

## A STUDY ON THE POSSIBILITY OF LIMITING DAMAGE TO FRUIT BY THE APPLE SAWFLY (*Hoplocampa testudinea* Klug) IN ORGANIC APPLE ORCHARDS

### Summary

In 2010-2012, in the Experimental Ecological Orchard of the Research Institute of Horticulture in Skierniewice, a study was conducted on the possibility of reducing populations of the apple sawfly (*Hoplocampa testudinea* Klug) using biological formulations. The tests involved treatments with an extract from the wood of *Quassia amara* (4 kg/ha) and an extract from the seeds of *Azadirachta indica* in the form of a ready-made formulation *NeemAzal-T/S* at a rate of 2.5 l/ha with the addition of a 0.3% sugar solution. A single treatment was performed in the first two years, and two treatments in the last year. The effectiveness of the protection of fruitlets against damage varied and for the *Q. amara* extract was from 8.3% (one treatment) to 86.1% (two treatments), and for the *NeemAzal-T/S* formulation from 4.8% (one treatment) to 44.3% (two treatments). In relation to the damage to fruits, the efficacy of the treatments also varied, ranging from 10.3% to 60% for the *Q. amara* extract, and from 0% to 46.7% for *NeemAzal-T/S*.

**Key words:** organic orchard, *Hoplocampa testudinea* Klug, *Quassia amara*, *NeemAzal-T/S*, experimentation

## MOŻLIWOŚĆ OGRANICZENIA USZKODZEŃ OWOCÓW PRZEZ OWOCNICĘ JABŁKOWĄ (*Hoplocampa testudinea* Klug) W EKOLOGICZNYM SADZIE JABŁONIOWYM

### Streszczenie

W latach 2010–2012 w Ekologicznym Sadzie Doświadczalnym Instytutu Ogrodnictwa wykonano badania nad możliwością ograniczenia populacji owocnicy jabłkowej (*Hoplocampa testudinea* Klug) przy pomocy preparatów biologicznych. Badano wywar z drewna gorzkiej właściwej (*Quassia amara*) (4 kg/ha) oraz ekstrakt z nasion miodli indyjskiej (*Azadirachta indica*) w postaci gotowego preparatu *NeemAzal-T/S* w dawce 2,5 l/ha z dodatkiem 0,3% roztworu cukru. W pierwszych dwu latach wykonano 1 zabieg, a w ostatnim roku 2 zabiegi. Efektywność zabezpieczenia zawiązków owocowych przed uszkodzeniami była zróżnicowana i wyniosła dla wywaru z *Quassia amara* od 8,3% (1 zabieg) do 86,1% (dwa zabiegi), a preparatu *NeemAzal-T/S* od 4,8% (1 zabieg) do 44,3% (2 zabiegi). W stosunku do uszkodzeń owoców efektywność zabiegów również była zróżnicowana i wyniosła od 10,3% do 60% dla wywaru z *Quassia amara* oraz od 0% do 46,7% dla preparatu *NeemAzal-T/S*.

**Słowa kluczowe:** sad ekologiczny, *Hoplocampa testudinea* Klug, *Quassia amara*, *NeemAzal-T/S*, badania

### 1. Introduction

In the organic production system, it is difficult to obtain high quality fruit. In an apple orchard, the presence of pests feeding on inflorescences, fruitlets or fruits can seriously reduce the quality and yield of the resulting crop. The small number of plant protection products available in organic farming in Poland [1] makes it difficult to control the major pests. On the other hand, a continuous increase can be seen in consumer demand for organic fruit [2, 3]. The lack of a sufficient number of effective eco-friendly plant protection products makes it necessary to conduct tests with biological active substances able to control populations of pests [4, 5], and tests with substances of plant origin have been conducted for a few decades now [6, 7, 8, 9]. In parallel to the research on the use of biological active substances in plant protection, observations of the occurrence of pests in organically-grown crops are being carried out. One of the pests that occurs annually in apple orchards and poses a constant threat is the apple sawfly (*Hoplocampa testudinea* Klug) [5, 10, 11]. In the years of mass occurrence, the apple sawfly

