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A New Trend for Controlling Tomato Leaf-Miner, *Tuta absoluta* (Meyrick)

Refat O. H. Allam[1], Amr M. M. Badawy[2]
1- Department of Plant Protection, Faculty of Agriculture, South Valley University, Egypt.
2- Zoology Department, Faculty of Science, South Valley University, Egypt.
E-Mail: Amr.badawy@Sci.svu.edu.eg

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ABSTRACT

The tomato leafminer, *Tuta absoluta* causing a huge economic problem in Egypt. The effects of Agree 50% WG, Avaunt 15% EC, Excellent 1.9% EC, Titan, Castor aqueous extract, K.Z oil, and Alboleum oil against the tomato leaf- miner, *T. absoluta* (Meyrick) were evaluated. Avaunt 15% EC is succeeded in *T. absoluta* management since it is initially reduced of the infestation were 80.42 and 78.29, respectively. Meanwhile, the total mean of reduction after 1, 3, 10, and 15 days were 79.20, and 79.26 respectively, for the 1st and 2nd spray. While the initial reduction of Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil were 80.68, 80.38, 79.70, 71.62, 72.44, and 70.68, respectively for 1st spray. Furthermore, the initial reduction of Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil were 80.76, 77.23, 77.30, 72.58, 70.00, and 69.98 for 2nd spray, respectively. The total mean of reduction for Avaunt 15% EC, Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil were 79.20, 74.71, 74.59, 72.72, 70.35, 69.15, and 64.96 for 1st spray, respectively. Although, the total mean of reduction for Avaunt 15% EC, Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil was 79.26, 74.73, 73.88, 73.40, 68.49, 67.47, and 62.27 for 2nd spray, respectively.

INTRODUCTION

Tuta absoluta, the tomato leafminer, invade a huge number of crops. it has grown into one of the cosmopolitan pests for tomato (Larrain, 1986) Lietti, *et al.*, 2005). Egypt and other countries in Africa were recorded as a spot of this pest infestation (Bloem & Spaltenstein, 2011). Larvae of *T. absoluta* attack tomato plants' parts, both yield and fruit quality can be significantly diminished by direct feeding of larvae, and consequently by pathogens arriving at tunnels causing fruit rot. Seriously compromised tomato fruits made them lose their commercial value(Robredo-Junco & CardenosoHerrero, 2008).

Controlling tomato leafminer is challenging, especially using traditional synthetic pesticides in the field. (Guedes & Picanço, 2012**;** Guedes & Siqueira, 2012**;** (Tomé *et al.*, 2012)**.** The extensive reliance on the use of synthetic pesticides instantaneously drives to insecticide resistance dilemma.(López & Botto, 2005; Duarte *et al.*, 2009; Silva *et al.*, 2011**;** Gontijo *et al.*, 2012**;** Guedes & Siqueira, 2012**;** Haddi *et al.*, 2012). Insecticide resistance problem and the rising concerns and constraints to pesticide practices have been endorsing

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the improvement and developing concerns in bioinsecticides or pesticides (Isman, 2006; Rosell *et al.,* 2008), which are effective in organic cultivation but controlling leafminer in tomatoes not yet taken in consideration.

The tetraterpenoid azadirachtin obtained from the neem has acquired limited attention even though its proclaimed insecticidal and behavioral response on agriculture pest (Naumann & Isman, 1995**;** Liang *et al.,* 2003**;** Riba *et al.,* 2003**;** Seljåsen & Meadow, 2006**;** Pineda *et al.,* 2009). Furthermore, azadirachtin is safer for biological control agents than insecticides (Medina *et al.,* 2004; Charleston *et al.,* 2006**;** Mordue *et al.,* 2010). The awareness of the safeness of azadirachtin towards natural enemies have been denounced (Gordon & Gimme, 2001**;** (Medina *et al.,* 2004**;** Cordeiro et al., 2010**;** Arnó & Gabarra, 2011**;** Biondi *et al.,* 2012), but the increase of pest-resistant to conventional pesticides developing so fast (Schmutterer & Ascher, 1995**;** Feng & Isman, 1995). consequently, insecticide alternatives remain more promising controlling practices than traditional synthetic insecticides.

