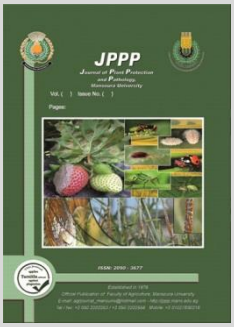
Journal of Plant Protection and Pathology

Journal homepage: www.jppp.mans.edu.eg
Available online at: www.jppp.journals.ekb.eg

Effectiveness of Different Formulations of Emamectin Benzoate, Indoxacarb, and Esfenvalerate Insecticides against *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) in El-Behera Governorate, Egypt

Salim, Y. M. M.*

Plant Protection Department, Faculty of Agriculture, Damanhour University, Damanhour, El-Beheira, PO Box 59, Egypt



ABSTRACT

Tomato pinworm (leafminers), *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is a difficult to control and an invasive insect pest that causes devastating damage to tomatoes. It was introduced in Egypt in 2009 from the North African Countries. Therefore, the availability of various management strategies is essential for tomato production in Egypt. The current study aimed to evaluate the insecticidal activity of different formulations of Emamectin Benzoate, Esfenvalerate, and Indoxacarb against *T. absoluta* under field conditions. All tested insecticides revealed elevated degrees of control of this insect in El-Behera Governorate. The management levels were > 74% and there were significant differences among the Emamectin Benzoate insecticidal formulations against *T. absoluta* compared to both Indoxacarb and Esfenvalerate after 10 days of spray in both seasons 2019 and 2020. The tested insecticides were found to be effective in controlling this insect for about 10 days after the spraying and could be recommended to be among the integrated management strategies.

Keywords: Tomato leafminer; *Tuta absoluta*; Insecticide Formulations, *Solanum lycopersicum*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is among the most economically important vegetables globally and is the most vegetable crop in Egypt (FAO 2020). It is a rich food commodity with phytochemicals, vitamins, minerals, and essential amino acids. The estimated annual global production in 2017 was 182 million tonnes (21 million tonnes in Africa), and tomato is the sixth most valuable cultivated crop, worth US$ 87.9 billion in 2016. In Africa, total production amounts to 37.8 million tonnes annually, with the biggest producers being Egypt, Nigeria, Tunisia, and Morocco (FAOSTAT 2020). Production of tomatoes is challenged by various pests and pathogens (Miyao *et al.* 2020).

Worldwide, *Tuta absoluta* (tomato leafminer) is one of the most devastating pests of tomatoes. It was firstly reported in South America then spread to Spain in 2006, and to Africa via Algeria, Morocco, and Tunisia in 2008 (Desneux *et al.* 2010). Its first report in Egypt was in 2009 (EPPO 2005). The *T. absoluta* infestation causes significant yield and quality losses of tomatoes and other crops. Losses are reflected as an economic loss through the reduction of marketable yield and indirectly through the increased production and pest management costs. In Egypt, it was reported that summer plantation that is harvested from the end of August to early September had the highest levels of infestation of *T. absoluta* (Saad *et al.* 2014) and the yield losses were reported to range from 11% to 100% (Moussa *et al.* 2013; 2018). Therefore, the harmful effects of *T. absoluta* are extended to consumers as the increased price of the commodity and the potential presence of elevated levels of pesticide residues due to the application of large quantities during the management of this insect pest (Desneux *et al.* 2007; Birhan 2018; Rwomushana *et al.* 2019).

The *T. absoluta* insect attacks, not only the green foliage but also the flowers and fruits which lead to partial or complete yield destruction. To manage this devastating insect, farmers apply various strategies of detection, monitoring, pheromone traps, pesticides (chemical, microbial, botanicals, and organic), destruction of infected plants, and biocontrol agents (Rwomushana *et al.* 2019). Due to the high infestation rates, growers apply large quantities of broad-spectrum insecticides, which might lead to widespread development of resistance, contamination of the fruits with pesticide residues, and human and environmental health hazards (Khalid 2011; Roditakis *et al.* 2018; Silva *et al.* 2011). Therefore, spraying effective and relatively safe insecticides would be desirable for the environment and consumers. The current study aimed to compare the effectiveness of different formulations of Emamectin Benzoate, Esfenvalerate, and Indoxacarb insecticides against *T. absoluta* during the most infected time of the year (the summer plantation) in two field seasons.