can cause large losses in yield. The adult individuals appear at the pink bud stage in apple and are particularly active during the flowering period [12]. The females lay eggs under the skin at the base of the sepals. Caterpillars hatch after about 14 days. The larvae damage fruitlets and during feeding bore a channel to the core. One larva can damage several fruitlets, which stop growing and generally drop off. On some developing fruits on which apple sawfly larvae have been feeding there appear characteristic marks in the form of ribbon-shaped scars. After becoming fully developed, the larvae make cocoons in the soil and pupate in them. They overwinter as pupae at a depth of 8 to 24 cm. The adult individuals fly out of the soil in the spring of the following year [13].

Annual monitoring of the occurrence of crop damage by the major agrophages indicates that the apple sawfly has in recent years damaged an average of 2.7% to 3.2% of fruitlets in Poland, and about 4.3% in the Łódź region [14, 15, 16]. In 2008-2009, in the organic orchards around Skierniewice, the reported percentage of fruit damaged by the apple sawfly was 0.5% to 1.6% on average [5].

## 2. Material and methods

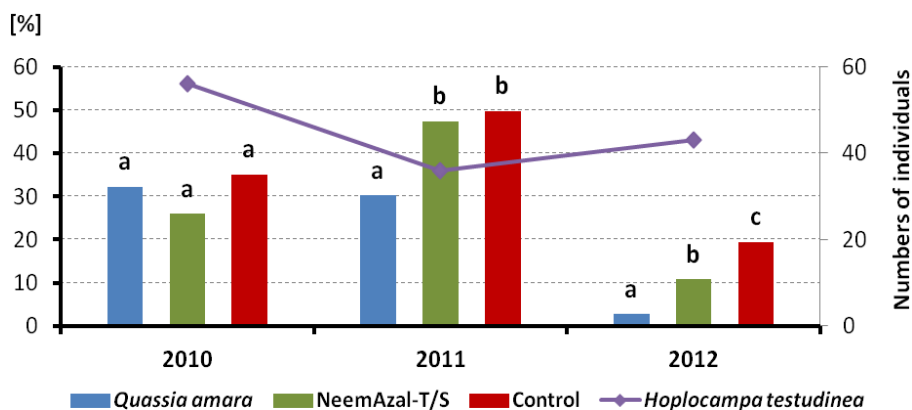
The study on the possibility of limiting the populations of the apple sawfly under the conditions of central Poland was conducted in 2010-2012 in the Experimental Ecological Orchard of the Research Institute of Horticulture in Skierniewice. The experiment covered a plot with apple trees of the cultivar 'Pinova' growing at a spacing of 3.5 x 3 m, and each combination consisted of 20 trees (4 replications of 5 trees each). Earlier studies had shown that adult individuals of the apple sawfly were best caught on white sticky traps [17, 18, 19, 20]. They were used on the experimental plot to monitor the presence of the apple sawfly and to determine the threshold level and the optimum date for carrying out protective treatments. The traps were inspected every two or three days, and the number of the captured individuals was recorded. For the experiment, an extract from the wood of *Quassia amara* (bitterwood tree) was prepared as prescribed by the company (Biocont) distributing the *Q. amara* wood, using 4 kg of the wood per 1 ha [21]. The quassinoids contained in the extract are characterized by high contact and stomach toxicity to insects. Another biological agent used in the experiment was an extract from *Azadirachta indica* (Indian neem tree) in the form of the ready-made formulation NeemAzal-T/S, applied at 2.5 l/ha with the addition of a 0.3% sugar solution. The product contains azadirachtin, which exhibits insecticidal, repellent, and antifeedant activity. In addition, azadirachtin can reduce the reproductive capacity of insects [22, 23]. The treatments were performed with a motorized backpack sprayer, using 750 l of working liquid per 1 ha. In 2010 and 2011, a single treatment was performed to control the apple sawfly, while in 2012 two treatments. The dates of the treatments were determined by the monitoring of the apple sawfly. The effectiveness of controlling the apple sawfly was assessed on the basis of the number of damaged fruitlets fallen from the trees within about 2 weeks from the time of noticing the first injuries. At harvest time, random samples of apples from each combination (min. 400 fruits) were collected and assessed for damage caused by the apple sawfly.