Several research have studied the potential of *B. thuringiensis* in regulating *T. absoluta* (Mollá *et al.,* 2011**;** González-Cabrera *et al.,* 2011**;** Ladurner *et al.,* 2011**;** Sellami *et al.,* 2015). *Beauveria bassiana* was reported for its efficacy towards immature stages of *T. absoluta* (Gregorio *et al.,* 2009; Urbaneja *et al.,* 2009). Considering insufficient define biological agents are operating against tomato leafminer and to conquer the dilemma of resistance that may occur against biological agents. The use of ecofriendly and efficiently biodegradable plant products with natural insecticidal activity has elevate in recent years. Plant materials with insecticidal properties have been used to control insects all over the world for long time, because of their low toxicity to animal and humans. (Belmain *et al.,* 2001). Using of minerals' oils and *Bacillus thuringiensis* on *Tuta absoluta* was poorly studied on tomato fields in southern Egypt. Therefore, the present investigation may contribute to add some information about safe control of the pest, which in twin may help in achieving a successful control program for checking of the ravages of pests in tomato fields. The present work was undertaken to evaluate the efficacy of some pesticides and certain alternatives against the tomato leafminer, *T. absoluta* on tomato under field and laboratory conditions.

MATERIALS AND METHODS

Insecticidal Test Against *T. absoluta* Larvae Under Field Conditions:

The present work was carried out to evaluate the toxicity of Avaunt 15% EC, Excellent 1.9% EC, Agree 50% WG, Titan, aqueous extraction Castor (*Ricinus communis*), and two minerals oils (K.Z oil and Alboleum oil) at recommended concentrations, table (1) against *T. absoluta* associated with tomato plants during the summer cultivations of 2016/2017 and 2017/2018 seasons at the Experimental Farm, Faculty of Agriculture, South Valley University, Qena, Egypt. The Experimental design was a complete randomized block design with three replicates, and each replicate was 7m. long by 6m. wide (1/100 Fd). Tomato cultivars (Super Jakal) were cultivated in October.

The pesticides and their alternatives were sprayed using a knapsack sprayer with one nozzle, as foliar treatment, diluted with distilled water at the rate of 200-liter spray liquid per feddan. Two sprays were applied. The control plots were sprayed with distilled water. The experiment was established with randomized complete block design (RCBD) was performed with each treatment replicated 3 times. The control treatment was sprayed with deionized water as untreated. Avoid sampling circumference plants to ignore border effects. Leaves collecting always executed in the morning. Samples were randomly collected at cross direction per each plot at weekly intervals. Live and dead larvae were counted. The total number of larvae and mines was counted under the microscope.

Table 1: List of tested compounds against 3rd instar of *T. absoluta.*

Trade name	Active ingredient	Rate/Fd
Avaunt 15% EC	Indoxacarb (oxadiazine)	500 gm.
Excellent 1.9% EC	Emamectin benzoate	300 ml.
Agree 50% WG	*Bacillus thuringiensis* subsp.	50 ml.
Castor	Aqueous extract of *Ricinus communis*	100 ml.
Titan	Azoxystrobin nano materials	100 ml.
KZ Oil 95% EC	Mineral oil	3 L.
Alboleum oil 95% EC	Mineral oil	3 L.

To evaluate the effect of pesticides on *T. absoluta,* samples of 10 leaves were randomly picked from every single replicate. Sampled leaves representing upper, middle, and lower leaves of the chosen shoots, then placed in paper bags. All samples were transferred to the laboratory for inspection. Inspection of infestation was carried out 1 hour before the application, 1,3,7,10, and 15 days after spraying.

Percent reduction in infestation was calculated using (Henderson & Tilton, 1955).

% Reduction Percentage =100 {1-(Cb/Ca x Ta/Tb)}

Where:

T a = Aveg. % of infestation in treatment plots after spray.

C b = Aveg. % of infestation in check plots before spray.

T b = Aveg. % of infestation in treatment plots before spray.

C a = Aveg. % of infestation in check plots after spray.