MATERIALS AND METHODS

Insecticides

The list of investigated insecticides including common and trade names, formulations, and rate of field application was presented in Table 1. Insecticides were obtained from the Central Agricultural Pesticide Laboratory, Department of Pesticide Residues and Environmental Pollution, Agricultural Research Center, Dokki, Giza 12618, Egypt.

* **Corresponding author.**
E-mail address: yehia.salim@agr.dmu.edu.eg
DOI: 10.21608/jppp.2021.58796.1012

Table 1. List of tested insecticides including common name, trade name, formulation, and field application rate as recommended by the manufacturer.

Common Name	Trade Name	Formulation[a]	Application rate
Emamectin benzoate	Loober®	5.7% WG	20 g/100 L
	Surrender®	5 % SG	120 g/Feddan
	Heberon®	5% SG	80 g/Feddan
	Benomactin®	5.7% SG	60 g/Feddan
	Egychem®	5.7% WG	80 g/Feddan
Esfenvalerate	Thunder®	5% EC	40 cm^3/100 L
	Fast®	5% EC	40 cm^3/100 L
Indoxacarb	Ebezo®	30% WG	60 /Feddan
	Vantage®	14.5% SC	25cm^3/100 L
	EbezoPlus®	30% WDG	60 g/Feddan
	Nsight®	30% SC	15 cm^3/100 L

[a]**WG: Water Dispersible Granule, SG: Water Soluble Granule, EC: Emulsifiable Concentrates, and WDG: Water Dispersible Granule (CIPAC 2020).**

Field location and experimental design

Field experiments were carried out during the 2019 and 2020 summer seasons at El-Galad village, Abou Hommos city, El-Beheira Governorate, Egypt. The field plots were designed as completely randomized design (CRD) with four replications. The plot size was 21 m^2 (1/200 of feddan), with 6 m length and 3.5 m width. The tomato variety that was used was AlissaF1. All other agricultural practices were applied at the recommendations of the Egyptian Ministry of Agriculture. Insecticides application was performed using a 20 L high-pressure agricultural power sprayer pump (Shyam Enterprises, Madhya Pradesh, India).

Fruit inspection for infestation with *T. absoluta*

The infestation rate was recorded before spray and after 1, 5, 7, and 10 days post-spraying. The mean number of larvae/25 sampled plants/replicate in each treatment compared to the untreated plots (control). Insecticides were sprayed two times in the same field season (the 2nd spray was applied 15 days after the 1st spray). All data were normalized and averaged. Percentages of reduction of infestation (efficacy percentages of management) were calculated using Henderson and Tilton (1955) equation from the average data of the two sprays.

$$\text{Efficacy (\%)} = \left(1 - \frac{n \text{ in Co before treatment} \times n \text{ in T after treatment}}{n \text{ in Co after treatment} \times n \text{ in T before treatment}}\right) \times 100$$

where: n: insect population, T: treated plot, and Co: control plot

Statistical analysis

Data were statistically analyzed as a one-way analysis of variance (ANOVA) and the least significant differences (LSD) were calculated using the Student-Newman-Keuls (SNK) method at probability level of 0.05 (SAS 2016).

RESULTS AND DISCUSSION

Numbers of larvae of T. absoluta that were found in tomato fruits were counted before and after the application of tested insecticides (Figure 1). After spraying Emamectin Benzoate-based formulations: Loober®, Surrender®, Heberon®, Benomactin®, and Egychem®, Esfenvalerate-based formulations: Thunder® and Fast®, and Indoxacarb-based formulations: Ebezo®, Vantage®, Ebezoplus®, and Nsight®, larval instars of T. absoluta were counted in 25 fruits of tomato/replicate. Numbers of the insect were significantly reduced to zero after 5 days of spray and lasted for more than 10 days for all tested formulations except for Egychem®, Fast®, Ibezo®, and Ibezoplus® that showed an average of 1.7 insects of the four replicates after 10 days of application on both 2019 and 2020 seasons.