The results were statistically analyzed with the Statistica 10 software. Percentages were transformed using the Bliss formula. To assess the significance of the differences, Duncan's test at a significance level of  $p = 0.05$  was used.

## 3. Results and discussion

In 2010-2012, the apple sawfly occurred in numbers exceeding the threshold level (Fig. 1). The limit was 20 individuals caught on a trap during the period from pink bud to the end of flowering [19]. The lowest number of captured apple sawflies was recorded in 2011, and the highest in 2010. The injuries to fruitlets caused by the sawfly larvae were assessed in samples of the fruitlets fallen from the trees. The lowest number of damaged fruitlets was recorded in 2012 after two treatments (3.8% – *Quassia*, 8% – *NeemAzal-T/S*), and the highest in 2010 after a single treatment (31.9% – *Quassia*, 25.7% – *NeemAzal-T/S*) (Fig. 1). The effectiveness of the *Quassia amara* extract in the control of the apple sawfly in relation to the damage to fruitlets varied and in 2010, 2011 and 2012 was 8.3%, 39.4% and 86.1%, respectively. The extract from the seeds of *Azadirachta indica* showed lower effectiveness, which was 26.2%, 4.8% and 44.3%, respectively. The damage to fruits caused by sawfly larvae was assessed at harvest. The *Q. amara* extract was much better in protecting the fruit crop from damage. In 2010-2012, the percentage of damaged apples ranged from 0.6% (2010) to 5% (2012). The *A. indica* extract protected the crop to a lesser extent, with the number of apples damaged in 2010-2012 ranging from 0.8% to 8.8% (Fig. 2). The efficacy of the tested formulations varied and was, on average, 10.3% to 60% for the *Q. amara* extract, and from 0% to 46.7% for the extract from *A. indica* seeds.

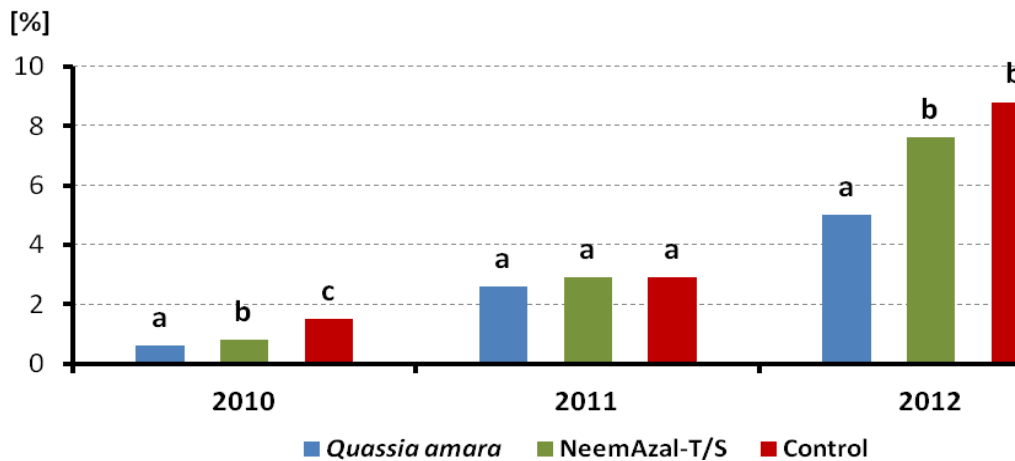
In previous studies with *Quassia amara* wood extracts, varying efficacies of quassinoids in the control of the apple sawfly had been obtained. In the 1990's in Switzerland, less than 5% of fruit damaged by caterpillars of the apple sawfly was achieved [24]. A high efficacy of treatments to control the apple sawfly using a *Q. amara* extract in the form of a ready-made product was demonstrated in Germany in 2002-2004. Various doses of the extract were used, and the effectiveness of the protection programme varied between 52.3% and 81.5% [20, 25]. The effect of a *Q. amara* extract in the protection of crops against the apple sawfly was also investigated in France in 2004-2009. A correlation was found between the formulation used and the reduction in fruit damage [26]. In the Czech Republic, the efficacy of a *Q. amara* extract in controlling the apple sawfly was 29-65% on one experimental plot and 83-98% on another [27].