Bioassay:

Bioassay was conducted in the (Plan Protection department Lab, Faculty of Agriculture, South Valley University).Ten larvae were placed in 120 mm Petri dishes. Aqueous dispersions of commercial insecticide formulations were used. Tomato leaf dip bioassay (Cahill, M. *et al.*, 2009). Dipping tomato leaves for 5 sec. in aqueous solutions of recommended insecticide concentrations while the untreated leaves were dipped in distilled water. Each treatment was replicated 6 times and mortality was recorded after 24, 48, and 72 hours.

Statistical Analysis:

Results for the bioassay were analyzed with SAS 9.2 using Duncan test at α= 0.05. Mortality rates of larvae were submitted to ANOVA test. For the Field experiment collected data were analyzed statistically for analysis of variance to determine the significant difference among the treatments. Reduction percent was calculated according to the percent reduction in infestation (Henderson & Tilton, 1955), using LdP line software, (Bakr, 2005).

RESULTS AND DISCUSSION

Insecticidal Test Against *T. absoluta* Larvae Under Field Conditions:

The effects of Agree 50% WG, Avaunt 15% EC, Excellent 1.9% EC, Titan, Castor aqueous extract, K.Z oil, and Alboleum oil against the tomato leaf- miner, *T. absoluta* (Meyrick) were evaluated. The present data stated that tested insecticides could be arranged in descending order according to their potency as follows: Avaunt 15% EC > Excellent 1.9% EC > Agree 50% WG > Castor aqueous extract > Titan > K.Z oil > Alboleum oil According to the recommendation of the Egyptian ministry of agriculture for using insecticides and their alternatives in controlling pests, effective materials should give initial effect not less than 70% reduction and residual effect not less than 40% reduction (Anonymous, 2001)**.** Based on this recommendation, the result in Tables 2 and 4 showed that the recommended rate of Avaunt 15% EC is succeeded in managing *T. absoluta* since its initial reduction of the infestation were 80.42 and 78.29, respectively. Meanwhile, the total mean of reduction after one hour, 1, 3,5,7,10 and 15 days were 79.20 and 79.26 respectively, for the 1st and 2nd spray. while, the initial reduction of Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil were 80.68, 80.38, 79.70, 71.62, 72.44, and 70.68 for first spray. While, the initial reduction of Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil were 80.76, 77.23, 77.30, 72.58, 70.00, and 71.27 for 2nd spray, respectively. (Dağlı et al., 2012) stated that Avaunt 15% EC has a high impact on the larvae and the mortality was 100% this means that this Pest developed resistance towards this insecticide and we should do more investigations to find more effective compounds.

The total mean of reduction for Avaunt 15% EC, Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil were 79.20, 74.71, 74.59, 72.72, 70.35, 69.15, and 64.96 for 1st spray, respectively. While The total mean of reduction for Avaunt 15% EC, Excellent 1.9% EC, Agree 50% WG, Castor aqueous extract, Titan, K.Z oil, and Alboleum oil were 79.26, 74.73, 73.88, 73.40,68.49, 67.47, and 62.27 for 2nd spray, respectively.

Data in, table (2) showed that reduction percent of infestation by *T. absoluta* due to the application of tested pesticides and their alternatives indicated that Excellent 1.9% EC was the most effective compound in reducing the infestation. It exhibited that the initial reduction was 80.68 %. On the other hand, Castor aqueous extract exhibited 79.70 and 77.30 % in its initial effects of both sprays, respectively. These results agreed with those of (Chowański et al., 2014) stated that Insecticides extracted from plants have a harmful impact on the environment and create a low risk of insecticide resistance than synthetic insecticides; therefore, they can be proposed as a safe tool for controlling this pest.

Several problems have resulted from the intensive use of conventional pesticides for pest control such as insect resistance; outbreaks of pest population; destruction of non-pest species; environmental pollution and human health hazards. Nanomaterials and Plant extractions and mineral oils such as KZ oil and Alboleum oil could be considered promising alternatives to insecticides for use against *T. absoluta* and they are currently being marketed for that purpose in liquid and dust forms. These findings agreed with those reported by many investigators (Maurya & Malik, 2016)**.** Also, mineral oil might play an important role as effective alternatives (Helmy *et al.,* 2012)**.**

