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SIDE EFFECT OF INSECTICIDES AGAINST SOME BENEFICIAL SPECIES

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Abstract

Beneficial species of predators and parasitoids play an important role in sustainable pest control. Toxicity evaluation of insecticides against the natural enemies of the pests is very important in the selection of a product intended for application within the Integrated Pest Management (IPM). The effectiveness of beneficial species as biological control agents may be compromised by side effects caused by insecticides. Tests were conducted under laboratory conditions to determine the toxicity of 18 insecticides against the beneficial species *Encarsia formosa* Gahan, *Macrolophus pygmaeus* Rambur and *Amblyseius cucumeris* Oudeman. Plant protection products Rapax (i.e. *Bacillus thuringiensis* subsp. *kurstaki* strain EG 2348) 0.1%, Dipel 2X (i.e. *Bacillus thuringiensis* var. *kurstaki* strain ABTS) 0.1%, Naturalis (i.e. *Beauveria bassiana* strain ATCC 74040) 0.1%–0.15%, Helicovex (i.e. *Helicoverpa armigera nucleopolyhedro virus Hear NVP*, *DSMZ–BV0003*) 0.02%, Neem Azal T/S (i.e. azadirachtin) 0.3% and Limocide (i.e. orange oil) 0.4% were slightly toxic (toxicity up to 37%) to the tested bioagents. They can be successfully applied in integrated plant protection systems. Toxic to highly toxic were the following insecticides: Koragen 20 SC 0.02%, Voliam Targo 063 SK 0.08%, Ampligo 150 ZK 0.04%, Closer 120 SC 0.04%, Confidor Energy OD 0.08%, Vaztak new 100 EC 0.03%. These insecticides should be avoided when introducing bioagents into greenhouses.

Keywords: *Encarsiaformosa*, *Macrolophuspygmaeus*, *Amblyseius cucumeris,* toxicity, plant protection products

INTRODUCTION

Growing vegetable crops in greenhouses often requires the intensive use of plant protection products since the application of chemical insecticides is still the main method for pest control. Often their use leads to the emergence of resistance in pest populations and poses a risk to the environment and human health. Many of these plant protection products are effective against target pests but are harmful to natural enemies, reducing the effectiveness of biological control (Sugiyama et al., 2011). Using beneficial species to control pests is a successful management alternative and pests`natural enemies occupy an important place in the processes of keeping the biological balance in agrocenoses.

The greenhouse whitefly *Trialeurodes vaporariorum* Westwood (*Hemiptera*: *Aleyrodidae*) is a key pest of greenhouses and field crops, which has developed pesticide resistance over the years. It has emerged as a pest which management is difficult due to its indiscriminate resistance to high doses of insecticides. The use of natural enemies is environmentally safe alternative in the management tactic. The efficacy of *Encarsia formosa* Gahan (*Hymenoptera*: *Aphelinidae*) was determined by studying its biological characteristics on *T. vaporariorum. E. formosa* can be included in programs for biocontrol against whitefly population on crops grown under protected conditions (Deeksha et al., 2023).

Macrolophus pygmaeus Rambur (*Hemiptera*: *Miridae*) is a widespread predatory bug used for biological control of various pests in greenhouse tomato production in Europe, including the invasive tomato leafminer *Tuta absoluta* (Meyrick) (*Lepidoptera*: *Gelechiidae*) (Sylla et al., 2016).

Predatory mites of the *Phytoseiidae* family are very effective in controlling pests and mites in greenhouses (Nadimi et al., 2008). The predatory mite *Amblyseius cucumeris* Oudemans (*Phytoseiidae*) is one of the main predators of various species of insect pests and mites such as the spider mites and western flower thrips in greenhouse vegetables (Yang et al., 2014, Dougoud et al., 2017). Predatory insects and mites may be adversely affected by chemical insecticides by feeding on pollen, nectar, or plant tissue which are contaminated with the active ingredient or by feeding on hosts that consume leaves contaminated with the active ingredient. Parasitoids can also be negatively affected by insecticides because foliar application can reduce host population levels so that there are not enough hosts to attack and thus it reduces the parasite populations. In addition, feeding female parasitoids may inadvertently ingest a lethal concentration of the active ingredient or a sublethal dose, which may inhibit searching for food or oviposition (Cloyd & Bethke, 2011).

