EFFICACY OF NEW INSECTICIDES GENERATION IN THE CONTROL OF TOMATO LEAF MINER (*Tuta absoluta* Meyrick)*

Sanel Haseljić[1], Fejzo Bašić[1], Josip Jurković[1], Pakeza Drkenda[1], Lutvija Karić[1], Saud Hamidović[1], Siniša Mitrić[2]

Original scientific paper

Abstract

The tomato leaf miner (*Tuta absoluta*) is a pest that causes significant damage to tomato production in Bosnia and Herzegovina. According to previous research, the inadequate application of older generation insecticides in the control of tomato leaf miner has led to a series of harmful consequences, such as increased resistance of the pest, reduction of the natural enemies population and an increase in pesticide residues in the agricultural products and in the environment. The aim of this work was to examine the efficacy of the newer insecticides generation in controlling of tomato leaf miner in greenhouse production in southern Bosnia and Herzegovina. Testing the efficacy of insecticides was carried out on tomato plants (Matias hybrid) in greenhouses in the localities of Višići, Gabela and Klepci. The effectiveness was tested on the following variants of insecticides: Indoxacarb, Emamectin benzoate, Methoxyfenozide, Lufenuron, Chlorantraniliprole, Azadirachtin, Spinosad and the combination of Abamectin + Lufenuron. Based on the number of live larvae in the mines, according to Abbott, the efficiency values of the applied insecticide variants were calculated. The combination of insecticides based on the active substances Abamectin and Lufenuron showed the highest percentage of efficiency (53.52%). The insecticide based on the active substance Spinosad showed the lowest percentage of efficiency. Lower efficiency values of the majority tested insecticides are probably a consequence of their specific mechanism of action, physical-chemical properties and environmental conditions in which they were applied.

Keywords: *Tuta absoluta, larvae, insecticides, Abamectin, Lufenuron*

INTRODUCTION

The tomato moth (leaf miner) (*Tuta absoluta* Meyrick, Lepidoptera: Gelechiidae) is a pest that is widespread in many parts of the world. In the territory of Bosnia and

*Paper presented at the 34th International Scientific-Expert Conference of Agriculture and Food Industry, October 9-11, 2024, Sarajevo, Bosnia and Herzegovina

[1]University of Sarajevo - Faculty of Agriculture and Food Sciences, Bosnia and Herzegovina.
[2]Faculty of Agriculture - University of Banja Luka, Bosnia and Herzegovina.
Correspondence: s.haseljic@ppf.unsa.ba

Herzegovina, it was first noted in 2010 in the southern parts (Ostojić *et al*., 2010) and then in the northern parts of the country (Đurić & Hrnčić, 2010). After that, it gradually spread towards the central parts of the country. Since its introduction, tomato moth has become one of the most significant pests in tomato production in Bosnia and Herzegovina. Many studies have confirmed that tomato moth is a thermophilic species that prefers climatically warmer areas for the development of its life cycle (Barrientos *et al*., 1998; Borgorni *et al*., 2003; Pereyra and Sanchez, 2006). If adequate control measures are not applied, it is believed that this pest can reduce the quality and yield of tomatoes (80-100%) in both field and greenhouse production conditions. Suppression of tomato moth is very complex and limited by the specific lifestyle (behavior) and bioecological characteristics of the pest (Haseljić *et al*., 2022).

The chemical control measure of this pest was already used at the beginning of the eighties of the last century (Souza & Reis, 1986). In that period, protective agents based on organophosphates and pyrethroids were mostly used in control of tomato moth. Pyrethroids are neurotoxic insecticides, they act on sodium channels in the cell membranes of the nervous system, causing disruption of the nerve impulses flow, wich resulting in paralysis and death of the pest. Inadequate application of these preparations and other insecticides of the older generation has over time led to increased resistance of tomato moth (Siqueira *et al*., 2001; Lietti *et al*., 2005; Silva *et al*., 2011; Reyes *et al*., 2012), which is ultimately affected the reduction of efficiency. Inadequate application of the older generation of insecticides leads to a decrease in the number and activity of natural enemies, as well as to an increase in residues on agricultural products and in the environment. With insecticides of the newer generation tried to overcome the mentioned implications. The active substances of newer insecticides are Spinosad, Indoxacarb, Abamectin, Tebufenozide and Chlorfenapyr (Insecticide Resistance Pest Management - IRAC), and they were introduced into production at the end of the last century (Lietti *et al*., 2005). Insecticides based on Indoxacarb, Lufenuron, Spinosad, Thiacloprid and Imidacloprid showed a positive effect in controlling tomato moth in Malta (Mallia, 2009), and in Italy, agents based on Chlorpyrifos and Pyrethrin showed also good results (Tropea Garzia *et al*., 2009).

