JOURNAL OF PLANT PROTECTION RESEARCH Vol. 52, No. 2 (2012)

INTERACTION BETWEEN BENEFICIAL ORGANISMS IN CONTROL OF SPIDER MITE *TETRANYCHUS URTICAE* (KOCH.)

*Żaneta Fiedler**

Institute of Plant Protection – National Research Institute, Department of Biological Control
Władysława Węgorka 20, 60-318 Poznań, Poland

Received: October 25, 2011
Accepted: January 3, 2012

Abstract: Strict regulations limiting the availability of synthetic pesticides on vegetable crops in greenhouses have created a new challenge for plant protection. Many pests such as whiteflies, thrips aphids, spider mites, and other, still remain dangerous and difficult to control on vegetable crops in greenhouses. In the experience of many and in a review of world literature, it has been noted that effective methods of biological control of many pests are already available, or can be easily adapted for practice.
According to the Polish Directives, biological methods should be used prior to any application of chemical products. Thus, biological control is a priority in plant protection, especially for vegetable crops in greenhouses.
Tetranychus urticae is the most important pest in greenhouse crops. Successful control of this pest is very difficult. In laboratory studies the predator mites *Amblyseius swirskii* and *Phytoseiulus persimilis* showed a high efficacy when used together to control of two-spotted spider mites (86% mortality). When predators were used separately they were less effective against the pest (about 63% mortality). The studies showed that *A. swirskii* was competitive with *P. persimilis* populations for controlling the two-spotted spider mite. Other predators mites: *Amblyseius degenerans* and *Amblyseius californicus* used in the experiments demonstrated neutral interaction.

Key words: beneficial organisms, *Tetranychus urticae*

INTRODUCTION

The idea of biological control is simple: the managing of a pest by deliberate use of living organisms. In the natural ecosystem, such events occur innumerable times and are a major component by which populations of an organism are regulated. In application to agriculture, the goal is to effectively manage populations of beneficial organisms and manage their ability to reduce pest activities within environmental, legal and economic constraints. For many years biological agents have been applied in the biological control of the most severe greenhouse pests, such as aphids, mites, greenhouse whiteflies and thrips. But the efficacy of these biological agents is not always as would be expected. For example, fungi is dependent upon numerous abiotic factors and therefore, results are not always satisfactory. Currently, biological products that are commercially available are based mainly on natural enemy species (Fiedler 2006).

Registration requirements presently applied to biological control agents in member states of the European Union (EU) are not always considered acceptable by the biopesticide industry, scientists and legislators. Costly and lengthy procedures of data collection and final evaluation of already used and new agents, make registration a painful and confusing experience for all parties. This is particularly true for beneficial microorganism and viruses which are subjected to registration requirements similar to those of chemical pesticides. In contrast, parasitic and predatory arthropods and entomopathogenic nematodes, which are widely used in plant protection, are not regulated by EU legislation. National requirements are applied to these macroorganisms and the requirements differ across the EU member countries. An initiative by the EU, to simplify and harmonize the biological control agent registration requirements and procedures has recently been undertaken. The responsibility has fallen on the European plant protection-related community in the form of the international project REBECA (Regulation of Biological Control Agents) (Tomalak 2007).

The present registration situation of biological control agents in Poland is that macroorganisms are not registration requirements. Thus, there are a lot of new natural enemies commercially available in our country. Spider mites are a big problem in the agricultural sectors. Their great reproductive capacity enables them to cause enormous damage in a short period of time. In many protected crops the two-spotted spider mite, *Tetranychus urticae*, is the most serious pest. Spider mite larvae, nymphs and adults feed on the underside of leaves and cause yellow spots. In severe cases, yellowing of most of the leaf may occur. The result is decreased plant growth and production.