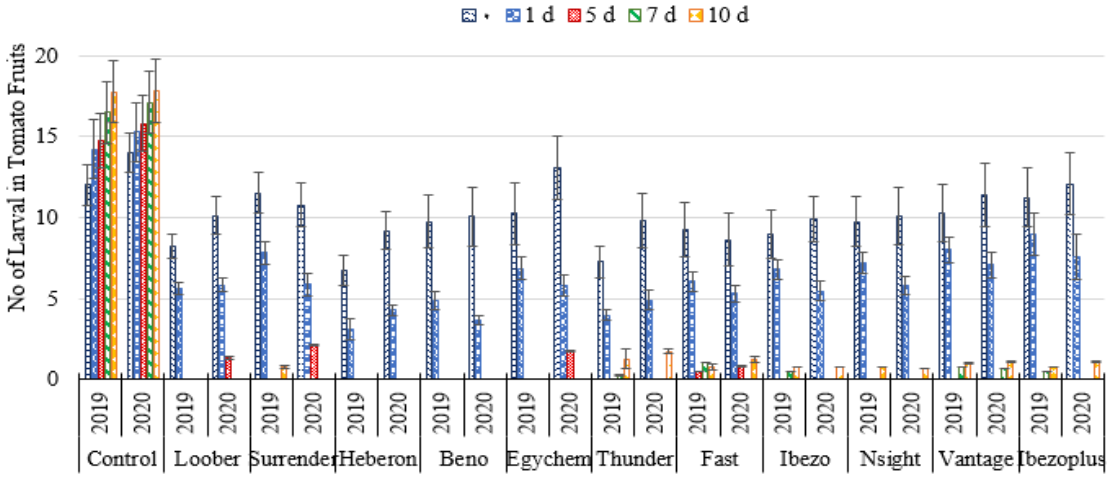


Figure 1. Average numbers of larval instars of *T. absoluta* in 4 replicates each of 25 tomato fruits before and after 1, 5, 7, and 10 days of field spray during the summers of 2019 and 2020 seasons.

The efficacy of control of *T. absoluta* using Emamectin Benzoate, Esfenvalerate, and Indoxacarb formulations during the summers of 2019 and 2020 seasons was presented in Table 2. It was obvious that Emamectin Benzoate formulations were significantly effective in controlling the *T. absoluta*, where their effects against the insect started early (after 1 day of spray) compared to Esvenvalerate and Indoxacarb formulations. After 1 day of

spray, the most effective insecticides were Heberon® and Benomactin® in 2019 and 2020 seasons, respectively. No differences were found between the different formulation of Emamectin Benzoate (Table 2). The efficiency of reduction of the insect population reached 100% after 5 days post-spray and was effective for a long time (up to 10 days) on both seasons. Except for the Surrender® formulation, which showed a 92% reduction of *T. absoluta* in 2019 but it killed 100% of the larval instars in 2020 after 10 days post-spraying. Current results were similar to those reported by Moussa *et al.* (2013), where they reported that Emamectin Benzoate at 5% SG gave 97% of reduction of *T. absoluta* after 10 days of spraying. Also, Saad *et al.* (2020) reported that Emamectin Benzoate mixed with Thiamethoxam were effective for controlling *T. absoluta*.

For esfenvalerate-based formulations: Thunder® and Fast®, there were significant differences in the management of *T. absoluta* (Figure 1 and Table 2). Percentages of reduction of *T. absoluta* larval numbers were significantly less for Fast® compared to Thunder® after 1 and 5 days of the field application but an opposite trend was noticed after 10 days of spray. After 7 days of spray, there were no differences between the two compounds in the efficacy of management of *T. absoluta*.

Also, Indoxacarb-based formulations were efficient in controlling the tomato leafminer insect for a prolonged time after the spray, but their action was started significantly after 5 days of spray (Table 2). Ibezo®, Nsight®, Vantage®, and IbezoPlus® provided an average reduction % of 32.9 to 37.8 after 1 day of spray for 2019 and 2020, respectively. However, a 100% reduction rate was reported after 5 and 7 days of spray in both 2019 and 2020 seasons. After 10 days of spray, the reduction rates of *T. absoluta* population ranged from 90 to 93 and 92.5 to 94.7% in 2019 and 2020, respectively (Table 2).

Average overall percentages of reduction percentages of *T. absoluta* larval insects in tomato fruits were significantly higher for Emamectin formulations compared with Esvenvalerate and Indoxacarb in both seasons with no differences between seasons (Figure 2). Heberon® and Benomactin® were the most effective compounds in managing the numbers of *T. absoluta*. Also, the comparison between different formulations of each insecticide on different field seasons did not show any differences. It was reported that indoxacarb has significantly controlled the larval infestations of *T. absoluta* in Spain (Russell 2009), in Italy (Garzia *et al.* 2009; 2012), in Malta (Mallia 2009), in Egypt (Shalaby *et al.* 2012; Hanafy and El-Sayed 2013) under field condition.

