bacillus thuringiensis* Commercial Biopreparats on the Larvae of the Tomato Leaf Miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae)

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Abstract

Effects of 5 commercial biopreparats named; Dacron®, Florbac®, Dipel®, Delfin® and Rebound® containing different *Bacillus thuringiensis* (*Bt*) strains on the 3rd instar larvae of the tomato leaf miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) were determined under laboratory conditions. *T. absoluta*, tomato (Gusto F1) variety and some commercial biopreparats were used as materials in the study. Production of *T. absoluta* larvae were performed under the conditions of the growth chambers where the tomato variety was grown (25±1°C, 60±5% RH and 16:8 photoperiod). Under laboratory conditions, 1, 3 and 5% concentrations of commercial biopreparats were applied on the 3rd instar larvae of the pest, and the experiment was carried out with 5 replications according to a randomized parcels design. As a result of the application of 1% IU/mg concentrations of Dacron® and Delfin® commercial biopreparats, 100% mortality rate was determined in the 3rd instar larvae of *T. absoluta* on the 7th day counts. When 3 and 5% IU/mg concentrations of all commercial biopreparats were applied, a mortality rate of 100% was recorded on the 3rd instar larvae of *T. absoluta* on the 5th and 7th day counts. *In-vitro*, as the concentration of commercial biopreparats increased, mortality rate of the 3rd instar larvae of *T. absoluta* increased. However, it would be appropriate to conduct field trials with the same commercial biopreparats to recommend their use of them commercially.

Keywords: *Bacillus thuringiensis*, *Tuta absoluta*, Mortality rate, Biopesticide

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an annual vegetable crop in the Solanaceae family. It is one of the important sources of income in the regions where it is grown. Various problems are encountered in tomato production, such as plant nutrition, irrigation, diseases, pests and weeds' control (Duman, 2016). The tomato leaf miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae), is among the economic pests that cause quality and quantity losses in tomato crop (Anonymous, 2016). The first record of *T. absoluta* in Turkey was in Izmir in 2009 and later it spreaded to other regions (Kılıc, 2010). Although different control methods such as: cultural, biological, biotechnical and chemical control are used for pest control, chemicals are preferred due to their easy application and high effect in a short time. But in this context, many chemical insecticides have been reported creating resistance in the pests (Siqueira et al., 2000). Besides, use of these chemicals, resulted in negative effects on the environment and human health (Durmusoglu et al., 2010). Biological control is among the safe alternative cont-

rol methods applied (Zappala et al., 2013). Among biological control agents, the entomopathogens cause the death of the insects effectively (Karabörklü et al., 2018). *Bacillus thuringiensis* (*Bt*), the most widely used bacterial bioinsecticide among entomopathogens, is a gram positive bacteria in the Bacillaceae family (Feitelson et al., 1992). It is reported that *Bt* is used for the control of pests from orders Lepidoptera, Coleoptera, Diptera, Hymenoptera, Homoptera, Orthoptera and Mallophaga. This bacteria produces specific crystal protein inclusions (δ endotoxin) with toxic insecticidal effects for the control of pest species (Pazos and Salamanca, 2007). Because of this feature, *Bt* has become the most important biopesticide in the world market. It has been reported that *Bt* preparations applied in powder form on tomato plants grown in greenhous and fields are effective (Youssef and Hassan, 2013). The present study aimed to evaluate the effects of commercial biopreparats containing different strains of *Bt* on the 3rd instar larvae of *T. absoluta* under laboratory conditions.

MATERIALS AND METHODS

Tomato plants

Tomato seedlings of Gusto F1 variety (10-15 cm), obtained from a private seedling company, were used in the experiments. Tomato seedlings were transplanted into (20-25 cm diameter) plastic pots containing a 1:1 mixture of soil and peat. The planted tomato seedlings were irrigated periodically and maintenance procedures were carried out. During the growing period, no fertilization or chemical control was used in case of diseases and/or pests.

Producing of Tuta absoluta

The leaves infested with *T. absoluta* from tomato fields in Çivril district of Denizli province were brought to the laboratory in plastic storage containers with a paper bag. Infestation was ensured by leaving the larvae in the galleries from the leaves and leaving them on clean tomato plants in a climate room. Thus, the production of the tomato lifeminer was continued with the transfer of clean tomato plants to the growth chamber at regular intervals. The production of tomato plants and tomato lifeminer was carried out in the growth chambers of Pamukkale University Faculty of Applied Sciences, Department of Organic Farming Business Management, at 25±1°C, 65±5% RH and 16:8 hrs photoperiod.