However, the efficacy of beneficial species as biological control agents can be compromised by lethal or sublethal side effects caused by insecticides (Fytrou et al., 2017). Evaluation of the side effects of insecticides on beneficial insects is essential and has attracted much research (Simmonds et al., 2002). The effects of insecticides on natural enemies will be fully appreciated when the risk assessment includes acute toxicity as well as sublethal and chronic effects (Desneux et al., 2007, Wang et al., 2012). Based on these findings, the selection of appropriate insecticides that have less negative impact on a specific natural enemy is crucial for the development and success of IPM (Moura et al., 2006, He et al., 2018).

A good knowledge of the selective action of plant protection products and their toxicity towards beneficial species enables an optimal combination of the individual elements in the pest control systems. In the development of integrated and biological plant protection systems, non–toxic to slightly toxic insecticides to bio–agents are of interest. The protection of useful species in the agrocenoses of vegetable crops is an important prerequisite for successful control of pests and it is a guarantee of quality production.

The aim of the study is to determine the toxicity of some plant protection products to *Encarsia Formosa* Gahan, *Macrolophus pygmaeus* Rambur и *Amblyseius cucumeris* Oudeman.

MATERIALS AND METHODS

To assess the toxic effect of plant protection products pot (container) experiments were carried out under laboratory conditions in a thermostat at temperature of 24±1ºC during 2022–2023. The objects of the study were: the imago of the endoparasite on the larvae of the greenhouse whitefly – *Encarsia formosa* Gahan; adults and larvae of the predatory bug *Macrolophus pygmaeus* Rambur; adults, larvae and nymphs of the predatory mite *Amblyseius cucumeris* Oudeman. Methodologically, the contact of bioagent was indirect since the tomato leaves were treated by “dipping method”. The leaves were dipped in the insecticide solution of a certain concentration and dried. The bioagents were released under an isolator (3 repetitions of 30 individuals). An untreated control was included in the experiment. Mortality of individuals was recorded after 24h. Corrected toxicity was calculated using Abbott (1925) modified formula:

$$Toxicity\% = \left(\frac{Pb - Pk}{100 - Pk}\right).100$$

where: *Pb* – % mortality in the variant, *Pк*– % mortality in control.

Based on the parameters adopted by the Working Group of the Eastern Palearctic

Section of the International Organization for Biological Control, pesticides are classified into five groups: (1) Non–toxic, toxicity up to 20% (–), (2) Slightly toxic, toxicity up to 37% (+), (3) Median toxic, toxicity up to 63% (++), (4) Toxic, toxicity up to 80% (+++), (5) Strongly toxic, toxicity over 80% (++++) (Hassan et al., 1983).

Table 1. Studied plant protection products

Product	Active ingredient	Concentration %
Rapax	*Bacillus thuringiensis* subsp. *Kurstaki* strain EG 2348	0.1
Dipel 2 X	*Bacillus thuringiensis* var. *kurstaki* strain ABTS	0.1
Naturalis	*Beauveria bassiana*s trainATCC 74040	0.1–0.15
Helicovex	*Helicoverpa armigera nucleopolyhedro virus Hear NVP*, *DSMZ–BV0003*	0.02
Neem Azal T/S	azadirachtin	0.3
Krisant EC	pyrethrins	0.075
Limocide	orange oil	0.4
Sineis 480 SC	spinosad	0.03
Coragen 20 SC	chlorantraniliprole	0.02
Exalt 25 SC	spinetoram	0.24
Voliam Targo 063 SC	abamectin+chlorantraniliprole	0.08
Ampligo 150 ZC	lambda cyhalothrin+chlorantraniliprole	0.04
Closer 120 SC	sulfoxaflor	0.02–0.04
Vaztak new 100 EC	alpha–cypermethrin	0.03
Valmec	abamectin	0.1
Affirm 095 SG	emamectin benzoate	0.15
Confidor Energy OD	imidacloprid+deltamethrin	0.08
Mospilan 20 SP	acetamiprid	0.02