Table 2. Percentages of reduction of *T. absoluta* insect in tomato fruits after 1, 5, 7, and 10 days of spray Emamectin Benzoate, Esfenvalerate, and Indoxacarb insecticides and calculated using Henderson and Tilton equation (1955).

Insecticide	CN[a]	% of Reduction after 1, 5, 7, and 10 days of Spray															
		1				5				7				10			
		2019	±SD	2020	±SD	2019	±SD	2020	±SD	2019	±SD	2020	±SD	2019	±SD	2020	±SD
Loober®	EB	53.83	±6.25	47.286	±4.37	100	±9.81	88.27	±7.87	100.00	±9.81	100.00	±9.82	100.00	±12.54	100.00	±11.74
Surrender®	EB	42.61	±5.25	50.166	±4.11	100	±8.69	82.62	±7.61	100.00	±11.69	100.00	±9.74	92.32	±10.24	100.00	±10.93
Heberon®	EB	77.70	±8.87	57.292	±4.83	100	±11.31	100.00	±10.24	100.00	±11.70	100.00	±10.19	100.00	±14.34	100.00	±10.37
Benomactin®	EB	57.79	±4.25	66.652	±6.39	100	±11.34	100.00	±9.83	100.00	±12.34	100.00	±11.04	100.00	±14.21	100.00	±9.97
Egychem®	EB	43.52	±3.25	59.402	±4.01	100	±11.32	88.25	±7.65	100.00	±12.32	100.00	±10.83	100.00	±12.34	100.00	±10.34
Thunder®	EF	53.61	±4.05	54.202	±4.87	100	±10.85	100.00	±9.94	97.49	±11.85	100.00	±10.27	74.87	±11.23	86.31	±9.34
Fast®	EF	44.73	±3.25	43.658	±5.26	95.61	±8.01	91.49	±6.81	92.14	±8.01	100.00	±10.92	90.08	±9.98	89.00	±9.78
Ibezo®	IN	36.34	±2.25	49.862	±5.74	100	±9.98	100.00	±10.08	95.96	±8.98	100.00	±9.95	91.15	±10.78	93.74	±9.81
Nsight®	IN	37.77	±3.65	47.479	±5.97	100	±10.98	100.00	±10.34	100.00	±12.98	100.00	±10.18	91.64	±10.27	94.70	±9.97
Vantage®	IN	33.88	±4.25	43.122	±6.04	100	±10.22	100.00	±10.96	94.68	±11.20	95.11	±9.67	90.02	±10.24	92.49	±8.12
IbezoPlus®	IN	32.85	±3.45	42.659	±5.82	100	±11.85	100.00	±10.76	96.77	±11.18	100.00	±10.43	93.29	±10.58	92.72	±8.34
[b]$LSD_{0.05}$		5.71		6.38		6.49		6.12		6.53		5.89		5.47		5.63	

[a]CN: common name, EB: Emamectin Benzoate, EF: Esfenvalerate, IN: Indoxacarb, SD: standard deviation. Each mean within a year was the average of 2 sprays, and [b]LSD: least significant difference according to the Student-Newman-Keuls (SNK) method at $P \leq 0.05$.

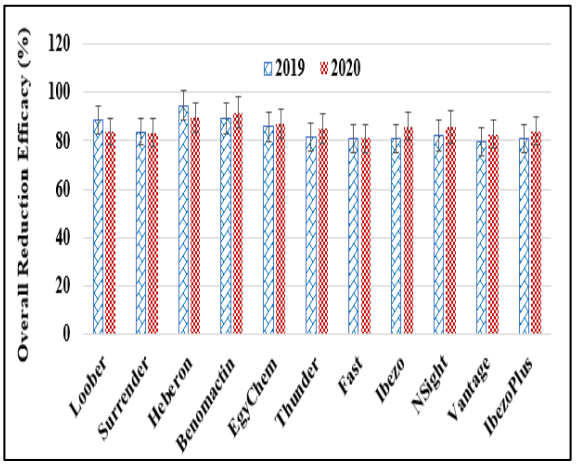


Figure 2. Overall mean of reduction efficacy of tested insecticides after 1, 5, 7, and 10 days of spray against *T. absoluta* insect in tomato fruits.

CONCLUSION

Tomato pinworm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is an invasive pest of tomato plants and difficult to control. Therefore, finding effective pesticides and management strategies is essential for tomato production. The current study evaluated the insecticidal activity of different formulations of Emamectin Benzoate, Esfenvalerate, and Indoxacarb against *T. absoluta*. All tested insecticides revealed elevated degrees of control this insect pest in El-Behera Governorate.