Source: Own work / Źródło: opracowanie własne

Fig. 1. Extent of damage to apple fruitlets caused by the apple sawfly in 2010-2012 and the number of apple sawflies captured on white sticky traps

Rys. 1. Uszkodzenia zawiązków owocowych przez owocnicę jabłkową w latach 2010-2012 oraz liczba odłowionych owocnic na białe pułapki lepowe



Source: Own work / Źródło: opracowanie własne

Fig. 2. Extent of damage to apple fruits caused by the apple sawfly in 2010-2012

Rys. 2. Uszkodzenia owoców przez owocnicę jabłkową w latach 2010-2012

The results obtained in the present study were also variable. The effectiveness of the protective treatments with the *Q. amara* extract was different each year and higher after two treatments than after a single one. Despite the varying efficacy of the treatments, the protection of the fruit crop against pest damage was at an acceptable level considering the requirements of the organic fruit production system.

In Germany, a study investigated the effect of a mixture of an *A. indica* seed extract (NeemAzal-T/S) with a *Q. amara* wood extract on the apple sawfly. The efficacy of a single treatment was 38.1%, and after two treatments 56.6% [28]. In other studies, protective treatments with the formulation NeemAzal-T/S have not produced positive results in the control of the apple sawfly [29]. In Poland, however, positive results with an extract from *A. indica* seeds have been obtained in combating larvae of the Colorado potato beetle (*Leptinotarsa decemlineata* Say) [30], cabbage pests (*Pieris brassicae* L., *Mamestra brassicae* L.) [31], the cherry fruit fly (*Rhagoletis cerasi* L.), the black cherry aphid (*Myzus cerasi* Fabr.) [32], and the codling moth (*Laspeyresia pomonella* L.) [33].

In the study described here, the efficacy of the treatments with the formulation NeemAzal-T/S varied and was lower than the efficacy of the *Q. amara* extract.

#### 4. Conclusions

1. The use of the *Quassia amara* extract and the NeemAzal-T/S formulation reduced damage to apple fruitlets and fruits by larvae of the apple sawfly in varying degrees.
2. The highest effectiveness of protection to fruitlets against injuries by larvae of the apple sawfly was obtained after two treatments with the *Quassia amara* extract (86.1%). The efficacy of the extract from *Azadirachta indica* seeds was twice as low.
3. The effectiveness of protection to fruits against injuries by larvae of the apple sawfly ranged from 10.3% to 60% for the *Quassia amara* extract and from 0% to 46.7% for the NeemAzal-T/S formulation.

#### 5. Acknowledgements

The study was funded by the Ministry of Agriculture and Rural Development, and was conducted within the frame-

work of the Multi-Year Programme: 'Development of sustainable methods of horticultural production to ensure high biological and nutritional quality of horticultural products, and preserve the biodiversity and protect the resources of the natural environment', task PW 4.1.

