EVALUATION OF THE BIOLOGICAL AND ECONOMIC EFFICACY OF ACETAMIPRID 20% SP IN THE CONTROL OF TRIALEURODES VAPORARIORUM IN GREENHOUSE TOMATO PRODUCTION

ZAREV, D.[1] – NEŠOVIĆ, S.[1] – FILIPOVIĆ, K.[1] – PAUNOVIĆ, D.[1] – KRSTIĆ, J.[1] – CVIJANOVIĆ, V.[2*] – ZAREV, M.[1]

[1]*Faculty of Applied Sciences, University "Business academy in Novi Sad", Niš, Serbia*

[2]*Institute for Science Application in Agriculture, Belgrade, Serbia*

[*]*Corresponding author*
e-mail: cvija91@yahoo.com

(Received 1st Aug 2025; accepted 28th Oct 2025)

Abstract. *Trialeurodes vaporariorum* Westwood is a polyphagous pest that is of great economic importance worldwide due to the damage it causes to various types of vegetables. Neonicotinoid pesticides are primary method to control of this pest worldwide. Accordingly, we examined the biological effectiveness of Acetamiprid 20% SP, in controlling imagoes and larvae of *T. vaporariorum*. According to the obtained results, Acetamiprid 20% SP showed exceptional efficiency in terms of reducing the number of *T. vaporariorum* imagoes and larvae, and it was used in a very low concentration. The most favorable concentration of the applied preparation, which can be used with excellent efficiency, was a concentration of 0.2 kg/ha. The results indicated that the use of this preparation can provide significant economic benefits for agricultural producers in the form of higher profits, reduced costs and a higher level of consumer satisfaction.
Keywords: *neonicotinoides, lower dosage, systemic, sucking pests, foliar plant protection*

Introduction

The development policies of the UN member states will be guided by the Sustainable Development Goals (SDGs) defined by the UN Agenda for Development in the following period until 2030. The second goal of sustainable development is to end hunger, which highlights the great importance attached to this aspect of development. However, according to the World Health Organization (WHO) indicates that one third of the world's population suffers from hunger and malnutrition (WHO, 2020). This is because agricultural production faces problems arising from the invasion of pests and weeds. In order to solve this problem, we can use the methods including the use of various chemical agents can be applied, primarily pesticides of inorganic origin.

Tomato (*Lycopersicon esculentum* L.) is an annual herbaceous plant that is among the three most abundant plants in the human diet. It is used in full or botanical maturity or when it is still green, it is used for pickling. Apart from the great importance of using raw tomatoes, there is an increasing demand for tomatoes that can be used in industrial processing, and which implies more and more tomato growing in a protected area (greenhouse) (Cvijanović et al., 2021). In order to have successful production in greenhouses, the use of well-nourished quality seedlings is of crucial importance. Planting dates are determined by the type of protected area and heating capacities. For the production of seedlings in a protected area, the time of sowing is determined according to the time of production, that is, according to the planting date. Tomato production faces

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

numerous challenges, and one of them is *Trialeurodes vaporariorum*, which is a widespread pest that causes direct damage to plants and transmits viral plant diseases (Liu and Wang, 2020). This pest represents the greatest danger in greenhouse production. The pest causes primary damage - it sucks the sap, which causes lower plant vitality, lower growth, and quality of fruits, as well as secondary damage - because it secretes honeydew on which the sooty mold (*Apisporium* spp) develops, which reduces the possibility of the photosynthesis process. The greenhouse whitefly is a vector for many viruses (Liu et al., 2015). Fruits become dirty and unsightly, damaged leaves gradually lose chlorophyll, become necrotic and fall off. *T. vaporariorum* management is problematic due to widespread pesticide resistance, and many greenhouse growers rely on biological control agents to regulate *T. vaporariorum* populations. However, they are often slow and vary in effectiveness, leading to subsequent application of chemical insecticides when pest populations exceed thresholds.

The life cycle includes five basic stages (*Table 1, Figure 1*). The total duration of the life cycle is 20–30 days, depending on temperature and humidity. Under favorable conditions (in greenhouses), it can be shorter (15–18 days). During the year, 10-15 generations can develop, which leads to rapid overpopulation.

Table 1. *Developmental stages of the white butterfly wasp*

Stage	Description	Duration	Key Characteristics
Egg	Oval, yellowish eggs laid in clusters on the underside of leaves	4–12 days	Light yellow color; 150–300 eggs laid per female
Larva – 1st instar (Crawler)	Mobile larva searching for feeding site	1–2 days	Only mobile larval stage; moves across leaf surface
Larva – 2nd to 4th instars	Fixed larva feeding on plant sap	7–14 days	Translucent to yellowish; secretes honeydew; causes direct plant damage
Pupa (Pseudopupal stage)	Non-feeding stage where metamorphosis occurs	4–7 days	Dome-shaped; black eyes visible; immobile; no feeding
Adult (Imago)	Small white flying insect with two pairs of wings, butterfly-like appearance	10–30 days	Feeds and lays eggs; vector of plant viruses; highly mobile and reproductive