ACKNOWLEDGMENT

The author would like to thank Prof Shokr Abdel-Salam, Central Agricultural Pesticide Laboratory, Department of Pesticide Residues and Environmental Pollution, Agricultural Research Center, Dokki, Giza, Egypt for providing the pesticides.

REFERENCES

Birhan, A. (2018) Tomato leafminer [(Tuta absoluta Meyrick) (Lepidoptera: Gelechiidae)] and its current ecofriendly management strategies: A review. Journal of Agricultural Biotechnology and Sustainable Development 10(2): 11–24.

CIPAC (Collaborative International Pesticides Analytical Council). (2020). Formulation codes. https://www. cipac.org /index.php/methods-publications/further-information/ formulation - codes (Accessed on October 2020).

Desneux, N., Decourtye, A. and Delpuech, J.-M. (2007) The sublethal effects of pesticides on beneficial arthropods. Annual Review of Entomology 52(1): 81–106.

Desneux, N., Wajnberg, E., Wyckhuys, K.A.G., Burgio, G., Arpaia, S., Narváez-Vasquez, C.A., González-Cabrera, J., Catalán Ruescas, D., Tabone, E., Frandon, J., Pizzol, J., Poncet, C., Cabello, T. and Urbaneja, A. (2010) Biological invasion of European tomato crops by Tuta absoluta: Ecology, geographic expansion and prospects for biological control. Journal of Pest Science 83(3): 197–215.

EPPO (2005) *Tuta absoluta*. OEPP/EPPO, Bulletin OEPP/EPPO Bulletin 35, 434–435 EPPO (2018) EPPO Global database (available online). EPPO, Paris. Available at: https://gd.eppo.int/ https://gd.eppo.int/taxon/GNORAB (Accessed Oct 2020).

FAO (2020) food loss analysis tomato value chain in Egypt. http://www.fao.org/3/ca5885en/CA5885EN.pdf (Accessed Oct 2020).

FAOSTAT (2020). FAO Statistical Database (FAOSTAT). Available at: http://www.fao.org/faostat/en/#data/QC (Accessed Oct 2020).

Garzia, G.T., Siscaro, G., Biondi, A. and Zappalà, L. (2012) *Tuta absoluta*, a South American pest of tomato now in the EPPO region: Biology, distribution and damage. EPPO Bulletin 42(2): 205–210.

Garzia, G.T., Siscaro G., Colombo A., and Campo G. (2009). Reappearance of *Tuta absoluta* in Sicily. Rinvenuta in Sicilia *Tuta absoluta*. L'Informatore Agrario 65:71.

Hanafy, H.E.M. and El-Sayed W. (2013). Efficacy of bio-and chemical insecticides in the control of *Tuta absoluta* (Meyrick) and *Helicoverpa armigera* (Hubner) infesting tomato plants. Australian Journal of Basic and Applied Sciences 7: 943-948.

Henderson, C.F. and E.W. Tilton. (1955). Tests with acaricides against the brown wheat mite. J. Econ. Entomol. 48: 157-161.

Khalid, H. (2011) Studies on insecticide resistance in *Tuta absoluta* (Meyrick), with special emphasis on characterisation of two target site mechanisms. PhD thesis, University of Catania, Italy, 148 pp. Available at: http://hdl.handle.net/10761/1226 (accessed 8 May 2019).

Mallia, D. (2009). Guidelines for the Control and Eradication of *Tuta absoluta*. Ministry for Resources and Rural Affairs, Plant Health Department, Malta. http://www.agric.gov.mt/plant-health-deptprofile.

Miyao, G., Goodell P.B., Davis R.M., Hembree K.J., Natwick E.T., Ploeg A., Aegerter B.J., Lanini W.T., Stapleton J.J., Stoddard C.S., Subbarao K.V., Trumble J.T., Zalom F.G. (2020). Revised continuously. UC IPM Pest Management Guidelines: Tomato. UC ANR Publication 3470. Oakland, CA. available at: https://www2.ipm. ucanr.edu/agriculture/tomato/ (Accessed Oct 2020).

Moussa, A.E., Abd El-Ghany, N.M. and Abdel-Razek, A.S. (2018) Efficacy of bio-rational insecticides against *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) on tomatoes. Bioscience Research 15(1): 28–40.