The aim of this research was to examine the effectiveness of the newer insecticides generation in controlling of tomato moth in Bosnia and Herzegovina.

MATERIALS AND METHODS

Testing the efficacy of new insecticides generation was carried out on tomato plants (hybrid Matias) in greenhouse production in the localities of Višići, Gabela and Klepci in the southern part of Bosnia and Herzegovina. Insecticides were applied during the growing season in the period 2012-2014.

The effectiveness was tested on the following variants of insecticides: Indoxacarb, Emamectin benzoate, Methoxyfenozide, Lufenuron, Chlorantraniliprole, Azadirachtin, Spinosad and the combination of Abamectin + Lufenuron. The mode of action and the applied concentrations of insecticides are shown in table 1. In each experimental

plantation there was a control variant with planted tomato that were not treated with insecticides.

The effectiveness of the applied insecticides was evaluated based on the number of live larvae in the mine (Braham & Hajji, 2012). Efficiency was calculated according to Abbott (1925) using the formula:

$$E = 1 - \frac{\text{number of larvae on treated plants}}{\text{number of larvae in the control}} \text{ x } 100\ (\%)$$

The obtained results were statistically processed using descriptive and inferential statistics (Kruskall Walis and post hoc Mann-Whitney U test) in the IBM SPSS program (v 27).

Table 1. Insecticide, concentration (C) and mode of action (MoA, IRAC)

Insecticide Trade name	Active Substance (A.s.)	C (%)	MoA
Avaunt 15 EC	Indoksakarb	0.1	Nerve action
Affirm	Emamectin benzoate	0.2	Nerve and muscle action
Runner 240 SC	Methoxyfenozide	0.04	Growth regulation
Match EC	Lufenuron	0.03	Inhibitors of chitin biosynthesis
Coragen 20 SC	Chlorantraniliprole	0.02	Nerve and muscle action
Neemazal- T/S	Azadirachtin	0.3	Uunknown or uncertain MoA
Laser	Spinosad	0.05	Nerve action
Vertimec 018 EC + Match EC	Abamectin + Lufenuron	0.075 + 0.03	Nerve and muscle action; Inhibitors of chitin biosynthesis

RESULTS AND DISCUSSION

Based on a three-year study, the results of the analysis (descriptive statistics) of the newer generation insecticides effectiveness in the control of the tomato miner in the area of Višići, Gabela and Klepci are shown in table 2.

The percentage of tested insecticides effectiveness ranged from 12.34 to 53.52%. The highest percentage of efficiency was achieved in the combination of active substances Abamectin + Lufenuron (trade name Vertimec + Match). Insecticides based on the active substances Indoxacarb (Avaunt) and Emamectin benzoate (Affirm) showed a slightly higher percentage of efficiency (41.88 and 41.65%). The active substances Spinosad (Laser), Chlorantraniliprole (Coragen) and Azadirachtin (Neemazal) showed the least effectiveness in controlling of tomato moth.

Considering the existence of differences in the effectiveness percentage of tested insecticides, the Kruskall Walis (K-W) test was performed. This test is a non-parametric analogue of one-factor analysis of variance. In this part of the results, the K-W test was used due to the fact that the assumption of normality data distribution and homogeneity of variances was not fulfilled.