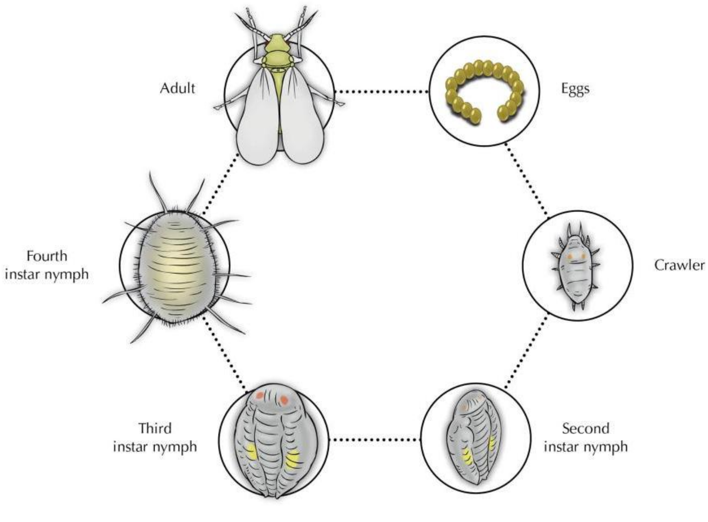

Figure 1. *Life cycle of Trialeurodes vaporariorum (Source: https://www.syngentaornamentals.co.uk/blog/expert-centre-blog/actions-against-whitefly)*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

New studies very rarely provide data on the exclusive infestation of the white butterfly aphid and loss of tomato yield, because they are often conditioned by other factors such as different pests, diseases (viral), stress (drought, heat), or protection regimes. Earlier researches recorded a loss of tomato yield in greenhouses from 5 to 30% (Johnson et al., 1992; Paweer et al., 2025).

Combining chemical and biological pesticides has great potential, but it can result in different outcomes, from positive to negative interactions (Elanchezhyan et al., 2025). Improper use of insecticides can damage or completely destroy the yield. The use of insecticides, apart from achieving the desired level of efficiency, is complicated by the problem of safe application due to the risk of exhibiting phytotoxic effects on the crop. Neonicotinoids represent a relatively new group of systemic insecticides with a specific mode of action (Wang et al., 2019). In the European Union and in our country, the use of four neonicotinoid insecticides is registered: imidacloprid, thiamethoxam, acetamiprid and thiacloprid. The insecticide acetamiprid has a high efficiency in controlling one of the most common causes of tomato spoilage, namely *T. vaporariorum*. This insecticide belongs to the first generation of neonicotinoid insecticides and therefore has a very similar mechanism of functioning, excellent systemic properties, relatively low toxicity for warm-blooded organisms and a long period of effect (Carbo et al., 2007). It is used to protect different types of crops, such as potatoes, onions, peppers, tomatoes, tobacco, hops, cabbage, cereals, pears, oranges, cherries, apples, etc. (Jeschke et al., 2011). Due to its efficacy in crop protection and relatively low environmental toxicity, acetamiprid has attracted much attention as a promising insecticide (Dai et al., 2024). Acetamiprid is known under the commercial names "Mospilan" as the original insecticide and generically such as "Volley", "Assail", "Pristine", "Rescate", "Saurus" (Carstens, 2023). It is formulated in the form of water-soluble powder, water-dispersible granules, concentrated suspensions and ready-made mixtures for usage. It is used in the amount of 75-300 g/ha for vegetables and 100-700 g/ha for orchards (Alsafran et al., 2022). The tolerance is 2.0 mg/kg for grapes, 1.0 mg/kg for tomatoes and peppers, 0.5 mg/kg for apples, cherries and cabbage, and 0.05 mg/kg for potatoes, corn and sugar beets. The waiting period is 14 days for cherries, potatoes, tomatoes, tobacco and corn, and 28 days for apples and vines, while the working waiting period is two days.

Acetamiprid has low mammalian/medium toxicity. Namely, the oral LD50 for mice is 184 mg/kg, and 146 mg/kg for rats. The dermal LD50 for rats is more than 2000 mg/kg, while the inhalation LC50 (4 h) is greater than 0.29 mg/dm3 of dust. The toxicity of acetamiprid to aquatic organisms is low, but it is toxic to birds. It is considered highly toxic to earthworms and bees (LD50 7.1 ng/bee) (Capela et al., 2022). It does not have an irritating effect on eyes and skin. No cases of acetamiprid poisoning among human beings have been reported in the literature. The EPA classifies it in the "E" group of carcinogens, that is, substances that are not considered carcinogenic to the human body.

The preparation used in this research, Acetamiprid 20% SP, belongs to the group of neonicotinoids with a pyridylmethylamine structure and exerts an agonistic effect on neuroreceptors for acetylcholine located in the nervous system of insects, whose prolonged stimulation ultimately leads to the interruption of the transmission of nerve impulses and the death of insects. It is classified in IRAC group 4A - an international organization that deals with the coordination of activities related to the management of the resistance of harmful insects to insecticides according to the mechanism of action. Group 4 insecticides act as inhibitors of nicotinic acetylcholine receptors (nAChR) in the insect nervous system. In this study, we evaluated the biological effectiveness of the

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

insecticide Acetamiprid 20% SP, commercially known as “Inferno", in tomato crops in a protected area at four locations.

Acetamiprid 20% SP also has great economic advantages when used to control *Trialeurodes vaporariorum* in tomato crops, especially in protected cultivation. The biological research that was conducted has shown that tomato growers become more profitable when this pest is effectively controlled because the use of this insecticide reduces crop losses. By preventing damage to leaves and fruits, Acetamiprid 20% SP provides fast and effective prevention and protection from insects, which reduces the need for future treatments. Therefore, this has a great impact on production costs, that is, it leads to investment optimization in plant protection.