Moussa, S., Sharma, A., Baiomy, F. and El-Adl, F.E. (2013) The status of tomato leafminer Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) in Egypt and potential effective pesticides. Academic Journal of Entomology 6: 110–115.

Roditakis, E., Vasakis, E., García-Vidal, L., Martínez-Aguirre, M., Rison, J.L., Haxaire-Lutun, M.O., Nauen, R., Tsagkarakou, A. and Bielza, P. (2018) A four-year survey on insecticide resistance and likelihood of chemical control failure for tomato leafminer Tuta absoluta in the European/Asian region. Journal of Pest Science 91: 421–435.

Russell, I.P.M. (2009). *Tuta absoluta*- Insect Profile. Russell IPM Ltd., http://www.tutaabsoluta.com/ insectprofile .php? ang=en).

Rwomushana, I., Beale T., Chipabika G., Day R., Gonzalez-Moreno P., Lamontagne-Godwin J., Makale F., Pratt C. and Tambo J. (2019). Evidence Note. Tomato leafminer (*Tuta absoluta*): impacts and coping strategies for Africa. CABI Working Paper 12, 56pp. DOI: https://dx.doi.org/10.1079/CABICOMM-62-8100.

SAS (statistical analysis systems) (2016). Version 9.4 of the SAS System for Windows. Cary. NC, USA: SAS Institute Inc.

Saad, A.S.A., Tayeb E.H.M., Abdel-Nabi, L.M. and Attia H.G.A.I. (2014). Integrated pest management for *Tuta absoluta* (Lepidoptera: Gelechiidae) infesting tomato plants in Egypt. J. Adv. Agric. Res. (Fac. Agric Saba Basha) 29(4): 756-767.

Saad, A.S.A., Tayeb E.H.M., Hassan A.T., and Attia H.G.A.I. (2020). IPM Strategy for *Tuta absoluta* on Tomatoes and Potatoes. Alexandria Science Exchange Journal 41(2): 275-283.

Shalaby, E.M., Soliman M.M., and Abd El-Mageed E.M. (2012). Evaluation of some insecticides against tomato leaf minor (*Tuta absoluta*) and determination of their residues in tomato fruits. Applied Biological Research 14: 113-119

Silva, G.A., Picanço, M.C., Bacci, L., Crespo, A.L.B., Rosado, J.F. and Guedes, R.N.C. (2011) Control failure likelihood and spatial dependence of insecticide resistance in the tomato pinworm, *Tuta absoluta*. Pest Management Science 67(8): 913–920.

كفاءة بعض التجهيزات التجارية لمبيدات الايماميكتين بنزوات ، الاندوكساكارب ،والاس فينفاليرات ضد حشرة ديدان ثمار الطماطم (*Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae)) بمحافظة البحيرة ، مصر

يحيي محمد محمد سالم

قسم وقايه النبات –كلية الزراعه – جامعة دمنهور

تعتبر حشرة ثمار الطماطم من الافات الخطرة والصعبة التحكم فيها ومكافحتها علي محصول الطماطم. لقد تم رصدها لاول مرة في مصر عام ٢٠٠٩ قادمة من اسبانيا عن طريق شمال افريقيا. ومنذ ذلك الوقت. تشكل عملية مكافحة ديدان ثمار الطماطم عائقا كبيرا علي زراعات الطماطم لذلك فلقد أجريت هذة الدراسة لتقييم فعالية بعض التجهيزات من المبيدات الحشرية (ايماميكتين بنزوات ، اندوكساكارب ،و اس فينفاليرات) ضد حشرة ديدان الثمار (*Tuta absoluta*) في الحقل (مدينة ابوحمص ، محافظة البحيرة). أظهرت النتائج ان جميع تجهيزات المبيدات المختبرة كانت ذات فعالية عالية (< ٧٤% فعالية) تحت الظروف الحقلية. كانت مبيدات الايماميكتين بنزوات أكثر فعاليه في مكافحة ديدان ثمار الطماطم مقارنة بتجهيزات الاندوكسارب والاس فينفاليرات ولمدة مكافحة اطول حتي ١٠ ايام من الرش خلال اعوام الدراسة (٢٠١٩ و ٢٠٢٠). ولقد أظهرت التجهيزات درجة عالية في خفض اعداد هذة الافة تحت الظروف الحقلية ولمدة تتعدي العشرة أيام من التطبيق الحقلي للمبيدات لذلك يمكن التوصية باستخدام تلك المبيدات ضمن برامج المكافحة المتكاملة لديدان ثمار الطماطم.