There have been many changes in greenhouses production technology: type of greenhouse, quality of the plastic cover, new high-yield hybrids and varieties, spe-

*Corresponding address:
z.fiedler@iorpib.poznan.pl

Table 1. Biological control agents available against mites in greenhouses, in Poland

Pests	Name of biopesticide	Alive organisms
Spider mites	Phytoseiulus System, Spidex, Fitopak, Phytoline p	*Phytoseiulus persimilis*
	Therodiplosis System, Feltiline, Spidend	*Therodiplosis persicae (Feltiella acarisuga)*
	Mirical –N, Miripak	*Macrolophus caliginosus*
	Spiral, Amblyline cal, Californicus System	*Amblyseius californicus*
	Amblyline cu, Amblyline flo, Amblyline ers-wp	*Amblyseius cucumeris*
	Anderline a, Andersoni System	*Amblyseius andersoni*
	Degenerans-System	*Amblyseius degenerans*

cific pesticides, soil fumigation, etc. However, the intensification of protected vegetable production has created optimal conditions for many pests. Integrated Pest Management (IPM) is often used in greenhouses vegetable crops in Poland. Programmes are based on the biological control of the main pests and sometimes the use of selective pesticides. In the last eight years 19 insecticides out of 38 used to control pests on vegetable crops in greenhouses were withdrawn (Program ochrony warzyw 2002, 2010). This means more biological agents will be used as an alternative for pest control pests in greenhouses. Why biological control?

1. With biological control there are no phototoxic effects on young plants, and premature abortion of flowers and fruit does not occur, also yield increases have been obtained with biological control.
2. In warm humid greenhouses releasing natural enemies takes less time and is more pleasant than applying chemicals.
3. Chemical control of some of the key pests is difficult or impossible because of pesticide resistance.
4. With biological control there is no safety period between the application and the harvesting of the fruit.
5. Biological control is permanent: once a good natural enemy – always a good natural enemy.
6. Biological control is appreciated by the general public, they have more respect for the required work, and sometimes the grower is able to receive a better price for the product.

These advantages are so important for growers that they will not easily return to chemical control. Today it is not a question of whether or not to use biological control but rather, how many species of natural enemies should be released.

For biological control of mites in greenhouses, the natural enemies commercially available in Poland are generally predators (Table 1).

In IPM programmes the importance is placed on the interaction between beneficial organisms in control of pests.

MATERIALS AND METHODS

Experiments were carried out under laboratory conditions. *T. urticae* was reared in and provided by the Institute of Plant Protection – National Research Institute, Poznań, Poland. Predators were bought from the Biobest company (Phytoseiulus – T System, Swirskii – System, Californicus – System, Degenerans – System). In laboratory tests, 30 spider mites *Tetranychus urticae* were placed on tomato leaves covered with moistened filter paper (POCh S.A., Poland) in Petri dishes (9 cm diam.). After tomato infestation with spider mites, predators were introduced in 10 replicates: 10 predator individuals separately, 5 predators individuals (two species) together, and the control (pest only). The predator *Amblyseius swirskii* was used together with *P. persimilis.* The predator *A. degenerans* was used with *A. californicus.*

Observation were conducted everyday for 2 weeks after a treatment, and each time the number of live and dead pest and predators were recorded. There was one Petri dish containing tomato leaves which spider mites and predators per treatment. Ten replications were made. All experiments were made in Petri dishes at 25°C. The collected data were subjected to an analysis of variance with Freeman-Tukey's and Student's tests.

RESULTS AND DISCUSSION

In practice, application of natural enemies and entomopathogenic nematodes is still the most frequently used of biological control methods. Chemical products are applied when the biological methods fail or show insufficient effectiveness. According to the Polish Act of Plant Protection issued on December 18th 2003, the biological methods should be used prior to any application of chemical products. Thus biological factors have became a priority in plant protection.

In laboratory studies predator mites *A. swirskii* and *Phytoseiulus persimilis* showed a high efficacy when used together for controlling two-spotted spider mite (86% mortality). Predators used separately were less effective against the pest (about 60% mortality) (Table 3). The studies showed that *A. swirskii* was competitive in relation to *P. persimilis* populations in control of *T. urticae* (Table 2). We observed that the number of *P. persimilis* were decreased when this predator was used together with *A. swirskii*. In tests with *A. degenerans* and *A. californicus*, the efficacy of predators when used together reached 72%. In laboratory studies *A. californicus* alone showed high efficacy in control of all of the two-spotted spider mite stages. This beneficial organism caused 66% mortality 15 days after introduction while *A. degenerans* caused only 44% (Table 5). Predatory mites: *A. degenerans*