#### 6. References

- [1] Szulc M. (ed.): Wykaz środków ochrony roślin w rolnictwie ekologicznym (List of plant protection products in organic farming). Institute of Plant Protection – National Research Institute, day version of 11-03-2014. Available at: <http://www.ior.poznan.pl/19,wyzkaz-sor-w-rolnictwie-ekologicznym.html?wiecej=26>.
- [2] Łuczka-Bakuła W., Smoluk-Sikorska J.: The organic fruit and vegetables price level and the development of organic food market. Journal of Research and Application in Agricultural Engineering, 2010, Vol. 55(4): 12-14. [Polish with English summary].
- [3] Kazimierzczak R., Zgiep U.: Channels of eco-products distribution on the example of fruit from organic orchards. Journal of Research and Application in Agricultural Engineering, 2013, Vol. 58(3): 248-254. [Polish with English summary].
- [4] Balázs K., Molnár M., Bujáki G., Gonda I., Karácsony D., Bartha J.: Possibility and problems of organic apple growing in Hungary. Biological Agriculture and Horticulture, 1997, Vol. 15(1-4): 223-232.
- [5] Badowska-Czubik T., Kruczyńska D.: Apple pests reducing crop and quality of apples from organic orchard. Progress in Plant Protection, 2010, Vol. 50(3): 1215-1219. [Polish with English summary].
- [6] Polonsky J.: Quassinoid bitter principles. Fortschritte der Chemie Organischer Naturstoffe, 1973, Vol. 30: 101-150.
- [7] Subrahmanyam B.: Azadirachtin – A naturally occurring insect growth regulator. Animal Sciences, 1990, Vol. 99(3): 277-288.
- [8] Schmutterer H.: Properties and potential of natural pesticides from the neem tree, *Azadirachta indica*. Annual Review Entomology, 1990, Vol. 35: 271-297.
- [9] Villalobos R., Marmillod D., Ocampo R., Mora G., Rojas C.: Variations in the quassin and neoquassin content in *Quassia amara* (Simaroubaceae) in Costa Rica: Ecological and management implications. Acta Horticulturae 1999, Vol. 502: 369-375.
- [10] Zijp J. P., Blommers L. H. M.: Apple sawfly *Hoplocampa testudinea* (Hym., Tenthredinidae) and its parasitoid *Lathrolestes ensator* in Dutch apple orchards (Hym., Ichneumonidae, Ctenopelmatinae). Journal of Applied Entomology, 2002, Vol. 126: 265-274.

