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Side effects of fungicides and insecticides on predatory mites, in laboratory conditions

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Abstract: Experiments were carried out on the toxicity of selected insecticides and fungicides to the predatory mites species: *Amblyseius swirskii, A. andersoni,* and *Phytoseiulus persimilis*. Among the tested active substances: abamectin, hexythiazox, and spinosad were safe to the predators. The mortality level of the tested predator was comparable to the control treatment, seven days after application. The percentage values of these predatory mites' mortality caused by these insecticides, applied at one and a half of the recommended dose did not exceed a low toxicity – 25% (referring to International Organisation for Biological and Integrated Control (IOBC) classification on the toxicity to beneficial organisms). The results of the tests revealed that imidaclopryd, lambda-cyhalothrin, and fenpyroksymat were highly toxic to the predatory mites. It was found that toxicity of fungicides to the tested predatory mite species depended on the date of the chemical treatment and the date the predators were introduced. The fungicide Topsin M 500 SC – thiophanate-methyl, appeared to be selective to the species *A. swirskii* and it could be used in the Integrated Pest Management (IPM) programs for greenhouse grown crops.

Key words: *Amblyseius andersoni, A. swirskii, Phytoseiulus persimilis,* predatory mites, side effects of pesticides

Introduction

Several species of spider mites occur on ornamental plants and vegetables cultivated in greenhouses. The most important are: the two-spotted spider mite *Tetranychus urticae* (Koch.) and the glasshouse red spider mite *Tetranychus cinnabarinus* (Boisd.). One female can lay up to 20 eggs per day and can live for two to four weeks, laying hundreds of eggs. A single mature female can spawn a population of a million mites in a month or less. This accelerated reproductive rate allows spider mite populations to adapt quickly to resistance pesticides. This is why chemical control methods can become somewhat ineffectual when the same pesticide is used over a prolonged period. In the experience of many and in a review of world literature, it is revealed that effective methods of biological spider mite control are already available, or can be easily adapted for practice (Stark and Banks 2003; Bernard *et al*. 2004).

Agricultural practice showed that the main goal of plant protection against harmful organisms cannot be achieved exclusively by mass application of pesticides. Numerous disadvantages of chemical treatments are: a rapid increase in pesticide production costs, a disturbance in the ecological balance due to the mortality of numerous beneficial organisms, the arising phenomenon of pests acquired resistance to applied pesticides, and an increased contamination of the environment and agricultural products with toxic substances. It is, therefore, important to determine the toxicity of pesticides for beneficial organisms, which are used to control pests in greenhouse crops. Compatibility studies of chemical and biological control agents are necessary to be able to give proper recommendations for integrated use (Wright and Verkerk 2006; Jansen 2010).

According to the Polish Directives, biological methods should be used prior to any application of chemical products. Biological control is a priority in plant protection, particularly for vegetable crops in greenhouses. Biological agents such as macroorganisms are not subject to registration requirements in Poland. Thus, there are natural enemies commercially available in Poland. A great many mites in the family Phytoseiidae are predators of spider mites. In addition to the Phytoseiidae family of mites, Integrated Pest Management (IPM) is often used in greenhouses vegetable crops but rarely with ornamental plants in Poland. Programs are based on the biological control of the main pests and sometimes the use of selective pesticides.

The main objective was to research the side effects of fungicides and insecticides on the predatory mites: *Amblyseius swirskii, Phytoseiulus persimilis,* and *Amblyseius andersoni* used for controlling spider mites in greenhouse crops.

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Materials and Methods

To study side effects of insecticides and fungicides on the predatory mite species, separate laboratory experiments were established. Ten individuals of each predator species were placed on tomato leaves which were in Petri dishes (9 cm in diam.) containing moistened filter paper. The following insecticides were used: Abarex 018 EC (abamectin), Kohinor 200 SL (imidaclopryd), Karate Zeon 050 CS (lambda-cyhalothrin), Nissorun 050 EC (hexytiazox), Ortus 05 SC (fenpyroksymat), Spin Tor 240 SC (spinosad) as well as some selected fungicides: Topsin M 500 SC (thiophanate-methyl), Previcur Energy 840 SL (hydrochloride propamoxarb), and Bravo 500 SC (chlorothalonil). Tomato leaves infested with predatory mite species (*A. swirskii, P. persimilis, A. andersoni*) were treated with the recommended dose, half dose, and one and a half dose of the tested insecticides. Spraying was performed with a sprayer hand. Each Petri dish with a leaf, was sprayed with 2 ml (Amarasekare and Shearer 2013) of the appropriate dose (according to the label measure; Table 1). The checks were sprayed with distilled water. The predators were bought from the Biobest company (stage of adult). In the case of the fungicide assessment, the predatory mites were released on tomato leaves 1, 3, and 5 days after the fungicide treatment. The fungicides were used only in the recommended dosages. The Petri dishes were control of predatory mites sprayed with distilled water only. All combinations were incubated under controlled conditions at a temperature of 25°C and 60% humidity. Observations were conducted 2, 5, and 7 days after the treatment. The number of alive and dead predators was recorded. One Petri dish containing tomato leaves infested with 10 predator individuals of one species was considered as one variant. The experiment was set up in 5 replications. The classification of the side-effect (mortality/reduction in beneficial capacity) of a pesticide followed established Integrated Organization for Biological and Integrated Control (IOBC) criteria: harmless 0–25%, slightly harmful 25–50%, moderately harmful 50–75%, harmful > 75%.