The strong efficacy of Acetamiprid at relatively low doses, which reduces the total cost per hectare of treated crops, further shows its economic advantages. Its long-term residual impact also reduces the frequency of use, which saves even more time and effort of agricultural producers. Maintaining the quality of tomatoes is crucial for preserving their market value (Ivanišević et al., 2015). Producers profit from a higher market price for fruits that show no signs of damage or pest activity. At the same time, the market position is improved by offering high quality products which leads to the satisfaction of consumers (Stojanović et al., 2018). In addition to its immediate benefits, Acetamiprid helps maintain production by reducing the need for more expensive or dangerous pesticides. In the long term, this can improve the market position of tomato growers by improving consumer perception of the product.

In order for this product to be used successfully, ideal conditions must be maintained in protected cultivation. The economic viability of production depends on producers achieving stable yields in each production cycle and reducing plant damage through effective pest control (Waterfield and Zilberman, 2012; Bottrell and Schoenly, 2018). By reducing the costs of secondary damage, such as secondary infections or the need for more fertilizers to restore plant health, significant cost savings are achieved and profit margins are increased, and according to the research, acetamiprid can be used for these needs.

Using effective products such as acetamiprid is important to achieve the quality and quantity required for export in the fiercely competitive global tomato industry. Thus, better economic prospects and growth for the domestic vegetable industry are guaranteed. The capacity of this product to reduce the risk of uncontrolled insect attacks, which can have disastrous consequences for small and mid-sized farmers, indicates the economic and sustainability justification of its use.

Materials and methods

The analyses of the efficacy of insecticides based on acetamiprid, in the tomato crop in a protected area, were carried out on four test fields at four localities: Mužlja (Runner hybrid), Omoljica (Pink Rock hybrid), Valjevska Kamenica (Apple of Novi Sad-Novosadski Jabucar) and Bela Crkva (Big Beef hybrid).

In the FAO classification, Chernozems (CH) are a Reference Soil Group characterized by a deep, dark-colored, humus-rich mollic A horizon (at least 20 cm deep) and subsurface concentrations of secondary carbonates, usually located within 2 meters of the surface, with no signs of gypsum accumulation or a petrocalcic horizon within the upper 100 cm. These fertile, grassland soils are found in the mid-latitudes of continental areas, like the steppes of Eurasia and the prairies of North America.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Temperature was monitored at four locations in two measurements (day and night) to assess its indirect impact on the effectiveness of the applied insecticide (*Table 2*). *Table 3* shows the dynamics of treatment application, monitoring and counting of harmful organisms.

Table 2. *Average temperatures by week during tomato production*

Location	Month	Average per week			Ventilation
		Week	Day	Night	
Mužlja	March	I	23	10	without ventilation
	April	II	29	16	without ventilation
	May	III	33	17	greenhouse ventilation
	June	IV	37	22	greenhouse ventilation
Omoljica	March	I	24	19	without ventilation
	April	II	28	18	without ventilation
	May	III	32	22	greenhouse ventilation
	June	IV	37	22	greenhouse ventilation
Valjevska kamenica	March	I	20	15	without ventilation
	April	II	24	17	without ventilation
	May	III	29	20	greenhouse ventilation
	June	IV	33	18	greenhouse ventilation
Bela crkva	March	I	25	20	without ventilation
	April	II	28	18	without ventilation
	May	III	34	20	greenhouse ventilation
	June	IV	38	22	greenhouse ventilation

Table 3. *Dynamics of application of treatment with monitoring and counting of the presence of harmful organisms*

Location	Activities	Date	Day	Night	Ventilation
Mužlja	Treatment	7-May	29	17	without ventilation
	Counting 0 days	7-May	29	17	without ventilation
	Counting 2 days	9-May	28	14	greenhouse ventilation
	Counting 8 days	15-May	35	15	greenhouse ventilation
Omoljica	Treatment	7-May	27	18	without ventilation
	Counting 0 days	7-May	27	18	without ventilation
	Counting 2 days	9-May	27	16	greenhouse ventilation
	Counting 8 days	15-Sep	36	20	greenhouse ventilation
Valjevska kamenica	Treatment	7-May	22	14	without ventilation
	Counting 0 days	7-May	22	14	without ventilation
	Counting 2 days	9-May	23	16	greenhouse ventilation
	Counting 8 days	15-May	32	18	greenhouse ventilation
Bela crkva	Treatment	7-May	28	17	without ventilation
	Counting 0 days	7-May	28	17	without ventilation
	Counting 2 days	9-May	27	16	greenhouse ventilation
	Counting 8 days	15-May	37	20	greenhouse ventilation

The tested preparation Acetamiprid 20% SP contains 20.2% of the active substance Acetamiprid, 5.0% Na-dodecyl sulfate, 2.0% OP-21 (ethoxylated ethyl phenol) and 72.8% Glucose. The active substance Acetamiprid (according to IUPAC (E)-N1-[(6-chloro-3-pyridyl) methyl]-N2-cyano-N1-methylacetamidine has the molecular formula C10H11ClN4, whose molecular weight is 222.67 g/mol.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Acetamiprid 20% SP in the research process was applied in a concentration of 0.12 kg/ha, 0.2 kg/ha and 0.25 kg/ha, while Volley 20 SP was used as a standard in a concentration of 0.25 kg/ha. An untreated control was also included in the analysis. The active ingredient of the preparation Volley 20 SP is acetamiprid at a concentration of 200 g/kg. This preparation belongs to the chemical group of neonicotinoids and is a systemic insecticide with contact and digestive action. The research of biological effectiveness was performed in accordance with standard EPPO methods: EPPO PP 1/36 (3): Efficacy evaluation of insecticides; EPPO PP 1/152 (4): Efficacy evaluation of plant protection products: Design and analysis of efficacy evaluation trials; EPPO PP 11181 (5): Efficacy evaluation of plant protection products: Conduct and reporting of efficacy evaluation trials; EPPO PP 1/135 (4): Guidelines for the efficacy evaluation of plant protection products: Phytotoxicity assessment; EPPO PP 1/225 (2): Efficacy evaluation of plant protection products: Minimum effective dose; EPPO PP 1/239 (3): Dose expression for plant protection products.