The experiments used newly imaginal 24h adult individuals of *E. formosa* and a mixed age population of *M. pygmaeus* and *A. cucumeris*. The bioagents were obtained from Bioplanet.eu by Amititsa Ltd. The obtained data were processed mathematically. A comparative analysis was made using the method of Duncan's multiple range test (1955). The anlyses were done with “MS Excel Analysis ToolPak Add–Ins” (https://support.office.com) and “R–3.1.3” in combination with “RStudio–0.98” and package “agricolae 1.2–2” (Mendiburu, 2015).

RESULTS AND DISCUSSION

Eighteen plant protection products with different mechanism of action were tested to determine their side effect against some beneficial species commonly used in growing vegetable crops in greenhouses. The obtained results for the toxicity of the investigated insecticides gave a possibility to classified them in the following groups:

Encarsia formosa Gahan (Table 2)

Slightly toxic, toxicity up to 37% (+) – Rapax 0.1%, Dipel 2X 0.1%, Naturalis 0.1%, Naturalis 0.15%, Helicovex 0.02%, Neem Azal T/S 0.3%, Limocide 0.4%,

Table 2. Toxicity of some insecticides to *Encarsia formosa* Gah. (imago)

Product	Active ingredient	Concen-tration %	Toxicity (%)				
			Average	Group	Min	Max	SD
Rapax	*Bacillus thuringiensis* subsp. *kurstaki*strain EG 2348	0.1	32.22[g]	+	26.67	36.67	5.09
Dipel 2 X	*Bacillus thuringiensis* var. *kurstaki* strain ABTS	0.1	31.11[g]	+	26.67	36.67	5.09
Naturalis	*Beauveria bassiana*strainATCC 74040	0.1	28.89[g]	+	20.00	36.67	8.39
Naturalis	*Beauveriabassiana* strain ATCC 74040	0.15	33.33[g]	+	26.67	40.00	6.67
Helicovex	*Helicoverpaarmigera nucleopolyhedrovirus Hear NVP, DSMZ–BV0003*	0.02	30.00[g]	+	20.00	36.67	8.82
Neem Azal T/S	azadirachtin	0.3	26.67[g]	+	23.33	30.00	3.34
Krisant EC	pyrethrins	0.075	68.89[bcde]	+++	66.67	70.00	1.92
Limocide	orange oil	0.4	35.55[g]	+	33.33	40.00	3.85
Sineis 480 SC	spinosad	0.03	62.22[def]	++	56.67	66.67	5.09
Coragen 20 SC	chlorantraniliprole	0.02	76.67[abc]	+++	73.33	80.00	3.34
Exalt 25 SC	spinetoram	0.24	74.45[abcde]	+++	70.00	76.67	3.85
Voliam Targo 063 SC	abamectin+chloran traniliprole	0.08	73.34[abcde]	+++	66.67	76.67	5.77
Ampligo 150 ZC	lambda cihalotrin+chlorantran iliprole	0.04	75.56[abcd]	+++	70.00	80.00	5.09
Closer 120 SC	sulfoxaflor	0.02	61.11[ef]	++	56.67	63.33	3.85
Closer 120 SC	sulfoksaflor	0.04	74.45[abcde]	+++	66.67	80.00	6.94
Vaztak new 100 EC	alpha–cypermethrin	0.03	84.44[a]	++++	80.00	86.66	3.85
Valmec	abamectin	0.1	51.11[f]	++	30.00	66.67	18.96
Affirm 095 SG	emamectin benzoate	0.15	53.33[f]	++	40.00	63.33	12.02
Confidor Energy OD	imidacloprid+ deltamethrin	0.08	81.11[ab]	++++	70.00	86.66	9.62
Mospilan 20 SP	acetamiprid	0.02	66.67[cde]	+++	63.33	70.00	3.34