The data collected were subjected to the analysis of variance with the Freeman-Tukey and Student's tests.

Results and Discussion

The tested active substance of the insecticides: abamectin, spinosad, and hexytiazox were safe for the applied predators and could be included to the IPM programs in greenhouse grown crops. The following active substance of the insecticides: imidaclopryd, fenpyroksymat, and lambda-cyhalothrin were highly toxic to the predators used in the experiment (Fig. 1).

The insecticides were applied at the recommended, a half of the recommended dose, and one and a half of the recommended dose on adult predatory mites. The mortality rates of these predatory mites did not change very significantly between imidaclopryd, lambda-cyhalothrin, and fenpyroksymat. These three insecticides were classified as very harmful (IOBC toxicity rating) (Table 1). The insecticide Karate Zeon 050 CS (lambda-cyhalothrin) was the most toxic and caused 100% mortality of predators, when used either at the recommended dose or at an increased dose (Table 1).

Abamectin, hexytiazox, and spinosad used in the recommended dosages were classified as harmless for the tested predatory mites (Table 1). The insecticides Abarex 018 EC and Spin Tor 240 SC were found to be safe products for the predatory mite species tested. No significant differences in mortality were recorded 7 days after the treatments with insecticides for the tested predatory mite species and the untreated control. These insecticides applied at one and a half of the recommended dose did not exceed the so called low toxicity level (25% mortality as referred to a toxicity scale of chemical products to beneficial organisms). The species *P. persimilis* was the most sensitive to all tested insecticides.

The result of our studies revealed that species *P. persimilis* was the most susceptible to all used fungicides based on the laboratory experiments, especially when the predator was released 1 and 3 days after the fungicide treatments. Generally, the applied fungicides showed a lower

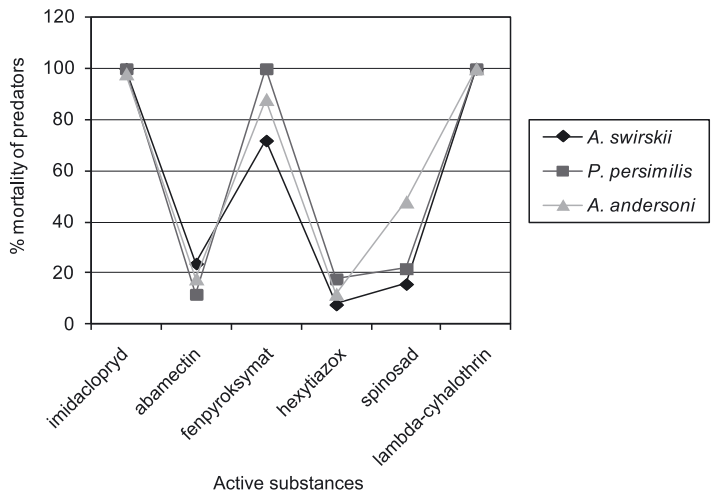

Fig. 1. Side effects of insecticides on the predatory mites: *A. swirskii, A. andersoni,* and *P. persimilis* (in recommended concentration) on the last observation day

Table 1. Direct toxicity of selected insecticides to the predatory mites 7 days after the treatment