EPPO method PP 1/36, the number of larvae that were alive and adults on the leaves was ascertained. The number of larvae that were alive was determined on one, previously marked and fully open leaf on each plant, in the experimental plot (10 leaves in total). The number of imagoes was determined on the tops of the plants, including the first fully open leaves, taking care not to disturb the insects due to the counting being as accurate as possible. The evaluations were made immediately before treatment, 2 - 4 days after treatment, and 5 - 8 days after treatment.

The statistical process of research results was performed in accordance with the recommendations of the standard EPPO methods PP 1/152 (4). The significance of the differences was examined by the analysis of variance (ANOVA). If the analysis of variance determined a statistically significant difference ($p < 0.05$) between the mean values, further pairwise comparisons were performed using the LSD test (Fisher's method) at the $\alpha=0.05$ significance level in order to determine which mean values have a significant difference (post hoc test). The mean values marked with the same letter do not differ statistically significantly, while there is a significant difference between mean values marked differently. The statistical analysis (ANOVA and LSD post hoc test) was performed in the statistical software package MiniTab 18.

The efficiency of the insecticide was determined using the Henderson-Tilton formula:

$$Efficacy\,\% = 1 - \frac{n\ in\ control\ before\ treatment\ X\ n\ in\ treatment\ after\ treatment}{n\ in\ control\ after\ treatment\ X\ n\ in\ treatment\ before\ treatment}\ x\ 100 \qquad \text{(Eq.1)}$$

Results

The results of testing the biological efficacy of Acetamiprid 20% SP in controlling larvae and adults of *T. vaporariorum* in the tomato crop in a protected area are shown in *Tables 4-15*. *Tables 4–6, 7–9, 10–12, and 13–15* present the results from the Mužlja, Omoljica, Valjevska Kamenica, and Bela Crkva sites, respectively. *Tables 4, 7, 10, and 13* show the number of live larvae and adults of *T. vaporariorum* before treatment; *Tables 5, 8, 11, and 14* show the numbers and insecticide efficacy 2 days after treatment; and *Tables 6, 9, 13, and 15* show the numbers and insecticide efficacy 8 days after treatment.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Table 4. *Number of live larvae and imagos of T. vaporariorum established immediately before treatment - preliminary assessment at the Mužlja locality*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	170	126	209	191	696.0	174.00b	35.7
		imagos	94	87	116	101	398.0	99.50a	12.4
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	206	248	184	223	861.0	215.25ab	27.0
		imagos	78	59	70	103	310.0	77.50a	18.7
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	217	195	173	201	786.0	196.50ab	18.2
		imagos	110	94	83	79	366.0	91.50a	13.9
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	181	244	263	198	886.0	221.50a	38.4
		imagos	98	100	66	87	351.0	87.75a	15.6
5	Volley 20 SP c(0.25 kg/ha)	larvae	170	200	232	240	842.0	210.50ab	32.1
		imagos	91	77	109	64	341.0	85.25a	19.3

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.259$ for larvae; $p_2 = 0.438$ for imagos; mean values marked with the same letter do not differ statistically significantly

Table 5. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Mužlja location 2 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	211	159	248	225	843.0	210.75a	37.7	-	-
		imagos	133	111	155	165	564.0	141.00a	24.1	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	39	51	29	45	164.0	41.00b	9.4	84.27	84.68
		imagos	19	11	15	21	66.0	16.50b	4.4	84.98	85.33
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	9	7	5	7	28.0	7.00c	1.6	97.06	97.54
		imagos	3	2	0	0	5.0	1.25b	1.5	99.04	99.45
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	0	2	2	0	4.0	1.00c	1.2	99.63	100.12
		imagos	0	0	0	0	0.0	0.00b	0.0	100.00	100.41
5	Volley 20 SP c(0.25 kg/ha)	larvae	1	1	2	1	5.0	1.25c	0.5	99.51	100.00
		imagos	0	0	1	1	2.0	0.50b	0.6	99.59	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Table 6. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Mužlja locality 8 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	255	210	310	286	1061.0	265.25a	43.2	-	-
		imagos	170	156	214	231	771.0	192.75a	35.5	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	50	66	38	57	211.0	52.75b	11.8	83.92	84.91
		imagos	31	18	24	30	103.0	25.75b	6.0	82.85	83.48
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	14	12	9	11	46.0	11.50c	2.1	96.16	97.30
		imagos	8	7	5	5	25.0	6.25bc	1.5	96.47	97.21
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	3	6	7	2	18.0	4.50c	2.4	98.67	99.84
		imagos	3	2	4	2	11.0	2.75bc	1.0	98.38	99.13
5	Volley 20 SP c(0.25 kg/ha)	larvae	3	3	5	4	15.0	3.75c	1.0	98.83	100.00
		imagos	0	0	3	2	5.0	1.25c	1.5	99.24	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