Table 2. Efficacy of tested insecticides (descriptive statistics)

A.s.	Min	Max	Average	Std. error	Variance	Std. dev.	Coff. var.
Indoksakarb	35.04	50.63	41.88	1.81	29.59	5.44	12.99
Emamectin benzoate	31.47	51.14	41.65	2.09	39.27	6.27	15.05
Methoxyfenozide	21.5	44.71	36.97	3.03	82.74	9.1	24.6
Lufenuron	18.18	32.57	26.76	1.78	28.52	5.34	19.96
Chlorantraniliprole	11.21	22.45	16.85	1.07	10.32	3.21	19.07
Azadirachtin	10.49	22.73	17.17	1.42	18.17	4.26	24.83
Spinosad	5.38	16.26	12.34	1.53	21.03	4.59	37.16
Abamectin + Lufenuron	36.36	65.15	53.52	3.56	114.15	10.68	19.96

Table 3**.** Kruskall Walis test

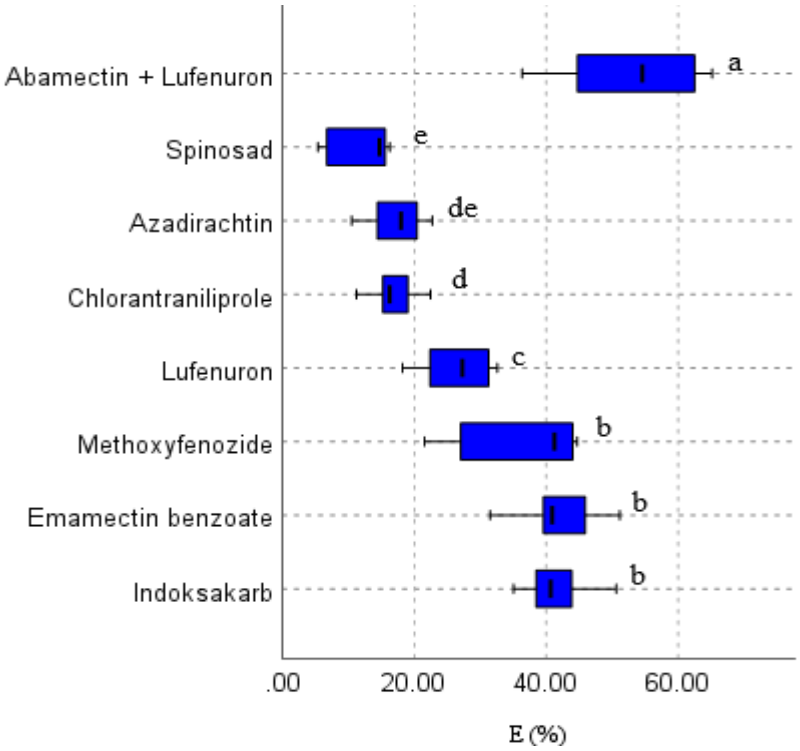
Hc (tie corrected):	58.96
Degree Of Freedom	7
p (same):	.000

Statistical processing of the data established a very significant influence of the analyzed insecticides in the control of tomato moth. Accordingly, to test the significance of the differences between the tested insecticides in the further analysis of the results, the M-W post hoc test was used with the Bonferroni's correction of the alpha value. Statistically highly significant (p 0.001) differences were found between the combination of active substances Abamectin + Lufenuron on the one hand and Spinosad, Azadirachtin and Chlorantraniliprole on the other. There were no statistically significant differences between Methoxyfenozide, Emamectin benzoate and Indoxacarb in terms of percentage efficiency. Also, no statistically significant differences were found between Azadirachtin on the one hand, and Spinosad and Chlorantraniliprole on the other.

The satisfactory efficiency of the Abamectin + Lufenuron insecticide combination with 53.52%, is the result of the synergism of these active substances. The synergistic effect of combining insecticides can be highly effective in controlling *Tuta absoluta*. In the research carried out by Illakwahhi & Srivastava (2019) in controlled conditions, a higher efficiency with combination of the active substances Abamectin and Neem oil was determined compared to the treatments when the mentioned active substances were

applied individually. Altowayyan *et al*. (2022) determined a significant improvement in the efficiency of Abamectin in combination with two entomopathogenic fungi (EPFs) *Beauveria bassiana* and *Metarhizium anisopliae* 5 days after the treatment of *Tuta absoluta* in greenhouse conditions. In this combination, the EPFs worked gradually after the infection of the larvae, while the chemical insecticide caused a more rapid knockdown effect.