***Legend**: different superscripts indicate significant difference, Duncan's multiple range test ($p < 0.05$). Non–toxic, toxicity up to 20% (–), Slightly toxic, toxicity up to 37% (+), Median toxic, toxicity up to 63% (++), Toxic, toxicity up to 80% (+++), Strongly toxic, toxicity over 80% (++++).

Median toxic, toxicity up to 63% (++) – Sineis 480 SC 0.03%, Closer 120 SC 0.02%, Valmec 0.1%, Affirm 095 SG 0.15%,

Toxic, toxicity up to 80% (+++) – Krisant EC 0.075%, Coragen 20 SC 0.02 %, Exalt 25 SC 0.24%, Voliam Targo 063 SC

0.08%, Ampligo 150 ZC 0.04%, Closer 120 SC 0.04%, Mospilan 20 SP 0.02%,

Strongly toxic, toxicity over 80% (++++) – Vaztak new 100 EC 0.03%, Confidor Energy OD 0.08%.

Macrolophus pygmaeus Rambur (Table 3)

Non–toxic, toxicity up to 20% (–) – Rapax 0.1%, Dipel 2X0.1%, Naturalis 0.1%, Helicovex 0.02%, Neem Azal T/S 0.3%,

Slightly toxic, toxicity up to 37% (+) – Naturalis 0.15%, Limocide 0.4%,

Median toxic, toxicity up to 63% (++) – Krisant EC 0.075%, Sineis 480 SC 0.03%, Closer 120 SC 0.02%, Exalt 25 SC 0.24%,Valmec 0.1%, Affirm 095 SG 0.15%, Mospilan 20 SP 0.02%,

Toxic, toxicity up to 80% (+++) – Coragen 20 SC 0.02 %, Voliam Targo 063 SC 0.08%, Ampligo 150 ZC 0.04%, Closer 120 SC 0.04%, Confidor Energy OD 0.08%,

Strongly toxic, toxicity over 80% (++++) – Vaztak new 100 EC 0.03%.

Amblyseius cucumeris Oudeman (Table 4)

Slightly toxic, toxicity up to 37% (+) – Rapax 0.1%, Dipel 2X 0.1%, Naturalis 0.1%, Naturalis 0.15%, Helicovex 0.02%, Neem Azal T/S 0.3%, Limocide 0.4%,

Median toxic, toxicity up to 63% (++) – Sineis 480 SC 0.03%, Closer 120 SC 0.02%, Valmec 0.1%, Affirm 095 SG 0.15%,

Toxic, toxicity up to 80% (+++) – Krisant EC 0.075%, Coragen 20 SC 0.02 %, Exalt 25 SC 0.24%, Voliam Targo 063 SC 0.08%, Ampligo 150 ZC 0.04%, Closer 120 SC 0.04%, Mospilan 20 SP 0.02%, Confidor Energy OD 0.08%.

Strongly toxic, toxicity over 80% (++++) – Vaztak new 100 EC 0.03%.