Table 7. *Number of live larvae and imagos of T. vaporariorum established immediately before treatment - preliminary assessment at the Omoljica locality*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	340	366	297	411	1414.0	353.50a	47.7
		imagos	166	114	96	179	555.0	138.7abc	40.0a
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	277	293	311	302	1183.0	295.75a	14.5
		imagos	144	166	199	201	710.0	177.50a	27.5
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	334	351	284	317	1286.0	321.50a	28.6
		imagos	127	131	150	157	565.0	141.25ab	14.5
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	404	373	320	281	1378.0	344.50a	54.7
		imagos	174	140	117	93	524.0	131.00bc	34.5
5	Volley 20 SP c(0.25 kg/ha)	larvae	255	291	302	341	1189.0	297.25a	35.4
		imagos	107	89	96	100	392.0	98.00c	7.5

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.171$ for larvae; $p_2 = 0.017$ for imagos; mean values marked with the same letter do not differ statistically significantly

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Table 8. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Omoljica location 2 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	392	412	355	472	1631.01	407.75a	48.9	-	-
		imagos	180	133	117	204	634.0	158.50a	40.4	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	55	62	71	66	254.0	63.50b	6.8	81.39	82.23
		imagos	18	29	31	30	108.0	27.00b	6.1	86.68	87.26
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	21	20	15	15	71.0	17.75c	3.2	95.21	96.19
		imagos	7	9	10	10	36.0	9.00b	1.4	94.42	95.06
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	7	5	5	5	22.0	5.50c	1.0	98.62	99.64
		imagos	1	2	0	0	3.0	0.75b	1.0	99.50	100.17
5	Volley 20 SP c(0.25 kg/ha)	larvae	4	3	5	2	14.0	3.50c	1.3	98.98	100.00
		imagos	2	0	0	1	3.0	0.75b	1.0	99.33	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

Table 9. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Omoljica locality 8 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	482	523	477	584	2066.0	516.50a	49.5	-	-
		imagos	231	187	153	264	835.0	208.75a	48.7	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	74	79	95	92	340.0	85.00b	10.1	80.33	81.79
		imagos	26	44	43	45	158.0	39.50b	9.0	85.21	87.58
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	33	26	25	22	106.0	26.50c	4.7	94.36	96.07
		imagos	13	15	17	15	60.0	15.00bc	1.6	92.94	95.53
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	15	9	10	11	45.0	11.25c	2.6	97.76	99.53
		imagos	4	5	3	2	14.0	3.50c	1.3	98.22	100.96
5	Volley 20 SP c(0.25 kg/ha)	larvae	9	7	10	5	31.0	7.75c	2.2	98.22	100.00
		imagos	5	5	3	3	16.0	4.00c	1.2	97.29	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Table 10. *Number of live larvae and imagos of T. vaporariorum established immediately before treatment - preliminary assessment at the Valjevska Kamenica locality*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	342	211	396	298	1247.0	311.75a	78.2
		imagos	117	144	98	81	440.0	110.00a	27.0
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	191	223	182	204	800.0	200.00b	17.8
		imagos	87	91	69	66	313.0	78.25b	12.6
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	133	99	148	196	576.0	144.00b	40.3
		imagos	106	99	84	103	392.0	98.00ab	9.8
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	222	200	126	244	792.0	198.00b	51.3
		imagos	76	82	111	60	329.0	82.25ab	21.3
5	Volley 20 SP c(0.25 kg/ha)	larvae	173	251	104	138	666.0	166.50b	63.0
		imagos	58	121	77	92	348.0	87.00ab	26.6

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.005$ for larvae; $p_2 = 0.238$ for imagos; mean values marked with the same letter do not differ statistically significantly

Table 11. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Valevska Kamenica location 2 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	388	251	447	353	1439.0	359.75a	82.2	-	-
		imagos	160	203	162	144	669.0	167.25a	25.2	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	40	52	28	37	157.0	39.25b	9.9	82.99	84.64
		imagos	25	19	10	10	64.0	16.00b	7.3	86.55	86.55
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	14	5	11	12	42.0	10.50b	3.9	93.68	95.54
		imagos	5	3	2	3	13.0	3.25b	1.3	97.82	97.82
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	8	4	0	7	19.0	4.75b	3.6	97.92	99.87
		imagos	0	0	2	1	3.0	0.75b	1.0	99.40	99.40
5	Volley 20 SP c(0.25 kg/ha)	larvae	10	0	0	5	15.0	3.75b	4.8	98.05	100.00
		imagos	0	0	0	0	0.0	0.00b	0.0	100.00	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Table 12. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Valjevska Kamenica locality 8 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	471	362	554	425	1812.0	453.00a	80.8	-	-
		imagos	222	269	213	181	885.0	221.25a	36.4	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	54	58	39	62	213.0	53.25b	10.0	81.68	84.65
		imagos	33	28	20	18	99.0	24.75b	7.0	84.27	84.27
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	24	12	20	15	71.0	17.75b	5.3	91.52	94.85
		imagos	7	2	0	10	19.0	4.75b	4.6	97.59	97.59
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	16	8	5	10	39.0	9.75b	4.6	96.61	100.12
		imagos	0	0	4	3	7.0	1.75b	2.1	98.94	98.94
5	Volley 20 SP c(0.25 kg/ha)	larvae	16	4	6	8	34.0	8.50b	5.3	96.49	100.00
		imagos	0	0	0	0	0.0	0.00b	0.0	100.00	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