The efficacy of Indoxacarb, Emamectin benzoate and Spinosad in this study was lower compared to the studies conducted by Moustafa *et al*. (2023) and Haseljić *et al.* (2023). It is important to single out the study conducted by Sapkal *et al*. (2018). In the conducted study, the effectiveness of chemical and biological insecticides in the control of the tomato moth was investigated. In the mentioned study, the effectiveness of the following insecticides was recorded: Chlorantraniliprole - 18.5%, Emamectin benzoate - 5%, Spinosad - 45% and Indoxacarb - 14.5%.



Graph 1. Efficacy of tested insecticides (Box plot, M-W test)

CONCLUSIONS

The combination of insecticides based on the active substances Abamectin and Lufenuron had a significant effect on increasing the percentage of effectiveness in controlling of tomato moth compared to all other analyzed insecticides. The efficacy of insecticides based on the active substances Indoxacarb, Emamectin benzoate and

Methoxyfenozide was satisfactory. The active substances Spinosad, Chlorantraniliprole and Azadirachtin exhibited the lowest efficiency. Lower efficiency values of the remaining insecticides are probably a consequence of their specific mechanism of action, physico-chemical properties and environmental conditions in which they are applied.

REFERENCES

Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. Journal of Economic Entomology, 18, 265-267.

Altowayyan A. A., Hamed, E. K, Aldeghairi A. M. & Abdel-Baky, F. N. (2022). Synergistic Effects of Combining Three Commercial Bioproducts Against *Tuta absoluta* (Meyrick) Larvae (Lepidoptera: Gelechiidae). Pak J Biol Sci., 25(7), 660-668. doi: 10.3923/pjbs.2022.660.668

Barrientos, Z.R., Apablaza, H.J., Norero, S.A. & Estay, P.P. (1998). Threshold temperature and thermal constant for development of the South American tomato moth, *Tuta. absoluta* (Lepidoptera, Gelechiidae). Ciencia. Investigacion. Agraria, 25, 133–137.

Borgorni, P.C., Da Silva, R.A. & Carvelho, S.G. (2003). Leaf mesophyll consumption by *Tuta absoluta* (Meyrick, 1971) (Lepidoptera: Gelechiidae) in three cultivars of *Lycopersicon esculentum* MILL. Ciencia Rural, 33(1), 7-11.

Đurić, Z. & Hrnčić, S. (2010). Miner lista paradajza - *Tuta absoluta* Meyrick u Republici Srpskoj. Agroznanje, 11*(*3), 17-23.

Haseljić, S., Hrnčić, S., Bašić, F., Jurković, J. & Mitrić, S. (2023). Effectiveness of Chlorantraniliprole, Methoxyfenozide and Emamectin Benzoate Insecticides in Controlling *Tuta Absoluta*. In: Brka *et al.* 32nd Scientific-Expert Conference of Agriculture and Food Industry. Agriconference 2022. Lecture Notes in Bioengineering. Springer, Cham. https://doi.org/10.1007/978-3-031-47467-5_11

Haseljić, S., Mitrić, S., Bašić, F. & Šuta, N. (2022). Ethology and developmental cycle of of tomato leaf miner (*Tuta absoluta* Meyrick, 1917) depending on temperature conditions. Works of the Faculty of Agriculture and Food Sciences University of Sarajevo, 72/1, 103-113.

Illakwahhi, D. T. & Srivastava, B. B. L. (2019). Improving the Efficacy of Abamectin Using Neem Oil in Controlling Tomato Leafminers, *Tuta absoluta* (Meyrick). Advanced Journal of Chemistry-Section A, *2*(3), 216-224.

Lietti, M.M., Botto, E. & Alzogaray, R.A. (2005). Insecticide Resistance in Argentine Populations of *Tuta absoluta* (Lepidoptera: Gelechiidae). Neotropical Entomology, 34(1), 113-119.

Mallia, D. (2009). Guidelines for the Control and Eradication of *Tuta absoluta*. Ministry for Resources and Rural Affairs, Plant Health Department, Malta. Accessed November 4, 2009. http://www.agric.gov.mt/plant-health-deptprofile

Moustafa, M. A. M., El-Hefny, D. E., Abdel-kerim, R. N. & Kandil, M. A. (2023). Toxicity of Insecticides against Tomato Leaf Miner, *Tuta absoluta*, and Its

Predators and Determination of Their Residue Dissipation in Tomato Fruits. JAST; *25* (5), 1115-1128.