- [11] Kienzle J., Zimmer J., Maxin P., Rank H., Bathon H., Zebitz C. P. W.: Efficacy of Quassia extract on the apple sawfly *Hoplocampa testudinea* Klug. In: Boos M. (ed.) Ecofruit – 12<sup>th</sup> International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit-Growing. Weinsberg (Germany), 2006, January 31 – February 2: 239-242.
- [12] Vincent C., Bélair G.: Biocontrol of the Apple sawfly, *Hoplocampa testudinea*, with entomogenous nematodes. Entomophaga, 1992, Vol. 37(4): 575-582.
- [13] Gratwick M.: Apple sawfly. Crop pest in the UK, Collected edition of MAFF leaflets, 1992: 93-96.
- [14] Walczak F., Bandyk A., Jakubowska M., Roik K., Tratwal A., Złotkowski J., Heryng I., Gajewski M.: Harmfulness intensity of some important pests and diseases of crops in Poland in 2010. Progress in Plant Protection, 2011, Vol. 51(1): 133-152. [Polish with English summary].
- [15] Walczak F., Bandyk A., Jakubowska M., Roik K., Tratwal A., Wielkopolan B., Złotkowski J., Heryng I., Gajewski M.: Evaluation of damage to main crops caused by most important agrophages in Poland, in 2011. Progress in Plant Protection, 2012, Vol. 52(2): 472-488. [Polish with English summary].
- [16] Walczak F., Bandyk A., Jakubowska M., Roik K., Tratwal A., Wielkopolan B., Złotkowski J.: Evaluation of damage to main crops caused by most important agrophages in Poland, in 2012. Progress in Plant Protection, 2012, Vol. 53(4): 856-877. [Polish with English summary].
- [17] Owens E. D., Prokopy R. J.: Visual monitoring trap for European apple sawfly. Journal of Economic Entomology, 1978, Vol. 71(4): 576-578.
- [18] Zijp J. P., Blommers L. H. M.: Prediction of flight of apple sawfly, *Hoplocampa testudinea*, using temperature sums. Entomologia Experimentalis et Applicata, 1997, Vol. 84: 71-75.
- [19] Maciesiak A., Olszak R. W.: Przydatność białych pułapek lepowych do zwalczania owocnic w sadach (Usefulness of white glue traps to control apple sawfly in orchards). Ogólnopolska Konferencja Ochrony Roślin Sadowniczych (National Conference of Fruit Plant Protection - Poland), 19-20 February, 1998: 137-140. [Polish only].
- [20] Kienzle J., Kopp B., Schultz C.: Control of the Apple sawfly (*Hoplocampa testudinea* Klug) with extracts from *Quassia amara* L.: Quality and combination with NeemAzal-T/S. In: Boos M. (ed.) Ecofruit – 10<sup>th</sup> International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit Growing and Viticulture. Weinsberg (Germany), 2002, January 31 – February 2: 28-34.
- [21] Quassia amara – opis stosowania (Quassia amara – description of the application), 2013. Available at: [www.biocont.pl](http://www.biocont.pl) [Polish only].
- [22] Tomalak M.: Ekspertyza – Czynniki biologiczne dostępne w ochronie upraw ekologicznych przed szkodnikami (Expertise – biological agents available in protection organic cultivations against pests), 2009, Institute of Plant Protection – National Research Institute. Available at: [www.agengpol.pl](http://www.agengpol.pl) [Polish only].
- [23] Grdiša M., Gršič K.: Botanical insecticides in plant protection. Agriculture Conspectus Scientificus, 2013, Vol. 78(2): 85-93.
- [24] Höhn H., Höpli H. U., Graf B.: Quassia and neem: exotic insecticides in fruit culture. Obst- und Weinbau, 1996, Vol. 132(3): 62-63.
- [25] Kienzle J., Zimmer J., Klopp K., Maxin P., Yamada K., Bathon H., Zebitz C. P. W., Ternes P., Vogt H.: Control of the apple sawfly *Hoplocampa testudinea* Klug in organic fruit growing and possible side effects of control strategies on *Apheleus mali* Haldeman and other beneficial insects. In: Boos M. (ed.) Ecofruit – 11<sup>th</sup> International Conference on Cultivation Technique and Phytopathological Problems in Organic Fruit Growing, Weinsberg (Germany), 2004, February 3-5: 7-14.
- [26] Nateau K., Tournant L., Jamar I.: Décoction de Quassia amara et lutte contre L'Hoplocampe du pommier (*Hoplocampa testudinea* Klug). Journées Techniques Fruits et Légumes Biologiques, 2009: 1-6.
- [27] Psota V., Ouředníčková J., Falta V.: Control of *Hoplocampa testudinea* using the extract from *Quassia amara* in organic apple growing. Horticultural Science, 2010, Vol. 37(4): 139-144.
- [28] Zimmer J.: Bekämpfung der Apfelsägewespe (*Hoplocampa testudinea*). In: Boos M. (ed.) Ecofruit – 9 Internationaler Erfahrungsaustausch über Forschungsergebnisse zum Ökologischen Obstbau, Weinsberg (Germany), 2000, February 3-4: 53-57.
- [29] Kleeberg H., Hummel E.: Experiences with NeemAzal-T/S in 1999 – 2000. In: Metspalu L., Mitt S. (ed.) Practice oriented results on the use of plant extracts and pheromones in pest control. Proceedings of the International Workshop, Tartu (Estonia), 2001, January 24–25: 37-45.
- [30] Kowalska J., Kühne S.: Controlling of Colorado potato beetle (*Leptinotarsa decelneata* Say) in the organic fields with Spinosad. Journal of Research and Application in Agricultural Engineering, 2009, Vol. 54(3): 146-148 [Polish with English summary].
- [31] Kowalska J.: Using of azadirachtin and spinosad in protection of organic cabbage crops. Fragmenta Agronomica, 2010, Vol. 27(4): 56-61 [Polish with English summary].
- [32] Badowska-Czubik T., Rozpara E., Danelski W., Kowalska J.: Effectiveness of NeemAzal-T/S in cherry organic orchard. Journal of Research and Application in Agricultural Engineering, 2010, Vol. 55(3): 11-13 [Polish with English summary].
- [33] Badowska-Czubik T., Rozpara E., Danelski W., Kowalska J.: Effectiveness of NeemAzal-T/S and Madex SC in controlling of codling moth in organic apple orchard. Journal of Research and Application in Agricultural Engineering, 2011, Vol. 56(3): 20-22 [Polish with English summary].