Table 13. *Number of live larvae and imagos of T. vaporariorum established immediately before treatment - preliminary assessment at the Bela Crkva locality*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd
			A	B	C	D			
1	Untreated control	larvae	277	199	315	303	1094.0	273.50a	52.1
		imagos	186	119	231	210	746.0	186.50a	48.6
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	361	247	193	177	978.0	244.50a	83.2
		imagos	92	104	86	201	483.0	120.75a	54.0
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	166	303	224	181	874.0	218.50a	61.5
		imagos	172	90	152	77	491.0	122.75a	46.4
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	199	271	369	212	1051.0	262.75a	77.5
		imagos	81	111	179	95	466.0	116.50a	43.4
5	Volley 20 SP c(0.25 kg/ha)	larvae	388	190	200	303	1081.0	270.25a	93.7
		imagos	204	144	121	80	549.0	137.25a	51.8

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.828$ for larvae; $p_2 = 0.284$ for imagos; mean values marked with the same letter do not differ statistically significantly

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

Table 14. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Bela Crkva location 2 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	323	238	341	339	1241.0	310.25a	48.8	-	-
		imagos	217	149	270	254	890.0	222.50a	53.8	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	57	43	31	26	157.0	39.25b	13.8	85.85	86.27
		imagos	10	11	5	17	43.0	10.75b	4.9	92.54	92.54
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	7	16	10	7	40.0	10.00bc	4.2	95.97	96.44
		imagos	12	0	7	0	19.0	4.75b	5.9	96.76	96.76
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	0	7	10	0	17.0	4.25c	5.1	98.57	99.06
		imagos	0	3	3	0	6.0	1.50b	1.7	98.92	98.92
5	Volley 20 SP c(0.25 kg/ha)	larvae	2	0	0	4	6.0	1.50c	1.9	99.51	100.00
		imagos	0	0	0	0	0.0	0.00b	0.0	100.00	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

Table 15. *The number of live T. vaporariorum larvae and imagos and the effectiveness of insecticides at the Bela Crkva locality 8 days after treatment*

Number	Treatment		The number of live larvae and imagos of *T. vaporariorum* on 10 leaves per expt. plots				Σ	Ms	Sd	Efficiency [%]	Efficiency compared to the standard [%]
			A	B	C	D					
1	Untreated control	larvae	413	301	420	411	1545.0	386.25a	57.0	-	-
		imagos	279	233	350	317	1179.0	294.75a	50.4	-	-
2	Acetamiprid 20% SP c(0.12 kg/ha)	larvae	84	60	55	50	249.0	62.25b	15.1	81.97	82.24
		imagos	17	20	9	33	79.0	19.75b	10.0	89.65	90.48
3	Acetamiprid 20% SP c(0.2 kg/ha)	larvae	18	30	22	14	84.0	21.00c	6.8	93.19	93.50
		imagos	20	0	13	3	36.0	9.00b	9.2	95.36	96.25
4	Acetamiprid 20% SP c(0.25 kg/ha)	larvae	14	20	18	9	27.0	6.75c	6.2	95.89	96.21
		imagos	7	14	9	3	33.0	8.25b	4.6	95.52	96.41
5	Volley 20 SP c(0.25 kg/ha)	larvae	5	0	0	0	5.0	1.25c	2.5	99.67	100.00
		imagos	4	2	2	0	8.0	2.00b	1.6	99.08	100.00

Ms — mean value; Σ - sum; Sd - standard deviation; $p_1 = 0.000$ for larvae; $p_2 = 0.000$ for imagos mean values marked with the same letter do not differ statistically significantly

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

The applied preparation in a concentration of 0.2-0.25 kg/ha showed high efficiency in suppressing *T. vaporariorum*, which was at the level of the standard Volley 20 SP and it was applied in an amount of 0.25 kg/ha. Comparing the values of biological efficiency at different concentrations, it can be concluded that Acetamiprid 20% SP at a concentration of 0.25 kg/ha showed an efficacy above 95% for the controlling of both larvae and adults, in all four locations after 2 and after 8 days of treatment. The applied concentration of 0.2 kg/ha showed very similar results, so using this concentration is more recommendable from both an ecological and an economic point of view. On the other hand, Acetamiprid 20% SP in a concentration of 0.12 kg/ha in all four locations shows an efficiency lower than 90%, so it is not a recommended dose to achieve success in controlling *T. vaporariorum*. In the amount of 0.2-0.25 kg/ha, the examined Acetamiprid 20% SP showed high efficacy in suppressing *T. vaporariorum*, which was at the level of the Volley 20 SP standard, being applied in the amount of 0.25 kg/ha. In the minimum effective amount of 0.12 kg/ha, the examined product Acetamiprid 20% SP showed a significantly lower efficacy compared to the Volley 20 SP standard. The active substance acetamiprid is applied in the amount of 40-50 g/ha. The amount of water used for treatments, depending on the location, is 200-600 l/ha. A ready-made solution for tomato treatment is 0.067-0.25% active substance acetamiprid. All insecticide treatments, in all evaluations after treatment and in all locations, showed statistically very significant differences compared to the untreated control.

The number of greenhouse whiteflies on tomato plants was different, depending on the locality and experimental field (*Tables 4-15*). *T. vaporariorum* was mostly homogeneously present within the experimental plots. The average number of larvae on 10 leaves, in the untreated control, immediately before treatment, was from 174 at Mužlja location to 353.5 at Omoljica location, while the average number of imagoes was from 99.5 at Mužlja location to 186.5 at Bela Church. The number of larvae and imagoes of *T. vaporariorum* after treatment was significantly reduced in all treated plots. If used in accordance with the instructions for use, the preparation Acetamiprid 20% SP does not cause phytotoxic effects in the tomato crop in a protected area.

