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Research Article

Field efficacy of biorational insecticides, azadirachtin and Bt, on *Agrotis segetum* (Lepidoptera: Noctuidae) and its carabid predators in the sugar beet fields

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Abstract: *Agrotis segetum* (Denis & Schiffermüller) is an important polypahgous pest of sugar beet fields in many regions of world including Iran. Biorational pesticides are good and safe alternatives to the chemical insecticides which are compatible with goals of IPM programs. In this study, efficacy of three biorational pesticides, Azadirachtin (NeemAzal®), Bt (Bactospeine®) and Bt (Biolep®), and a conventional chemical insecticide, deltamethrin (Decis® EC), was studied on pest population and damages as well as carabid beetle population as its important predators in sugar beet field during two agricultural seasons (2015 and 2016). Sampling of the pest egg batches, larvae and the carabid beetles was carried out at 1 day before treatment (DBT) and 1, 3, 7 and 10 days after treatment (DAT). Finally, total yield and sugar content of sugar beet in the different treatments were evaluated for the two agricultural seasons. Results showed that NeemAzal was a significant oviposition deterrent for female moths of *A. segetum*. During both agricultural seasons, the highest and lowest larvicidal effects were observed in Decis and Bt (EC) treatments, respectively. Ten DAT, 40, 60, 13 and 73% reductions of pest population larvae were observed were observed in NeemAzal, Bt (WP), Bt (EC) and Decis treatments, respectively. Sugar beet yield in all treatments was significantly higher than control. Total yields in NeemAzal, Bt (WP), BT (EC) and Decis treatments were 17.5, 25.6, 12.9 and 43.7% more than control in 2015 and 8.7, 19.7, 4.8 and 37.1% respectively in 2016. But sugar content in the different treatments was not significantly different. Totally, the most adverse effects on carabid beetles were recorded in Decis® treatment.

Keywords: Chemical control, biological control, Deltamethrin, cut worm

Introduction

The common cutworm (turnip moth), *Agrotis segetum* Denis & Schiffermüller (Lep., Noctuidae) is a polyphagous pest with a current host distribution covering 25 Families of plants. The pest was reported throughout Europe, parts of Africa and Asia (Jakubowska *et al.* 2005) including in all geographical regions of Iran (Feizpoor et al., 2014). After emergence, the larva feeds on the epidermis of the leaves, bites stems of seedling and cuts them, sometimes eats up the entire seedling through the stem at ground

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level and their habit changes according to their growth. It attacks the young seedling at night as a nocturnal cutworm and during the day hides and lives inside the cracks, holes and litter or in the soil sometimes to a depth of up to 10 cm. The cutworm usually causes 20-37% reduction in yield (Atwal, 1976). Due to subterranean habits of the pest, its chemical control is very difficult (Bowden *et al.*, 1983). Nevertheless, cutworms are presently managed through application of chemical insecticides with different modes of action. But, applications of these chemicals has serious drawbacks, including reduced profits from high insecticide costs, side effects on natural enemies, development of resistance in populations and environmental pollution (Viji and Bhagat, 2001). Therefore, these adverse effects evoked the scientists to explore new ways of insect control with comparatively less persistent, safer but effective insecticides (Pedigo, 2002). Azadirachtin and Bt, are applied as two insecticides to control noctuid pests (Singh *et al.*, 2007). *Bacillus thuringiensis* Berliner subspecies *Kurstaki* has been applied to control lepidopteran pests for approximately 60 years (Schmidt, 2009). Neem or its main active ingredient, azadirachtin, is an environment-friendly botanical insecticide which affects the insects' reproductive organ, body development and other endocrine systems (Senthil-Nathan, 2013). The biorational pesticide is bio-degradable, mildly toxic or non-toxic to other biocontrol agents has and is usually of a low toxicity to humans and mammals (Schmutterer, 1990).

Deltamethrin as the most powerful synthetic pyrethroid has very broad-spectrum control and affects the insects' transmission of messages sent from the brain by blocking nerve impulses and causing paralysis, which leads to fast knockdown when poisoning lasts more than a few hours (Hasibur *et al.*, 2014).

Biological control by natural enemies (NEs) is main strategy in IPM programs. One of the major criteria for selection of a suitable pesticide in IPM program is its compatibility with NEs and biocontrol agents (Pedigo, 2002). Many natural enemies are active against *A. segetum* in sugar beet fields, especially carabid beetles.