Among the tested bioagents with relatively higher sensitivity to the insecticides included in the study, the parasite *E. formosa* stands out, followed by *A. cucumeris* and *M. pygmaeus*. The groups of non-toxic to slightly toxic plant protection products towards to the tested bioagents include: Rapax 0.1%, Dipel 2X 0.1%, Naturalis 0.1%, Naturalis 0.15%, Helicovex 0.02%, Neem Azal T/S 0.3%, Limocid 0.4%. These bioinsecticides belong to the microbial and botanical products. Among the phytopesticides Krisant EC 0.075% belongs to the group of moderately toxic to toxic insecticides, which is probably due to its rapid contact action as a representative of pyrethrins. The insecticides Sineis 480 SC 0.03% (spinosins), Valmec 0.1% and Affirm 095 SG 0.15% (avermectins) belonged to the group of moderately toxic products towards the tested bioagents. An intermediate position from moderately toxic to toxic was occupied by the products Closer 120 SC 0.02% (sulfoximines), Exalt 25 SC 0.24% (spinosins) and Mospilan 20 SP 0.02% (neonicotinoids). The plant protection products Coragen 20 SC 0.02% (diamides), Voliam Targo 063 SC 0.08% (diamide+avermectin), Ampligo 150 ZC 0.04% (pyrethroid+diamide), Closer 120 SC 0.04% (sulfoximines) were toxic towards the tested bioagents. Toxic to highly toxic were the products Vaztak new 100 EC 0.03% (pyrethroids) and Confidor Energy OD 0.08% (neonicotinoid + pyrethroid).

In recent years, studies have been conducted to determine the side effects of various plant protection products against beneficial species. The toxicity of 24 insecticides for whitefly control against *Eretmocerus mundus*Mercet, *Eretmoceruseremicus* Rose and *Zolnerowich* and *Encarsiaformosa* Gahan was determined using the dipping method. Neonicotinoids, synthetic pyrethroids, organophosphates, emamectin benzoate and spinosad are harmful to beneficial species. Parasitoids were not seriously affected by *Bacillus thuringiensis*–based insecticides (Sugiyama et al., 2011). Many essential oils have a long tradition of use against pests. However, studies concerning the ability of these products to be part of an IPM cultivation are hardly known.

Studies on existing populations of predatory mites and predatory and parasitoid insects on pepper were carried with orange oil as an active substance. The products showed harmless or slightly toxic results, according to the IOBC classification (Kolokytha & Sterk, 2017). Simmonds et al. (2002) reported that pyrethrum was toxic both to the whitefly and its parasite *E. formosa* Gahan. In general, the products derived from *A. indica* have the greatest potential for use in IPM systems for greenhouse whitefly control that include *E. formosa* as a biocontrol agent.

Table 3. Toxicity of some insecticides to *Macrolophus pygmaeus* Rambur

Product	Active ingredient	Concen-tration %	Toxicity (%)				
			Average	Group	Min	Max	SD
Rapax	*Bacillus thuringiensis* subsp. *kurstaki*strain EG 2348	0.1	16.67^{g}	–	13.33	20.00	3.34
Dipel 2 X	*Bacillus thuringiensis* var. *kurstaki* strain ABTS	0.1	16.67^{g}	–	16.67	16.67	0.00
Naturalis	*Beauveria bassiana* strain ATCC 74040	0.1	17.78^{g}	–	16.67	20.00	1.92
Naturalis	*Beauveria bassiana* strain ATCC 74040	0.15	22.22^{g}	+	20.00	23.33	1.92
Helicovex	*Helicoverpa armigera nucleopolyhedro virus Hear NVP, DSMZ–BV0003*	0.02	18.89^{g}	–	16.67	20.00	1.92
Neem Azal T/S	azadirachtin	0.3	20.00^{g}	–	16.67	23.33	3.33
Krisant EC	pyrethrins	0.075	61.09^{cde}	++	56.67	66.60	5.05
Limocide	orange oil	0.4	23.33^{g}	+	20.00	30.00	5.77
Sineis 480 SC	spinosad	0.03	58.89 de	++	56.67	60.00	1.92
Coragen 20 SC	chlorantraniliprole	0.02	65.55^{bcd}	+++	63.33	70.00	3.85
Exalt 25 SC	spinetoram	0.24	62.22^{cde}	++	56.67	70.00	6.94
Voliam Targo 063 SC	abamectin+ chlorantraniliprole	0.08	75.53^{ab}	+++	66.60	80.00	7.74
Ampligo 150 ZC	lambda cihalotrin+chlorantraniliprole	0.04	67.76^{bcd}	+++	56.67	80.00	11.71
Closer 120 SC	sulfoxaflor	0.02	57.78^{de}	++	56.67	60.00	1.92
Closer 120 SC	sulfoksaflor	0.04	65.56^{bcd}	+++	56.67	70.00	7.70
Vaztak new 100 EC	alpha–cypermethrin	0.03	82.22^{a}	++++	80.00	83.33	1.92
Valmec	abamectin	0.1	52.22^{ef}	++	40.00	60.00	10.72
Affirm 095 SG	emamectin benzoate	0.15	46.67^{f}	++	40.00	60.00	11.55
Confidor Energy OD	imidacloprid+ deltamethrin	0.08	72.20^{abc}	+++	66.60	80.00	6.97
Mospilan 20 SP	acetamiprid	0.02	58.89^{de}	++	56.67	60.00	1.92