Table 2. Mean % of *A. cucumeris* and *A. swirskii* populations after the release of predators (together or separately) for reducing spider mites *T. urticae* (laboratory conditions)

Treatments	Mean number of *A. cucumeris* and *A. swirskii* populations/Petri dish			
	before	after 5 days	after 10 days	after 15 days
P. persimilis (P.p) + *A. swirskii* (A.s.)	5 P.p. (b) 5. A.s. (b)	5 P.p. (b) 5 A.s. (b)	3.4 P.p. (cd) 5 A.s. (c)	2.2 P.p. (d) 4.4. A.s. (c)
A. swirskii	10 (a)	10 (a)	10 (a)	10 (a)
P. persimilis	10 (a)	9.4 (a)	8.4 (ab)	8.4 (ab)

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

Table 3. Number of *T. urticae* populations after the release of the predators (separately or together) on the last day of observation

Treatments	Number of *T. urticae*		
	before	after 15 days	% mortality
A. swirskii (10 specimes)	30 a	9.6 b	68 b
P. persimilis (10 specimes)	30 a	12.6 b	58 b
P. persimilis (5 specimes) + *A. swirskii* (5 specimes)	30 a	4.2 a	86 c
Control (only pest)	30 a	46.4 c	0 a

Values within each column followed by the same letter are not significantly different (Student's test)

Table 4. Mean % of *A. degenerans* and *A. californicus* populations after the release of predators (together or separately) for reducing spider mites *T. urticae* (laboratory conditions)

Treatments	Mean number of *A. degenerans* and *A. californicus* populations/Petri dish			
	before	after 5 days	after 10 days	after 15 days
A. degenerans (A.d.) + *A. californicus* (A.c.)	5 A.d. (a) 5. A.c. (a)	5 A.d. (a) 5. A.c. (a)	4.2 A.d. (a) 4.4. A.c. (a)	4.2 A.d. (a) 4.4. A.c. (a)
A. degenerans	10 (b)	9.6 (b)	9.6 (b)	9.2 (b)
A. californicus	10 (b)	10 (b)	9.2 (b)	8.6 (b)

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

Table 5. Number of *T. urticae* populations after the release of predators (separately or together) on the last day of observation

Treatments	Number of *Tetranychus urticae*		
	before	after 15 days	% mortality
A. degenerans (10 specimes)	30 a	16.8 b	44 b
A. californicus (10 specimes)	30 a	10.2 a	66 c
A. degenetans (5 specimes) + *A. californicus* (5 specimes)	30 a	8.4 a	72 c
Control (only pest)	30 a	42 c	0 a

Values within each column followed by the same letter are not significantly different (Student's test)

and *A. californicus* used in the experiments demonstrated a neutral interaction (Table 4).

Nowadays, it is not a question of whether or not to use biological control but rather, how many of the species of natural enemies should be released. In literature, there are reports about interaction between predators in the control of different pests (Wiliams 2001; Chesson and Kuang 2008). Barber observed that *A. californicus* was slower than *P. persimilis*, and both predator species cannibalized eggs and juveniles when spider mite numbers were low (Barber *et al*. 2003). The present study and literature data showed that interaction between beneficial organisms in controlling pests is very important (Dicke 2007; Prosper 2007; Wright and Verkerk 2006). Interaction is indispensabile factor in IPM programmes.

In recent years, IPM programs focused more on pro-ecological approaches of pest control in greenhouse production and on lessening the number of chemical treatments (Bednarek and Goszczynski 2002; Dabrowski 2000; Dabrowski and Kropoczyńska-Linkiewicz 2001; Kogan 1998; Lipa 2000). The coordination of different elements from biological techniques in greenhouse plant protection, offers new promising perspectives. It is important to note that many biological control strategies benefit from being used together with other conventional and cultural methods in IPM. Biological control is used on a large scale in all main vegetable crops. In The Netherlands, for example, more than 90% of all tomatoes, cucumbers and sweet peppers are produced under IPM. In Poland about 30% of vegetables are produced under IPM. The growers now clearly have seen the specific advantages of biological control in greenhouses. This success has occurred primarily as a result of the outstanding cooperation between research, extension, growers, and producers of natural enemies, often within the framework of International Organisation for Biological Control (IOBC).