Data represented in tables (2 & 4) showed the initial reduction of K.Z oil and Alboleum oil were 72.44% and 70.68% for 1st spray and 70.00 % and 71.27 % for 2nd spray, respectively, and all of the used compounds are above 70% reduction. From these results, it should be suggested to employ some effective alternatives such as K.Z oil and Alboleum oil in controlling *T. absoluta* incompatible program with chemical insecticides instead of conventional insecticides. The initial deposit of Avaunt 15% EC, Excellent 1.9% EC, and Agree 50% WG were 80.42, 80.68, and 80.38 % for 1st spray. While it was 78.29, 80.67, and 77.23 % for the 2nd spray, respectively. This illustrates that the traditional insecticides exhibited outstanding potency in reducing infestation by *T. absoluta* as compared with the oils. However, this is not enough to recommend using these insecticides widely in controlling this pest species. It is better to suggest using alternatives of pesticides in controlling *T. absoluta* incompatible program with other controlling agents instead of the traditional insecticides alone.

Data stated in tables (2,3,4 & 5) indicated that all the used insecticides had affected the insect population. The most effective insecticide was Avaunt 15% EC while the

Alboleum oil was the least effective one. While the mean percent of reduction for one hour, 1, 3,5,7,10, and 15 days intervals were 72.72 and 73.40 % for both sprays, respectively. Data clearly show that there is a wide range in the response of the insects to the action of the seven tested compounds. It is noticeable that the percent reduction of infestation depended on the type of used compounds.

The present study recommends that Avaunt 15% EC insecticide was better than Excellent 1.9% EC, Agree 50% WG insecticides for managing *T. absoluta,* while Castor aqueous extract was better than Titan, K.Z oil and Alboleum oil and it should use as an alternative candidate. So that, Castor aqueous extract, K.Z oil, and Alboleum oil should be considered in integrated pest management (IPM) programs of *T. absoluta*.

Table 2: The reduction percentage of the selected compounds against Larvae of *T. absoluta* for the first spray**.**

Compounds	Rate / Fd.	Pre-spry count	% Reduction post-treatment (day)							Mean
			1 hr.	1	3	5	7	10	15	
Avaunt	500 gm.	68.33	80.42	89.83	86.15	75.88	77.36	71.55	73.25	79.20
Excellent	300 ml.	62.67	80.68	74.98	85.11	64.21	77.17	72.26	68.54	74.71
Agree	50 ml.	73.33	80.38	76.94	93.96	66.23	71.81	73.28	59.56	74.59
Castor	100 ml.	68.33	79.70	80.20	72.30	69.04	67.55	70.33	69.92	72.72
Titan	100 ml.	60.00	71.62	82.07	80.74	63.27	60.29	63.82	70.61	70.35
K.Z oil	3 L.	79.67	72.44	71.20	79.15	74.44	58.34	56.57	71.93	69.15
Alboleum oil	3 L.	58.00	70.68	72.70	77.34	67.29	64.00	50.58	52.15	64.96

Table 3: The reduction percentage of the selected compounds against Tunnels of *T. absoluta* for the first spray

Compounds	Rate / Fd.	Pre-spry count	% Reduction post-treatment (day)							Mean
			1 hr.	1	3	5	7	10	15	
Avaunt	500 gm.	65.00	80.33	72.84	88.73	74.18	67.41	68.93	66.21	74.09
Excellent	300 ml.	72.67	61.23	66.75	75.85	80.98	57.70	54.37	81.78	68.38
Agree	50 ml.	40.33	58.89	77.80	72.17	69.80	60.29	50.72	73.31	66.14
Castor	100 ml.	44.33	70.10	60.13	75.60	65.33	67.54	57.24	66.15	66.01
Titan	100 ml.	42.33	55.93	75.02	68.45	61.34	45.80	53.28	72.39	61.74
K.Z oil	3 L.	47.33	51.66	64.26	68.13	62.22	56.82	39.48	68.43	58.71
Alboleum oil	3 L.	36.67	54.70	58.86	48.23	56.43	37.19	41.18	52.07	49.81

Table 4: The reduction percentage of the selected compounds against Larvae of *T. absoluta* for the second spray