Ostojić, I., Tolić, D., Zovko, M., Gotlin-Čuljak, T. & Ćutuk I. (2010). Prvi nalaz lisnog minera rajčice, *Tuta absoluta* Meyrick. VII. Simpozijum o zaštiti bilja u Bosni i Hercegovini, Teslić, Zbornik rezimea, 34.

Pereyra, P.C & Sánchez, N.E. (2006). Effect of Two Solanaceous Plants on Developmental and Population Parameters of the Tomato Leaf Miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Neotropical Entomology 35(5), 671-676.

Reyes, M., Rocha, K., Alarcón, L., Siegwart M. & Sauphanor, B. (2012). Metabolic mechanisms involved in the resistance of field populations of *Tuta absoluta* (Meyrick) (Lep., Gelechiidae) to spinosad. Pestic. Biochem. Physiol, 102(1).

Sapkal, S. D., Sonkamble, M. M. & Savde V. G. (2018). Bioefficacy of newer insecticides against tomato leaf miner, *Tuta absoluta* (Meyrick) on tomato, *Lycopersicon esculentum* (Mill) under protected cultivation. Int J Chem Stud*, 6(*4), 3305-3309.

Silva, G.A., Picanço, M. C., Bacci, L., Crespo, A.L.B., Rosado, J.F. & 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), 913–20.

Siqueira, H.A., de Guedes, R.N., Fragoso, D.B. & Magalhães, L.C. (2001). Abamectin resistance and synergism in brazilian populations of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Int. J. Pest Manag, 47, 247-251.

Souza, J.C. & Reis P.R. (1986). Controle da tracë a-do-tomateiro em Minas Gerais. Pesquisa AgropecuaÂria Brasileira, 21, 343-354.

Tropea Garzia, G. (2009). *Physalis peruviana* L. (Solanaceae), a host plant of *Tuta absoluta* in Italy. IOBC/WPRS Bulletin, 49, 231–232.

EFIKASNOST INSEKTICIDA NOVE GENERACIJE U SUZBIJANJU LISNOG MINERA PARADAJZA (*Tuta absoluta*)

Sažetak

Miner paradajza (*Tuta absoluta*) je štetnik koji nanosi značajne štete u proizvodnji paradajza u Bosni i Hercegovini. Prema dosadašnjim istraživanjima, neadekvatna primjena insekticida starije generacije u suzbijanju minera paradajza dovela je do niza štetnih posljedica, kao što su povećana otpornost štetnika, smanjenje populacija prirodnih neprijatelja te povećanje rezidua pesticida u poljoprivrednim proizvodima i okolišu. Cilj ovog rada bio je ispitati efikasnost insekticida novije generacije u kontroli minera paradajza na području Bosne i Hercegovine. Ispitivanje efikasnosti insekticida provedeno je na paradajzu (hibrid Matias) u plastenicima na lokalitetima Višići, Gabela i Klepci. Efikasnost je ispitana na sljedećim varijantama aktivnih materija insekticida: Indoksakarb, Emamektin benzoat, Metoksifenozid, Lufenuron, Hlorantraniliprol, Azadiraktin, Spinosad i kombinacija Abamectin + Lufenuron. Na temelju broja živih gusjenica u minama, prema Abbottu, izračunat je procenat efikasnosti primijenjenih varijanti insekticida. Kombinacija insekticida na bazi aktivnih materija Abamektin i Lufenuron je ispoljila najveći postotak efikasnosti. Najniži postotak učinkovitosti pokazao je insekticid na bazi djelatne tvari Spinosad. Manje vrijednosti efikasnosti većeg broja ispitivanih insekticida su vjerovatno posljedica njihovog specifičnog mehanizma djelovanja, fizičko-hemijskih osobina i uslova sredine u kojim su primijenjeni.

Ključne riječi: *Tuta absoluta, larve, insekticidi, Abamektin, Lufenuron*