The objective of the present experiments was to investigate effects of three insecticides and deltamethrin, as a conventional chemical, on *A. segetum* and carabid beetles as its important NE under field conditions.

Materials and Methods

Experimental design

The present experiment was carried out at the farmer's field of Ghale Salim, Chaharmahal and Bakhtiari province, Iran (32°32'35.8"N 50°45'46.4"Ealtitude and 2054 m above sea level) during two agricultural seasons, 2015-2016. Sugar beet seeds, cultivar Took an, were planted at rate of 2kg/ha. All agronomic practices like growing, fertilizing, weeding and irrigation (every 7 days) of sugar beet followed according to agriculture organization advisement of Chaharmahal and Bakhtiari province. The experimental plot area was 150m^2, row to row spacing 0.3m, plot to plot distance 0.5m and between the blocks, 1m. The experiment was done in a randomized complete block design.

Azadirachtin (NeemAzal® T/S EC 1), Bt (WP 90), MVP Bactospeine subsp. Kurstaki; Bt (Biolwp®EC, 10^{8}cells/ml), and deltamethrin, (Decis® EC 2.5) were applied at the rates of: 2 liter/ hectare, 2kg/hectare, 2 liter/ hectare and 1 liter/hectare, as per manufacturer's recommendation, respectively.

Ten days after peak of the moth flight (25 June 2015 and 29 June 2016), the treatments were performed. Treatments were applied using a hand operated knapsack sprayer having 20 liters capacity fitted with hollow cone nozzle. Control plots were sprayed with water only. The equipment was set to deliver 1000L/ha, following the growers' usual practice.

Sampling

Ten plants were randomly selected per treatment/plot by traveling in an X-shaped pattern through each plot and all developmental stages of the pest from upper, middle and lower

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portions of plants were weekly recorded. In each sampling date, 10 plants were sampled per plot. Two sex pheromone lures (Avan Mashregh Zamin Company, Iran) were placed inside Delta sticky traps and the male flight activity was weekly monitored.

Sprayings started with beginning of *A. segetum* mass trapping. Density of the pest larvae on sample leaves were evaluated 1 day before treatment (DBT) and 1, 3, 5, 7 and 10 days after treatment (DAT). Sampled leaves were observed and egg patches as well as live larvae of *A. segetum* were counted. The percentages of *A. segetum* egg and larvae reductions were calculated according to Henderson and Tilton's equation (1955) to determine the field efficacy of the tested insecticides during various days after treatments.

$$\textit{Efficacy}\ (\%) = (1 - \frac{Cb \times Ta}{Ca \times Tb}) \times 100$$

Where Cb and Ca are the number of insects in control plots before and after treatment and Tb and Ta are the number of insects in treated plots before and after treatment, respectively

Harvesting was done on 17th October and 16th November in experiments of 2015 and 2016, respectively and total yield was separately weighed in each plot. Twenty kg of sugar beet were randomly selected from each treatment and sent to sugar content determination unit of sugar factory of Chaharmahal and Bakhtiari province.

Density of carabid beetles (Col., Carabidae) in each treatment was monitored by pit fall traps. One pit fall trap was randomly placed in each replication. Numbers of caught carabid beetles in each trap were recorded at 1 DBT and 1, 3, 7 and 10 DAT.

Data analysis

Randomized completed block design with four replications were used in the trials. Data obtained were submitted to analysis of variance (ANOVA) using F test and means were compared by Duncan's Standardized Range Test at 0.05 probability level. All analyses were done using SAS statistical software version 9.1 (SAS Institute, Inc., 2004).

Results

Effect of the insecticides on *A. segetum* and its damage

Among the insecticides, NeemAzal significantly reduced the pest egg batch in comparison with control. The number of egg batches in the other treatments had no significant difference in comparison to the control (Table 1). Therefore, it is demonstrated that NeemAzal was significant oviposition deterrent for female moths of *A. segetum*. NeemAzal treatment caused 85.1% reduction in egg patch number in 2016.