Compounds	Rate / Fd.	Pre-spry count	% Reduction post-treatment (day)							Mean
			1 hr.	1	3	5	7	10	15	
Avaunt	500 gm.	74.00	78.29	83.70	81.84	78.31	79.41	76.32	76.93	79.26
Excellent	300 ml.	74.00	80.67	75.95	88.27	67.10	70.62	76.50	63.99	74.73
Agree	50 ml.	67.00	77.23	74.71	78.46	62.52	78.04	76.59	69.61	73.88
Castor	100 ml.	70.00	77.30	79.83	68.84	69.73	71.33	74.30	72.49	73.40
Titan	100 ml.	61.33	72.58	77.72	70.35	68.51	58.96	62.40	68.94	68.49
K.Z oil	3 L.	79.33	70.00	67.48	73.17	71.43	59.57	58.94	71.71	67.47
Alboleum oil	3 L.	60.33	71.27	64.89	67.91	63.76	62.02	54.74	51.33	62.27

Table 5: The reduction percentage of the selected compounds against Tunnels of *T. absoluta* for second spray

Compounds	Rate / Fd.	Pre-spry count	% Reduction post-treatment (day)							Mean
			1 hr.	1	3	5	7	10	15	
Avaunt	500 gm.	59.33	69.85	70.53	79.94	71.50	65.49	67.49	63.24	69.72
Excellent	300 ml.	45.67	55.76	55.86	73.10	62.45	59.24	55.29	65.24	60.99
Agree	50 ml.	44.00	56.13	68.46	58.25	60.89	55.15	48.79	69.29	59.57
Castor	100 ml.	42.33	54.96	68.68	55.91	59.53	49.76	51.42	64.76	57.86
Titan	100 ml.	59.33	46.87	51.15	56.39	65.56	50.70	45.00	73.51	55.60
K.Z oil	3 L.	49.33	46.30	58.15	55.10	48.44	47.27	41.84	58.82	50.85
Alboleum oil	3 L.	42.67	54.64	53.55	45.62	48.36	46.56	48.48	55.32	50.36

Chemical methods have been the most common control method used by growers. However, the extensive usage of pesticides has caused negative effects, such as the selection of resistance biotypes, causing growers to increase dosages or repeated application for a short time that obtained less satisfactory results over time (Siqueira *et al.,* 2000)**.** The newer insecticide classes have provided good activity against this pest (Irac, 2010; Shahini *et al.,* 2021)**.** A rotation of compounds with different modes of action usually provides a sustainable and effective approach to managing insecticide resistance (Irac, 2009).

Bioassay:

Selected compounds were tested at lab conditions 26°C ±2 against *T. absoluta* 3rd instar larvae according to the recommended rates. Table (6) and fig (1) showed that Agree 50% WG was the most effective compound on the larvae for the 1st day of treatments with a 4.5 mean number of individuals. However, Titan was the least effective one 8.8. For the 2nd day, Avaunt 15% EC has the highest impact on larvae with 1.8 this result agreed with (Shalaby *et al.,* 2012) and Aqueous extract of Castor was the least effective compound 7.0 comparing with control. After the 3rd day Agree 50% WG was the most powerful compound for controlling *T. absoluta* larvae with 0.5 mean number of individuals. Moreover, aqueous extract of Castor was the same as 2nd day 6.7. From these results we recommend using the insecticide list that used in this bioassay, Agree 50% WG for controlling such a pest because of its ability to maintaining killing larvae within days as mentioned by (Khidr *et al.,* 2013; Balzan & Moonen, 2012 and Hafsi *et al.,* 2012) that *Bacillus thuringiensis* was the most effective in larval reduction percentage.