Commercial biopreparats used

Commercial biopreparats containing different strains of *Bt* used in the experiments were obtained from companies. Information of the commercial biopreparats used in the experiment are given in Table (1).

Efficacy of the commercial biopreparats

In order to determine the effects of the commercial biopreparats on the tomato leaves, the experiment was carried out with 5 replications according to randomized parcels design. For this purpose, a layer of blotter paper was placed inside the plastic Petri dish (10 cm diameter) and a compound tomato leaf was placed on it. Five individuals of the 3rd instar *T. absoluta* larvae were placed on tomato leaf. 1, 3 and 5% IU/mg concentrations of each biopreparat were sprayed 3 times, from a distance of 15-20 cm, with the help of a hand sprayer. The experiments were carried out in growth chambers with 25±1°C, 65±5% RH and 16 hrs photoperiod.

Statistical analysis

Data obtained were analyzed one-way ANOVA and to calculate the differences between groups, the Tukey multiple comparison test ($P < 0.05$) was used. Using the IBM SPSS® (Version 20.0, August 2011, SPSS Inc., Chicago, IL, USA) statistics program version. The mortality rates of treated *T. absoluta* larvae were corrected by (Abbott, 1925).

RESULTS

Effects of 1, 3 and 5% IU/mg concentrations of commercial bioprepares containing different strains of *Bt* on the 3rd instar larvae of *T. absoluta* are given in Table (2). As a result of 1% dose applications of commercial bioprepares, the highest mortality rates were determined in Rebound® commercial biopreparat with 40.00% on the 1st day counts, in Delfin® commercial biopreparat with 96.00% on the 3rd day counts, and in Dacron® and Delfin® commercial biopreparats with 100% on the 7th day counts. As a result of 3% dose applications of commercial bioprepares, the highest mortality rates were detected in Dacron® and Dipel® commercial biopreparats with %44 on the 1st day counts, and 100% on the 3rd day counts in Dipel® commercial biopreparats. On the 5th and 7th day counting results of the trial, 100% mortality rate was recorded in all commercial biopreparats. As a result

Table 1. Content and active ingredient ratio of commercial biopreparats used in the experiment

Trade name	Active ingredient	Active ingredient ratio
Dacron® WP	*Bacillus thuringiensis berliner var. kurstaki*	32000 IU/mg
Florbac® WG	*B. thuringiensis var. aizawai* strain ABTS-1857	35000 DBM/mg
Dipel® DF	*B. thuringiensis subsp. kurstaki* ABTS-351	32000 CLU/mg
Delfin® WG	*B. thuringiensis berliner var.* kurstaki	32000 IU/mg
Rebound® WP	*B. thuringiensis var. kurstaki*	16000 IU/mg

of 5% dose applications of commercial bioprepares, the highest mortality rates on the 3rd day counts were determined in the commercial biopreparats Delfin® (100%), Dacron® (96%), Rebound® (96%) and Dipel® (91%). These commercial biopreparats were statistically at the same group. On the 5th and 7th day counts, 100% mortality rate was determined in all commercial biopreparats (Table 2).

Table 2. Effects of commercial biopreparats on the 3rd instar larvae of *Tuta absoluta*

Biopreparats	Time Intervals (Days)							
	1st		3rd		5th		7th	
	NLI	Effect%	NLI	Effect%	NLI	Effect%	NLI	Effect%
	1% IU/mg Concentration							
Dacron®	4.40a	12.00	0.60bc	88.00	0.00b	100.00	0.00c	100.00
Florbac®	5.00a	0.00	2.40bc	52.00	0.80b	84.00	0.20bc	96.00
Dipel®	4.80a	4.00	0.80bc	84.00	0.20b	96.00	0.20bc	96.00
Delfin®	4.80a	4.00	0.20c	96.00	0.20b	96.00	0.00c	100.00
Rebound®	3.00b	40.00	1.60bc	68.00	1.60b	68.00	1.00bc	80.00
Control	5.00a	-	5.00a	-	5.00a	-	5.00a	-
	3% IU/mg Concentration							
Dacron®	2.80bc	44.00	0.40bc	92.00	0.00b	100.00	0.00b	100.00
Florbac®	4.80a	4.00	0.20c	96.00	0.00b	100.00	0.00b	100.00
Dipel®	2.80bc	44.00	0.00c	100.00	0.00b	100.00	0.20b	100.00
Delfin®	4.60a	8.00	1.20b	76.00	0.00b	100.00	0.00b	100.00
Rebound®	4.20a	16.00	0.40bc	92.00	0.00b	100.00	0.00b	100.00
Control	5.00a	-	5.00a	-	5.00a	-	4.40a	-
	5% IU/mg Concentration							
Dacron®	3.20a	36.00	0.20c	96.00	0.00b	100.00	0.00b	100.00
Florbac®	3.60a	28.00	2.20b	52.00	1.00b	100.00	0.20b	100.00
Dipel®	3.80a	24.00	0.40c	91.00	0.00b	100.00	0.20b	100.00
Delfin®	4.00a	20.00	0.00c	100.00	0.00b	100.00	0.00b	100.00
Rebound®	4.60a	8.00	0.20c	96.00	0.20b	100.00	0.00b	100.00
Control	5.00a	-	4.80a	-	4.40a	-	4.40a	-