Several current trends will lead to a strong increase in the application of biological and integrated control of pests and diseases in greenhouses. First, fewer new insecticides are becoming available because of the skyrocketing costs for their development and registration. Such costs particularly hit the relatively small greenhouse market. Secondly, pests continue to develop resistance to pesticides, a problem particularly prevalent in greenhouses, where intensive management and repeated pesticide applications exert strong pressure on pest organisms. Thirdly, there is a strong demand from the general public, for example in Poland to reduce the use of pesticides (Lenteren 2007). Because of political influence and the consumer's desire to reduce pesticide use, the future role of biological and integrated control is expected to also increase in Poland.

REFERENCES

Barber A., Campbell C.A.M., Crane H., Lilley R., Tregidga E. 2003. Biocontrol of two-spotted spider mite *Tetranychus urticae* on Phytoseiid mites *Phytoseiulus persimilis* and *Neoseiulus californicus.* Bioc. Sci. and Technol. 13 (3): 123–141.

Bednarek A., Goszczyński W. 2002. The cost of biological pest control in protected tomato crops. IOBC/WPRS Bull. 25 (1): 5–8.

Chesson P., Kuang J.J. 2008. The interaction between predation and competition. Nature 456: 235–238.

Dąbrowski Z.T. 2000. Konieczność zmian metod w opracowywaniu i wdrażaniu integrowanych metod ochrony roślin. [Necessary changes in the methodology of development and implementation of integrated pest management]. Prog. Plant Protection/Post. Ochr. Roślin 40 (1): 334–342.

Dabrowski Z.T., Kropczyńska-Linkiewicz D. 2001. System wspomagań decyzji w różnych systemach ochrony roślin. Metodyka podejmowania decyzji w różnych systemach ochrony roślin. Pam. Puł. – Mat. Konf. 124: 25–35.

Dicke M. 2007. The role of microorganisms In tr-trophic interactions In system consisting of plants, herbivores and carnivores. Biomedic. Life Sci. 9: 71–84.

Fiedler Z. 2006. Nowości w dziedzinie biologicznego zwalczania szkodników w szklarniach. Ogrodnik Polski 2 (29): 45–47.

Kogan M. 1998. Integrated pest management: historical perspectives and contemporary developments. Ann. Rev. Entomol. 43: 243–270.

Lenteren Joop C. van. 2007. Biological control for insect pests in greenhouses: an unexpected succes. In: "Biological Control a global perpective" (Vincent, Goettel, Lazarovits, eds.). CAB International, 440 pp.

Lipa J.J. 2000. Integrowanie metod ochrony roślin. Ochrona Roślin 8: 12–14.

Program Ochrony Warzyw na 2002. Owoce Warzywa Kwiaty. 1–2, Hortpress, Warszawa, 88 pp.

Program Ochrony Warzyw na 2010. Owoce Warzywa Kwiaty. 1–2, Hortpress, Warszawa, 146 pp.

Prosper J.I. 2007. Microorganisms, macroorganisms and ekology. Microbiol. Ecol. 62: 133–134.

Tomalak M. 2007. Rejestracja biologicznych środków ochrony roślin w Europie – nowe perspektywy. [Registration of biological agents of plant protection in europe – new perspectives]. Prog. Plant Prot./Post. Ochr. Roślin 47 (4): 233–240.

Wiliams M.E.D.C. 2001. Biological control of thrips on ornamental crops: Interactions between predatory mite *Neoseilus cucumeris* (Acari: *Phytosiedae*) and western flower thrips, *Frankliniella occidentalis* (Thysanoptera: *Thripidae)*, on cyclamen. Bioc. Sci. Techol. 11 (1): 28–44.

Wright D.J.R., Verkerk R.H.J. 2006. Integration of chemical and biological control systems for arthropods: Evaluation in multitrophic context. Pest Manage. Sci. 44 (3): 207–218.