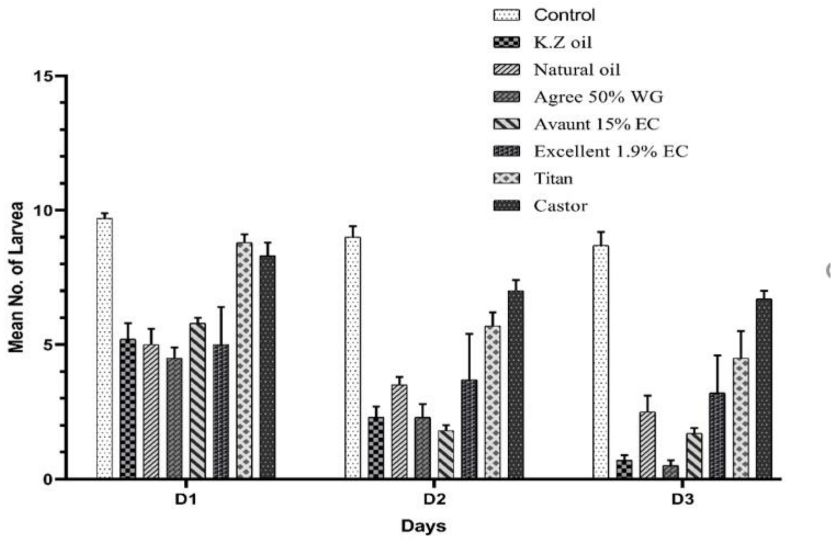

Fig.1: Mean number of individuals and SE for *T. absoluta* larvae after treated with tested compounds 3 days after treatment.

Table 6: Effect of tested compounds against *T. absoluta* larvae at laboratory conditions

Treatment	Day 1		Day 2		Day 3	
	Me	SE ±	Me	SE ±	Me	SE ±
Untreated	9.7	0.2	9.0	0.4	8.7	0.5
K.Z oil	5.2	0.6	2.3	0.4	0.7	0.2
Natural oil	5.0	0.6	3.5	0.3	2.5	0.6
Agree 50% WG	4.5	0.4	2.3	0.5	0.5	0.2
Avaunt 15% EC	5.8	0.2	1.8	0.2	1.7	0.2
Excellent 1.9% EC	5.0	1.4	3.7	1.7	3.2	1.4
Titan	8.8	0.3	5.7	0.5	4.5	1.0
Castor	8.3	0.5	7.0	0.4	6.7	0.3

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ARABIC SUMMARY

اتجاه حديث لمكافحة صانعة أنفاق الأوراق في محصول الطماطم

رفعت علوى حافظ علام [1] و عمرو محمد محمد بدوى[2]
[1] قسم وقاية النبات، كلية الزراعة بقنا، جامعة جنوب الوادى
[2] قسم علم الحيوان، كلية العلوم بقنا، جامعة جنوب الوادى

يهدف هذا البحث إلى دراسة وتقييم طرق وبدائل جديدة لمكافحة صانعة أنفاق الأوراق في الطماطم وتشمل استخدام مبيد اندوكسيكارب ومبيد ايمامكتين بنزوات بالإضافة لاستخدام بكتيريا الباسيلس ثيورنجنسيس والمستخلص المائي لنبات الخروع ومادة اذوكسيستروبين في صورة نانو وزيت معدنى كزد اويل وزيت معدنى البوليم اويل. تم تقييم فعالية طرق المكافحة على أساس نسبة خفض الإصابة فى يرقات الآفة وكذلك خفض عدد الانفاق وذلك بعد فترات ساعة و1، 3، 5، 7، 10 و15 يوم من كل معاملة. أوضحت النتائج ان مبيد افانت (اندوكسكارب) قد خفض نسبة الإصابة بإبادة فورية مقدارها 80.42 و78.29 على التوالي للموسم الأول والثانى وأمكن ترتيب فعالية المعاملات تنازليا كالاتى : افانت (اندوكسيكارب) ثم مبيد اكسيلنت (ايمامكتين بنزوات) ثم مبيد اجرى (بكتيريا *الباسيلس ثيورنجنسيس*) ثم المستخلص المائي للخروع ثم تيتان (اذوكسيستروبين) ثم كزد اويل ثم البوليم اويل بمتوسط نسبة إبادة 79.20، 74.71، 74.59، 72.72، 70.35، 69.15، 64.96 على التوالي للموسم الأول و 79.26، 74.73، 73.88، 73.40، 68.49، 67.47، 62.27 على التوالي للموسم الثانى. واظهرت النتائج ان جميع بدائل المبيدات المستخدمة نجحت في خفض نسبة الإصابة بإبادة فورية أكثر من 70% ولذا ينصح بإدراجها في برامج المكافحة المتكاملة لهذه الافة.