Legend: different superscripts indicate significant difference, Duncan's multiple range test ($p < 0.05$). Non–toxic, toxicity up to 20% (–), Slightly toxic, toxicity up to 37% (+), Median toxic, toxicity up to 63% (++), Toxic, toxicity up to 80% (+++), Strongly toxic, toxicity over 80% (++++).

Table 4. Toxicity of some insecticides to *Amblyseius cucumeris* Oudeman

Product	Active ingredient	Concen-tration %	Toxicity (%)				
			Average	Group	Min	Max	SD
Rapax	*Bacillus thuringiensis* subsp. *kurstaki*strain EG 2348	0.1	24.44[h]	+	23.33	26.67	1.93
Dipel 2 X	*Bacillus thuringiensis* var. *kurstaki* strain ABTS	0.1	26.67[h]	+	26.67	26.67	0.00
Naturalis	*Beauveria bassiana* strain ATCC 74040	0.1	23.33[h]	+	23.33	23.33	0.00
Naturalis	*Beauveria bassiana* strain ATCC 74040	0.15	28.89[h]	+	26.67	30.00	1.92
Helicovex	*Helicoverpa armigera nucleopolyhedro virus Hear NVP, DSMZ–BV0003*	0.02	28.89[h]	+	26.67	30.00	1.92
Neem Azal T/S	azadirachtin	0.3	21.11[h]	+	20.00	23.33	1.92
Krisant EC	pyrethrins	0.075	71.11[bcd]	+++	70.00	73.33	1.92
Limocide	orange oil	0.4	27.78[h]	+	23.33	36.67	7.70
Sineis 480 SC	spinosad	0.03	59.98[ef]	++	56.67	66.60	5.73
Coragen 20 SC	chlorantraniliprole	0.02	74.44[abc]	+++	70.00	83.33	7.70
Exalt 25 SC	spinetoram	0.24	66.64[cdef]	+++	63.33	70.00	3.34
Voliam Targo 063 SC	abamectin+chlorantranili prole	0.08	77.78[ab]	+++	70.00	83.33	6.94
Ampligo 150 ZC	lambda cihalotrin+chlorantranili prole	0.04	66.67[cdef]	+++	63.33	70.00	3.34
Closer 120 SC	sulfoxaflor	0.02	62.22[def]	++	56.67	70.00	6.94
Closer 120 SC	sulfoksaflor	0.04	67.78[bcde]	+++	63.33	70.00	3.85
Vaztak new 100 EC	alpha–cypermethrin	0.03	83.33[a]	++++	83.33	83.33	0.00
Valmec	abamectin	0.1	56.64[f]	++	40.00	66.60	14.51
Affirm 095 SG	emamectin benzoate	0.15	45.56[g]	++	40.00	56.67	9.62
Confidor Energy OD	imidacloprid+ deltamethrin	0.08	72.22[bcd]	+++	66.67	80.00	6.94
Mospilan 20 SP	acetamiprid	0.02	63.34[def]	+++	56.67	66.67	5.77

***Legend**: different superscripts indicate significant difference, Duncan's multiple range test ($p < 0.05$). Non–toxic, toxicity up to 20% (–), Slightly toxic, toxicity up to 37% (+), Median toxic, toxicity up to 63% (++), Toxic, toxicity up to 80% (+++), Strongly toxic, toxicity over 80% (++++).