*The means followed by the same letters within columns are not significantly different from each other according to Tukey's HSD (P< 0.05). NLI: Number of living individuals.

DISCUSSIONS

Studies have shown that *B. thuringiensis* var. *kurstaki* (*Btk*) isolates were found to be effective on all larval instars of *T. absoluta* (Giustolin et al., 2001; Cabello et al., 2009). In another study conducted with B1, B2, B3 and B4 isolates of *Btk*, the highest mortality rates were determined were 93.3, 90, 86.7 and 80% for 4th instar larvae, respectively (Youssef and Hassan, 2013). It was determined that *T. absoluta* damage was reduced by 98% as a result of the application of Turex®, Dipel DF® and Costar® commercial biopreparats containing *Bt* to tomato leaves under laboratory conditions (Gonzalez-Cabrera et al., 2011). As a result of the application of *Bt* (0.5 g/l) isolate under laboratory and greenhouse conditions, a mortality rate of 55-65% was recorded in the 2nd instar larvae of *T. absoluta* (Jallow et al., 2018).

One day after the application of (*Bt*) isolate at a concentration of 10^6 cells/ml to *T. absoluta* larvae using the spray method, the highest mortality rates were recorded in the 2nd and 3rd instar larvae (Rezaei and Talaei-Hassanlous, 2016). Alsaedi et al. (2017) applied 10^6 cells/ml concentration of *Btk* isolate to the 1st, 2nd, 3rd and 4th instar larvae

of *T. absoluta* and they have reported that the highest mortality rates were 20, 22.66, 18.66 and 23.33%, respectively.

It was reported that the damage of *T. absoluta* decreased by 91.92% as a result of the application of *Btk* (*Bt*, Delfin® WG, 32000 IU/ mg) -(100 g/hl) + granulated sugar (150 g/hl) in greenhouse conditions (Doganlar et al., 2015). In a study conducted by Satıs (2013) under field conditions, the rate of *T. absoluta* contamination was recorded as 14.8% in the plot where Rebound® (*Btk*, 150g+100g sugar/100 l water concentration) was applied, and as 28.2% in the control plots. In another study conducted under field conditions, a mortality rate of 75.9% was determined with Dipel®2X (*Btk*, 6.4%, 100 g/100 l concentration) (Moussa et al., 2013). As a result of the highest rate of application of Costar®, one of the commercial preparats, under field conditions, reported that the 3rd instar larvae showed higher sensitivity than the 2nd instar larvae (Tsoulnara and Port, 2016). In another study, the commercial preparats were 70% effective for Delfin® and 59% for Rebound at the licensed concentration (Catalbudak et al., 2018).

CONCLUSIONS

It was concluded that the 1% dose applications of commercial biopreparats named: Dacron®, Florbac®, Dipel®, Delfin® and Rebound® applied against the 3rd instar *T. absoluta* larvae, under laboratory conditions, where caused 100% mortality by Dacron® biopreparat on the 5th day counts and Delfin® commercial biopreparats on the 7th day counts. 3 and 5% dose applications of all commercial biopreparats used against tomato lifeminer were recorded 100% mortality on the 5th and 7th day counts. The resulted percentage of mortality increased by increasing the concentration of the commercial biopreparats tested. Evaluation of the tested commercial biopreparats under field conditions is needed.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

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Data availability

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Consent for publication

Not applicable.

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