Discussion

Many authors have investigated the efficacy of the use of insecticides from the group of neonicotinoids on whiteflies (Gužvanj, 2006; Quesada and Scharf, 2023). The different reaction of tomatoes and their increased sensitivity to different doses and types of insecticides was confirmed by Erdogan et al. (2021), Gorman et al. (2007) and Dai et al. (2024). Dai et al. (2024) found that the toxicity of neonicotinoids to adults was high, but was relatively low to third instar nymphs of *T. vaporariorum*. Moreover, first and second instar greenhouse whitefly nymphs are more sensitive to neonicotinoids than adults, while third instar nymphs are the least sensitive (Bi and Toscano, 2007; Erdogan et al., 2021). Therefore, the use of acetamiprid significantly reduces the number of adults and early-aged nymphs. However, greenhouse whitefly has enormous potential to develop resistance to insecticides (Pappas et al., 2013; Naveen et al., 2017; Shah et al., 2020), and increasing resistance levels to neonicotinoids also increases LC50s for first instar nymphs in greenhouse whitefly field strains (Jiang et al., 2019).

Since the temperature value has an indirect effect on the efficacy of the insecticide, it was observed that in all four locations, the average temperature ranged from 18 to 28 ºC,

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

which indicates the fact that under these temperature conditions, the efficacy of the insecticide Acetamiprid 20% SP is excellent (Soliman, 2012).

According to the data available in the Arthropod Pesticide Resistance Database, the occurrence of resistant populations of 21 insect species to acetamiprid was confirmed in a very large number of cases. One case of *T. vaporariorum* resistance to acetamiprid was reported (Karatolos et al., 2014). Due to the possible development of resistance and cross-resistance, it must not be used alternatively with products based on other neonicotinoids.

Conclusion

Acetamiprid 20% SP belongs to the group of neonicotinoid synthetic insecticides. It has an effect via contact and digestively. In the central nervous system of insects, it causes an irreversible blockade of postsynaptic receptors. It has distinctly systemic properties. It is particularly effective on sucking insects but also on pests that bite plant parts. Continuous monitoring and control of the greenhouse whitefly is very important in order to preserve the yield of tomatoes, especially in sheltered conditions. The purpose of this paper was to achieve sustainable agricultural development, which means managing agriculture and resources in such a way as to preserve the environment in the same or better condition for future generations, without economic profit decline. Customer satisfaction is of paramount importance in today's market. Consumers want a high-quality product, and that is what manufacturers, that is, sellers, should offer to them. Regarding tomatoes, the use of Acetamiprid 20% SP can contribute to the improvement of product quality and reduction of losses and costs. For this reason, its use enables consumers to get better quality products at affordable prices on the market and, on that basis, to achieve benefits both for the producers themselves and for the users, i.e., the consumers of this agricultural product. The reduction of plant damage, i.e., its adequate protection with the use of this product, contributes to the improvement of the product quality and yield. Therefore, it contributes to higher sales and growth of the profit margin for agricultural producers. On the other hand, it also contributes to greater satisfaction of consumers and end users and increases their loyalty.

Disclosure statement. No potential conflict of interest was reported by the authors.

REFERENCES

[1] Alsafran, M., Rizwan, M., Usman, K., Hamzah Saleem, M., Jabri, H. (2022): Neonicotinoid insecticides in the environment: A critical review of their distribution, transport, fate, and toxic effects. – Journal of Environmental Chemical Engineering 10(5): 108485.

[2] Bi, J. L., Toscano, N. C. (2007): Current status of the greenhouse whitefly, *Trialeurodes vaporariorum*, susceptibility to neonicotinoid and conventional insecticides on strawberries in southern California. – Pest Management Science 752: 747-752.

[3] Bottrell, D. G., Schoenly, K. G. (2018): Integrated pest management for resource-limited farmers: challenges for achieving ecological, social and economic sustainability. – The Journal of Agricultural Science 156(3): 408-426.

[4] Capela, N., Xu, M., Simões, S., Azevedo-Pereira, H., Peters, J., Sousa, J. (2022): Exposure and risk assessment of acetamiprid in honey bee colonies under a real exposure scenario in Eucalyptus sp. Landscapes. – Science of the Total Environment 840: 156485.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