Also, there were significant differences in larval numbers in the various treatments at different DAT (Table 2 and 3). During both agricultural seasons, the highest and lowest larvicidal effects were observed in Decis and Bt (EC) treatments, respectively. In 2015, at 10 DAT, 45.4, 72.7, 45.4 and 90.9% larval reduction were observed in NeemAzal, Bt (WP), Bt (EC) and Decis treatments, respectively. In 2016, the reduction% were 35.7, 44.9, 6.9 and 47.8% in NeemAzal, Bt (WP), Bt (EC) and Decis treatments at 10 DAT, respectively. Results showed that Bt in EC formulations had no significant effect on larvae. Whereas, high insecticidal effect was recorded for WP formulation of Bt.

Results showed that in all insecticide treatments, yields of the sugar beet were significantly higher than control (Table 4). Among insecticides, the highest and lowest yields were observed in Decis and Bt (EC), respectively. Total yields in NeemAzal, Bt (WP), BT (EC) and Decis were 17.5, 25.6, 12.9 and 43.7% more than control during agricultural season of 2015 and 8.7, 19.7, 4.8 and 37.1% during agricultural season of 2016, respectively.

The results indicated that sugar content in the different treatments was not significantly different.

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Table 1 Percent population reduction of *Agrotis segetum* egg patch in NeemAzal, Bt (WP), Bt (EC) and Decis treatments at 1 day after treatment (DAT) in 2015 and 2016.

Year	Efficacy (%) (Mean ± SE)[1]				F ($df_{t, e}$)	P-value
	NeemAzal	Bt (WP)	Bt (EC)	Decis		
2015	5.7 ± 5.0	13.3 ± 3.3	19.1 ± 4.9	31.0 ± 13.0	0.53 (4, 12)	0.740
2016	85.1 ± 2.7a	20.8 ± 3.1b	71.9 ± 2.2a	16.0 ± 2.8b	4.32 (4,12)	0.009

1. Means with the same letters in each row are not significantly different at 0.05 (Duncan's multiple range test). No oviposition was observed at 3, 5, 7 and 10 DAT in all experimental treatments.

Table 2 Percent population reduction of *Agrotis segetum* larvae in NeemAzal, Bt (WP), Bt (EC) and Decis treatments at 1, 3, 5, 7 and 10 days after treatment (DAT) in 2015.

Date	Efficacy (%) (Mean ± SE)[1]				F($df_{t, e}$)	P-value
	NeemAzal	Bt (WP)	Bt (EC)	Decis		
1 DAT	20.0 ± 3.0bc	33.3 ± 12.4b	6.6 ± 3.6c	86.6 ± 0.2a	22.27 (4,12)	< 0.0001
3 DAT	46.6 ± 8.0b	66.6 ± 10.1ab	40.0 ± 13.2b	93.3 ± 23.1a	23.10 (4,12)	< 0.0001
5 DAT	50.0 ± 14.3b	83.0 ± 25.2b	0c	100a	29.87 (4,12)	< 0.0001
7 DAT	58.3 ± 14.9bc	66.6 ± 22.2abc	41.6 ± 11.2c	91.6 ± 28.5a	15.48 (4,12)	0.0001
10 DAT	45.4 ± 13.3b	72.7 ± 16.2ab	45.4 ± 13.3b	90.9 ± 24.8a	24.30 (4,12)	< 0.0001

1. Means with the same letters in each row are not significantly different at 0.05 (Duncan's multiple range test).

Table 3 Percent population reduction of *Agrotis segetum* larvae in NeemAzal, Bt (WP), Bt (EC) and Decis treatments at 1, 3, 5, 7 and 10 days after treatment (DAT) in 2016.

Date	Efficacy (%) (Mean ± SE)[1]				F ($df_{t, e}$)	P-value
	NeemAzal	Bt (WP)	Bt (EC)	Decis		
1 DAT	11.0 ± 1.5b	65.3 ± 18.3a	59.1 ± 15.9a	21.1 ± 6.0b	4.9 (4, 12)	0.006
3 DAT	6.5 ± 3.1c	21.0 ± 5.0b	14.2 ± 7.2bc	73.9 ± 20.1a	32.3 (4, 12)	< 0.0001
5 DAT	24.0 ± 10.0b	26.5 ± 9.5b	14.2 ± 7.2b	73.9 ± 20.1a	29.5 (4, 12)	< 0.0001
7 DAT	29.8 ± 13.4b	63.1 ± 11.2a	7.1 ± 3.0c	47.8 ± 20.0ab	28.3 (4, 12)	< 0.0001
10 DAT	35.7 ± 23.1a	44.9 ± 20.4a	6.9 ± 2.6b	47.8 ± 21.5a	27.9 (4, 12)	< 0.0001

1. Means with the same letters in each row are not significantly different at 0.05 (Duncan's multiple range test).

Table 4 Yield and sugar contents in different treatments during agricultural seasons 2015 and 2016.