Insecticides (active substance)	Recommended concentration, according to the label measure [%]	Concentration*	Average mortality [%]		
			A. swirskii	*A. andersoni*	*P. persimilis*
Control 1	–	0	0 a	0 a	4 a
imidaclopryd	0.075	0.5	56 b	64 b	78 b
		1	92 c	98 c	100 c
		1.5	100 c	100 c	100 c
Control 2	–	0	0 a	4 a	6 a
spinosad	0.05	0.5	8 a	14 a	12 a
		1	18 a	44 a	21 a
		1.5	18 a	46 a	24 a
Control 3	–	0	0 a	0 a	2 a
abamectin	0.05	0.5	6 a	4 a	8 a
		1	22 a	18 a	12 a
		1.5	24 a	21 a	18 a
Control 4	–	0	0 a	0 a	0 a
fenpyroksymat	0.1	0.5	54 b	62 b	86 c
		1	74 b	82 c	100 c
		1.5	88 c	100 c	100 c
Control 5	–	0	4 a	2 a	2 a
hexytiazox	0.02	0.5	2 a	2 a	8 a
		1	8 a	12 a	20 a
		1.5	10 a	18 a	32 a
Control 6	–	0	2 a	4 a	0 a
lambda-cyhalothrin	0.04	0.5	68 b	78 c	84 c
		1	100 c	100 c	100 c
		1.5	100 c	100 c	100 c

Mean values in columns followed by different letters are significantly different (t-Student's test)
*1 – recommended concentration, according to the label measure; 0.5 – a half of the recommended concentration; 1.5 – one and a half of the recommended concentration

Table 2. Side effects of fungicides (at the recommended concentration) on predatory mites

Fungicides (active substance)	Recommended concentration, according to the label measure [%]	Days after releasing predators	Average mortality [%]		
			P. persimilis	*A. swirskii*	*A. andersoni*
Control 1	–	0	0 a	2 a	4 a
thiophanate-methyl	0.15	1	72 c	18 a	68 c
		3	38 b	12 a	46 b
		5	14 a	2 a	8 a
Control 2	–	0	2 a	8 a	6 a
hydrochloride propamoxarb	0.15	1	86 d	32 b	78 d
		3	48 b	22 b	52 c
		5	24 b	16 a	24 b
Control 3	–	0	4 a	0 a	2 a
chlorothalonil	0.25	1	100 d	84 d	96 d
		3	82 d	74 c	76 c
		5	77 c	68 c	54 c

Values within each column followed by the same letter are not significantly different ($p < 0.05$, Tukey's test)

toxicity to all beneficial organisms when the predatory mites were released 5 days after the application. The population of *A. andersoni* introduced one day after the application of the fungicide Topsin M 500 SC (thiophanate-methyl) was reduced by 68%, while for the same population introduced 5 days after the treatment, the mortality exceeded 8% (Table 2). This fungicide appeared to be selective to the species *A. swirskii*. The fungicide Topsin M 500 SC, due to its selectivity to *A. swirskii*, may be used in the IPM programs for greenhouse grown crops.

These results could be useful for pesticide selection and their use in IPM programs for vegetable crops in Poland.

The tested pesticides have shown different degrees of toxicity in relation to the selected predatory mites. In the review literature, information about research on selectivity of pesticides in relation to predatory mites in various crops can be found (Piątkowski 1989; Niemczyk 2002; Williams *et. al.* 2003; Bostanian *et al*. 2007; Nash *et al*. 2010). Blümel *et al*. (2002) concluded that acaricides such as spiromesifen and abamectin were harmless for predatory mites *Phytoseiulus persimilis*. Time introduction of beneficial organisms is very important. Amor *et al*. (2012) found that emamectin benzoate was compatible with *A. swirskii* when applied 3 days before the introduction of the arthropods, but emamectin benzoate was toxic when direct spraying was done. The active substance: abamectin and spinosad were safe for the applied predatory mites. We concluded that abamectin and spinosad are a good fit with integrated mite control programs. Lefebvre *et al*. (2011) found chlorantraniliprole and flubendiamide to have little or no toxicity for *Galendromus occidentalis*, although the former was recommended for further (field) evaluation.

Knowledge of insecticide selectivity to beneficial arthropods is important when considering their utility in IPM programs (Sterk *et al*. 2003; Sohrabi *et al*. 2012). The pesticides should be effective against pests, but relatively safe to natural enemies, and that requires knowing the complex of natural enemies affecting key pests species and the impact of pesticides on these organisms (Campbell *et al*. 1991). Therefore, when pesticides are used within IPM programs, selectivity is one of the main requirements.

Conclusions

1. The insecticides tested (active substance): abamectin, spinosad, and hexytiazox were safe for the applied predators (*A. swirskii, P. persimilis, A. andersoni*) and could be included in the IPM programs for greenhouse grown crops.
2. The species *P. persimilis* was the most sensitive to all tested insecticides and fungicides.
3. This fungicide Topsin M 500 SC (thiophanate-methyl) appeared to be selective to the species *A. swirskii*. This fungicide, due to its selectivity to *A. swirskii*, could be used in the IPM programs for greenhouse grown crops.

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