[5] Carbo, L., Martins, E. L., Dores, E. F., Spadotto, C. A., Weber, O. L., De-Lamonica-Freire E. M. (2007): Acetamiprid, carbendazim, diuron and thiamethoxam sorption in two Brazilian tropical soils. – Journal of Environmental Science and Health, Part. B, Pesticides, Food Contaminants, and Agricultural Wastes 42(5): 499-507.
[6] Carstens, K. (2023): Acetamiprid Review for European Food Safety Authority. – European Food Safety Authority (EFSA), Working Group on Acetamiprid, Parma, Italy, June 27, 2023.
[7] Cvijanović, V., Sarić, B., Dramićanin, A., Kodranov, I., Manojlović, D., Momirović, N., Momirović, N., Milojković-Opsenica, D. (2021): Content and distribution of macroelements, microelements, and rare-earth elements in different tomato varieties as a promising tool for monitoring the distinction between the integral and organic systems of production in Zeleni hit—Official enza and vitalis trial and breeding station. – Agriculture 11(10): 1009. https://doi.org/10.3390/agriculture11101009.
[8] Dai, X., Lin, Q., Liu, Y., Wang, R., Su, L., Yin, Z., Zhao, S., Zhang, F., Chen, H., Zheng, L., Zhai, Y., Zhang, L. (2024): Precise Control and Prevention Methods for Whitefly in Greenhouse Vegetables. – Agronomy 14(5): 989.
[9] Elanchezhyan, K., Rajinimala, N., Lenin Raja, D., Suba Sri Gokila, A. (2025): Farm-made pesticides-degrading lactic acid bacterial formulation for pest management in okra, *Abelmoschus esculentus* (L.) Moench. – Applied Ecology and Environmental Research 23(2):1717-1733.
[10] Erdogan, C., Velioglu, A. S., Gurkan, M. O., Denholm, I., Moores, G. D. (2021): Detection of resistance to pyrethroid and neonicotinoid insecticides in the greenhouse whitefly, *Trialeurodes vaporariorum* (Westw.) (Hemiptera: Aleyrodidae). – Crop Protection 146: 105661.
[11] Gorman, K., Devine, G., Bennison, J., Coussons, P., Punchard, N., Denholm, I. (2007): Report of resistance to the neonicotinoid insecticide imidacloprid in *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae). – Pest Management Science 558: 555-558.
[12] Gužvanj, V. (2006): Contribution to the Characterisation and Determination of some Neonicotinoids. – PhD thesis, Faculty of Science, University of Novi Sad.
[13] Ivanišević, D., Mutavdžić, B., Novković, N., Vukelić, N. (2015): Analysis and prediction of tomato price in Serbia. – Economics of Agriculture 62: 951-962.
[14] Jeschke, P., Nauen, R., Schindler, M., Elbert, A. (2011): Overview of the Status and Global Strategy for Neonicotinoids (dagger). – Journal of Agricultural and Food Chemistry 59(7): 2897-2908.
[15] Jiang, J., Liu, X., Huang, X., Yu, X., Zhang, W., Zhang, X., Mu, W. (2019): Comparative ecotoxicity of neonicotinoid insecticides to three species of *Trichogramma* parasitoid wasps (Hymenoptera: Trichogrammatidae). – Ecotoxicology and Environmental Safety 183: 109587.
[16] Johnson, M. W., Caprio, L. C., Coughlin, J. A., Tabashnik, B. E., Rosenheim, J. A., Welter, S. C. (1992): Effect of *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae) on yield of fresh market tomatoes. – Journal of Economic Entomology 85(6): 2370-2376. https://doi.org/10.1093/jee/85.6.2370.
[17] Karatolos, N., Denholm, I., Williamson, M., Gorman, K. (2014): Incidence and characterisation of resistance to neonicotinoid insecticides and pymetrozine in the greenhouse whitefly, *Trialeurodes vaporariorum* Westwood (Hemiptera: Aleyrodidae). – Pest Management Science 66: 1304-1307.
[18] Liu, T., Stansly, P. A., Gerling, D. (2015): Whitefly parasitoids: Distribution, life history, bionomics, and utilization. – Annual Review of Entomology 60: 273-392.
[19] Liu, J., Wang, X. (2020): Tomato Diseases and Pests Detection Based on Improved Yolo V3 Convolutional Neural Network. – Frontiers in Plant Science 11: 898.
[20] Naveen, N. C., Chaubey, R., Kumar, D., Rebijith, K. B., Rajagopal, R., Subrahmanyam, B., Subramanian, S. (2017): Insecticide resistance status in the whitefly, *Bemisia tabaci*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2306_1167511690

genetic groups Asia-I, Asia-II-1 and Asia-II-7 on the Indian subcontinent. – Scientific Reports 7: 40634.

[21] Pappas, M. L., Migkou, F., Broufas, G. D. (2013): Incidence of resistance to neonicotinoid insecticides in greenhouse populations of the whitefly, *Trialeurodes vaporariorum* (Hemiptera: Aleyrodidae) from Greece. – Applied Entomology and Zoology 48: 373-378.

[22] Paweer, M. M. Z., Namikoye, E. S., Nchore, S. B., Akutse, K. S. (2025): Can fungal endophytes suppress *Trialeurodes vaporariorum* and the transmission of tomato infectious chlorosis and chlorosis viruses in field conditions? – Frontiers in Cellular and Infection Microbiology 15: 1470821. https://doi.org/10.3389/fcimb.2025.1470821.

[23] Quesada, C. R., Scharf, M. E. (2023): Whiteflies can excrete insecticide-tainted honeydew on tomatoes. – Environmental Pollution 337: 122527. https://doi.org/10.1016/j.envpol.2023.122527.

[24] Shah, R., Al-Sadi, A., Scott, I., AlRaeesi, A., Al-Jahdhami, A. (2020): Insecticide resistance monitoring in whitefly (*Bemisia tabaci*) (Hemiptera: Aleyrodidae) in Oman. – Journal of. Asia- Pacific Entomology 23: 1248-1254.

[25] Soliman, M. (2012): Effects of UV-light, temperature and storage on the stability and biological effectiveness of some insecticides. – Journal of Plant Protection Research 52(2): 275-280.

[26] Stojanović, M., Becić, S., Nikolić, M., Stanković, J. (2018): Consumer preferences to organic agricultural products: The case of South Serbia. – KNOWLEDGE – International Journal 26(5): 1401-1406.

[27] Wang, Z., Dai, P., Yang, X., Ruan, C., Biondi, A., Zang, L. (2019): Selectivity of novel and traditional insecticides used for management of whiteflies on the parasitoid *Encarsia formosa*. – Pest Management Science 75: 2716-2724.

[28] Waterfield, G., Zilberman, D. (2012): Pest management in food systems: An economic perspective. – Annual Review of Environment and Resources 37(1): 223-245.

[29] WHO (2020): Health 2020: A European policy framework supporting action across government and society for health and well-being. – Copenhagen: WHO Regional Office for Europe. https:// www.euro.who.int/__data/assets/pdf_file/0006/199536/Health 2020-Short.pdf.