Macrolophus pygmaeus Rambur is a common predator in agroecosystems. The toxic effects of six insecticides and one fungicide on *M. pygmaeus* were evaluated. Chlorantraniliprole and emamectin–benzoate caused less than 25% mortality to *M. pygmaeus* and were classified as harmless. In contrast, thiacloprid and metaflumizone caused 100% and 80% mortality, respectively, and were classified as harmful. Indoxacarb and spinosad resulted in close to 30% mortality of predator, and were classified as slightly harmful, while the fungicide copper hydroxide caused 58% mortality and was rated as moderately harmful. Thiacloprid significantly reduced predation rates of *M. pygmaeus*, while chlorantraniliprole had no significant effect on predation rates. The results of the current study suggested that thiacloprid is not compatible with *M. pygmaeus*, while further research needs to be carried out for metaflumizone and copper hydroxide. All other products seem to be relatively compatible with *M. pygmaeus*, though studies on their sublethal effects will shed more light into their safety (Martinou et al., 2014).

Amblyseius cucumeris (Oudemans) is a useful key predator in integrated pest management (IPM) programmes. There are few studies on the toxic effects of insecticides on *A. cucumeris*. Acetamiprid was found to have significant adverse effects on different stages of development of *A. cucumeris* (Cheng et al., 2018).

The neonicotinoid insecticides imidacloprid, acetamiprid, etc. are used in greenhouses to control a wide range of pests. However, these systemic insecticides can also be harmful to natural enemies, including predators and parasitoids (Cloyd & Bethke, 2011). Pesticides have been a tool in the control of pests, diseases, and weeds of agricultural systems. However, little attention has been given to their toxic effects on beneficial insect communities that contribute to the maintenance and sustainability of agroecosystems. In addition to pesticide–induced direct mortality, their sublethal effects on beneficial species physiology and behavior must be considered for a complete analysis of their impact (Serrão et al., 2022).

A good knowledge of the toxicity of insecticides to beneficial species enables the optimal combination of individual elements in integrated and biological systems for pest control. Non–toxic to slightly toxic products to bioagents are of interest. The introduction and protection of useful species in the agrocenoses of vegetable crops is an important condition for successful control of pests and a guarantee of quality production.

CONCLUSION

When determining the side effect of some plant protection products against beneficial species (*Encarsia formosa* Gahan, *Macrolophus pygmaeus* Rambur and *Amblyseius cucumeris* Oudeman) the following was established: Non–toxic to slightly toxic insecticides were: Rapax 0.1%, Dipel 2X 0.1%, Naturalis 0.1%, Naturalis 0.15%, Helicovex 0.02%, Neem Azal T/S 0.3%, Limocide 0.4%. They are of interest to biological and integrated pest control systems. Median toxic to toxic insecticides were: Krisant EC 0.075%, Sineis 480 SC 0.03%, Exalt 25 SC 0.24%, Closer 120 SC 0.02%,Valmec 0.1%, Affirm 095 SG 0.15%, Mospilan 20 SP 0.02%. Among the studied insecticides toxic to highly toxic were: Koragen 20 SC 0.02%, Voliam Targo 063 SK 0.08%, Ampligo 150 ZK 0.04%, Closer 120 SC 0.04%, Confidor Energy OD 0.08%, Vaztak new 100 EC 0.03%.

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