Treatment	2015		2016	
	Yield ± SE (kg/m^2)[1]	Sugar content (%)	Yield ± SE (kg/m^2)[1]	Sugar content (%)
NeemAzal	4.72 ± 0.15bc	-	4.51 ± 0.10c	17.42 ± 4a
BT (WP)	5.05 ± 0.13b	-	4.97 ± 0.11b	18.42 ± 6a
BT (EC)	4.54 ± 0.12c	-	4.35 ± 0.13cd	17.67 ± 6a
Decis	5.78 ± 0.15a	-	5.69 ± 0.12a	17.41 ± 5a
Control	4.02 ± 0.12d	-	4.15 ± 0.10d	17.06 ± 6a
F	25.11	-	32.46	0.48
$df_{t, e}$	4, 12	-	4, 12	4, 12
P-value	0.0001	-	0.0001	0.75

1. Means with the same letters in each column are not significantly different at 0.05 (Duncan's multiple range test).

Effects of the insecticides on carabid beetles

After 1 and 3 DAT, the highest and lowest detected carabid beetles were observed in NeemAzal and Decis treatments (Table 5 and 6). Totally, the most adverse effects on carabid beetles were recorded in Decis treatment. There was no significant difference between carabid beetle numbers in the other treatments. Therefore, Decis is incompatible with IPM and NE conservation programs.

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Table 5 Population density of carabid beetles in NeemAzal, Bt (WP), Bt (EC) and Decis treatments at 1 day before treatment (DBT) and 1, 3, 5, 7 and 10 days after treatment (DAT) in 2015.

Date	Number of insects per pitfall trap (Mean ± SE)[1]					$F (df_{t, e})$	P-value
	NeemAzal	Bt (WP)	Bt (EC)	Decis	Control		
1 DBT	1.31 ± 0.09	1.31 ± 0.09	1.27 ± 0.21	1.18 ± 0.18	1.31 ± 0.09	0.97 (4, 12)	0.1300
1 DAT	1.31 ± 0.09	1.10 ± 0.13	1.27 ± 0.21	1.40 ± 0.10	1.40 ± 0.10	0.85 (4, 12)	0.5202
3 DAT	1.18 ± 0.18b	1.31 ± 0.09b	1.31 ± 0.09b	0.71 ± 0.00c	1.73 ± 0.08a	0.13 (4, 12)	0.0002
5 DAT	0.84 ± 0.13	1.18 ± 0.18	1.05 ± 0.21	0.84 ± 0.13	1.49 ± 0.09	2.61 (4, 12)	0.0887
7 DAT	1.09 ± 0.13b	1.18 ± 0.18b	1.31 ± 0.09ab	0.84 ± 0.13c	1.47 ± 0.16a	3.43 (4, 12)	0.0433
10 DAT	1.27 ± 0.21	1.18 ± 0.18	1.56 ± 0.13	1.05 ± 0.21	1.56 ± 0.13	2.70 (4, 12)	0.0816

1. Means with the same letters in each row are not significantly different at 0.05 (Duncan's multiple range test).

Table 6 Population density of carabid beetles in NeemAzal, Bt (WP), Bt (EC) and Decis treatments at 1 day before treatment (DBT) and 1, 3, 5, 7 and 10 days after treatment (DAT) in 2016.

Date	Number of insects per pitfall trap (Mean ± SE)[1]					$F (df_{t, e})$	P-value
	NeemAzal	Bt (WP)	Bt (EC)	Decis	Control		
1 DBT	1.40 ± 0.10b	1.05 ± 0.21b	1.47 ± 0.16ab	1.72 ± 0.14a	1.65 ± 0.06ab	3.47 (4, 12)	0.0419
1 DAT	1.65 ± 0.07a	1.40 ± 0.10b	1.56 ± 0.13a	0.84 ± 0.13c	1.47 ± 0.16b	6.45 (4, 12)	0.0052
3 DAT	1.47 ± 0.16a	1.18 ± 0.18a	1.27 ± 0.21a	0.71 ± 0.00b	1.36 ± 0.22a	3.96 (4, 12)	0.0283
5 DAT	1.18 ± 0.18	0.84 ± 0.13	1.09 ± 0.13	0.83 ± 0.13	1.05 ± 0.21	1.83 (4, 12)	0.1874
7 DAT	1.18 ± 0.18	0.84 ± 0.13	1.09 ± 0.13	0.83 ± 0.13	1.22 ± 0.00	1.95 (4, 12)	0.1663
10 DAT	1.18 ± 0.18	0.84 ± 0.13	1.18 ± 0.18	0.96 ± 0.15	1.4 ± 0.10	2.16 (4, 12)	0.1490

1. Means with the same letters in each row are not significantly different at 0.05 (Duncan's multiple range test).

Discussion

NeemAzal was significant oviposition deterrent to *A. segetum* moths. The findings are in line with the results of Greenberg *et al.* (2005) who demonstrated that neem based insecticides had significant oviposition deterrent effects on *Spodoptera exigua* Hubner (Lep., Noctuidae). Similar effects were reported for the azadirachtin on other noctuid moths such as *S. litura* Fabius (Naumann and Isman, 1995; Jayasankar et al., 2013), *Sesamia calamistis* Hampson (Bruce *et al*., 2004) and *Helicoverpa armiger*a Hübner (Packiam *et al*., 2012). In contrast, it is proved that the neem based insecticides were not significant deterrent to female moths of *Mamestra brassicae* L. (Seljasen and Meadow, 2006).

Decis and Bt (EC) had the highest and lowest efficacies against the pest larvae. Although, NeemAzal and Bt (WP) significantly reduced the larval densities. Decis, deltamethrin, is a broad spectrum chemical insecticide which is recommended for control of *A. segetum* in sugar beet fields of Iran (Jalalizand, 2016). Similarly, susceptibility of *Earias vitella* Fabricus (Lep., Noctuidae) to deltamethrin in cotton fields was reported by Jan *et al*. (2015). In spite of high efficacy of the insecticide against *A. segetum* larvae, its residues in sugar beet crop cause serious problem in sugar factory (Jalalizand, 2016). Also, resistance to the insecticide was previously recorded for some noctuid pests such as *Heliothis virescens* F. (Sayyed *et al*., 2008) and *H. armigera* (Alvi*et al.,* 2012; Hussain *et al*., 2014). In addition Decis had the highest adverse effect on the predator (Col., Carabidae). Therefore, other safer insecticides such as NeemAzal and Bt (WP) are recommended as better choices for use in sugar beet fields. Molting disruption and larval mortality of *Agrotis ipsilon* as well as anti-feedant properties were found by feeding on azadirachtin-sprayed creeping bentgrass (George and Potter, 2008).

Also it caused feeding activity reduction at 2.5 g/L, prolonging the period of molting, and 60% moltability reduction (Senthil-Nathan, 2013). Efficacy of azarirachtin based insecticides on some noctuid pests including *S. litura* (Nathan and Kalaivani, 2005), *S. littoral is* Biosduval (Pineda *et al*., 2009), *Trichoplusia ni* Hubner (Xian-Yan *et al*., 2010) and *H. armigera* (Abedi *et al*., 2014) has been previously documented.

Bt is a popular option for pest control. *Bacillus thuringiensis* is a Gram positive spore which produces proteinaceous crystals with insecticidal characteristics during sporulation that it makes Bt be distinct from other members of the *Bacillus cereus* group (Rasko *et al*., 2005; Zenas and Crickmore, 2012). Our findings agree with the laboratory experiment results of Gao *et al.* (2001), who showed that Bt is an effective biorational pesticide to control *A. fuscicoll* Miwa and other underground agricultural pests (Yaping *et al*., 2001). Similarly, the susceptibility of some other noctuid larvae including *H. armigera* and *H. punctigera* Wallengren (Liao *et al*., 2002), *Sesamia nonagrioides* Lefebvre and two populations of *Ostrinia nubilalis* Hübner to endotoxins of Bt were reported. These findings are in agreement with ElShafie and Abdelraheem (2012) who reported that the average yield of potato treated with NeemAzal®, a formulation of azadirachtin, was increased in comparison to control.

Our investigations showed that the least and most adverse effects on carabid beetles, as an important NE of *A. segetum*, were observed in the NeemAzal and Decis treatments.

The repellency, anti-feedant, deterrence activities (Mochiah *et al*. 2011), and safety to the beneficial insects make neem a sufficient pesticide for control of *A. segetum.* Several laboratory investigations have showed that azadirachtin is active against certain types of pestiferous insects but it doesn't harm several types of beneficial arthropods (Stark, 1992). This finding is in conflict with results of Scalercio *et al.* (2009) who stated that azadirachtin had high side effects on coleopteran predators in olive orchards. But Rondon *et al*. (2013) proved that the densities of carabid predators in potato field treated with azadirachtin were similar to non-sprayed field. Similarly, it is demonstrated that carabid beetles in turf grass were not affected by azadirachtin treatment (Brudea, 2009).

Conclusion

In spite of the higher efficacy of Decis; NeemAzal and BT in WP formulation were recommended for the pest control due to their high toxicities and protective effects against the pest and low risk to the pest's predators including carabid beetles. Results of this study can be used in IPM program of *A. segetum* in sugar beet fields.

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کارایی مزرعه‌ای حشره‌کش‌های زیست‌سازگار آزادیراختین و Bt روی *Agrotis segetum* (Lepidoptera: Noctuidae) و شکارگرهای کارابید آن در مزارع چغندرقند

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چکیده: کرم طوقه‌بر *Agrotis segetum* (Denis & Schiffermüller) یکی از آفات مهم پلی‌فاژ مزارع چغندرقند در بسیاری از مناطق جهان از جمله ایران می‌باشد. به‌کارگیری آفت‌کش‌های زیست سازگار جایگزین خوب و کم‌خطر سموم شیمیایی می‌باشد که با اهداف برنامه IPM سازگار می‌باشد. در این مطالعه، کارایی سه حشره‌کش زیست‌سازگار آزادیراختین (نیم آزال)، BT (در فرمولاسیون پودر وتابل) ، Bt (در فرمولاسیون امولسیون) و یک سم شیمیایی رایج (دلتامترین با نام تجاری دسیس) روی جمعیت و خسارت این آفت و سوسک‌های کارابید (به‌عنوان شکارگران مهم آن) در مزرعه چغندرقند طی دو سال زراعی (۱۳۹۴-۱۳۹۵) مورد مطالعه قرار گرفت. نمونه‌برداری از توده‌های تخم و لاروهای این آفت و سوسک‌های کارابید در یک روز قبل از تیمار (DBT)، یک، سه، هفت و ده روز بعد از تیمار (DAT) صورت گرفت. در پایان، عملکرد کل و عیار قند محصول چغندرقند در تیمارهای مختلف در طی فصول زراعی مورد تحقیق ارزیابی شد. نتایج نشان داد که نیم آزال دارای خاصیت ضد تخم‌گذاری برای شب‌پره‌های ماده‌ی *A. segetum* بود. در طول هر دو فصل زراعی، بیش‌ترین و کم‌ترین اثرات حشره‌کشی به‌ترتیب در تیمارهای دسیس و Bt (امولسیون) دیده شد. ده روز بعد از سم‌پاشی، ۴۰، ۶۰، ۱۳ و ۷۳ درصد کاهش جمعیت لارو به‌ترتیب در تیمارهای نیم آزال، Bt (پودر وتابل)، Bt (امولسیون) و دسیس در مقایسه با تیمار شاهد دیده شد. میزان عملکرد کل در تمامی تیمارهای حشره‌کش به‌صورت معنی‌داری بیش‌تر از تیمار شاهد بود. میزان عملکرد کل در تیمارهای نیم آزال، Bt (پودر وتابل)، Bt (امولسیون) و دسیس به‌ترتیب ۱۷/۵، ۲۵/۶، ۱۲/۹ و ۴۳/۷ درصد در سال زراعی ۱۳۹۴ و ۸/۷، ۱۹/۷، ۴/۸ و ۳۷/۱ درصد در طول سال زراعی ۱۳۹۵ نسبت به شاهد بیش‌تر بود، ولی میزان عیار قند در تیمارهای مختلف آزمایشی اختلاف معنی‌داری نشان نداد.

واژگان کلیدی: کنترل بیولوژیک، کنترل شیمیایی، آزادیراختین، بی‌تی، دلتامترین، طوقه‌بر

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