

## POSSIBILITY OF LIMITING THE NUMBER OF APHIDS (Homoptera: Aphidoidea) WITH PLANT EXTRACT, DECOCTION AND INFUSIONS IN ORGANIC CULTIVATION OF APPLE

### Summary

In the years 2013-2014, the effectiveness of plant-derived preparations in controlling the rosy apple aphid *Dysaphis plantaginea* (Passerini) and the green apple aphid *Aphis pomi* (de Geer) was assessed in an organic apple orchard. Use was made of own in-house made preparations that included infusions of the field horsetail *Equisetum arvense* (L.), garlic *Allium sativum* (L.), seeds of white mustard *Sinapis alba* (L.) and Indian mustard *Brassica juncea* (L.) (2014), a decoction of the wood of *Quassia amara* (L.), an extract from the seeds of the Indian neem tree *Azadirachta indica* (L.), and horticultural potassium soap with tansy, with the addition of ethyl alcohol. Protective treatments were performed three times at seven-day intervals. Approx. 6 days after the last treatment, samples of shoots and leaves were collected, and the impact of the preparations on the mortality of aphids was assessed. In both years, the highest reduction in the number of aphid colonies of both species was recorded after the application of the decoction of *Quassia* wood (81.8% – in 2013, and 52.9% – in 2014), garlic extract (77.3% – in 2013), and the neem extract (59.1% – in 2013, and 66.2% – in 2014). The potassium soap limited the number of colonies of aphids to a lesser extent, but the results for both years were reproducible (31.8% – 2013, and 30.9% – 2014). Consistent percentage of mortality of the green apple aphid and the rosy apple aphid was also recorded in both years after the application of the extract from neem seeds (34.1% – 2013, and 35.1% – 2014). The other preparations showed a much more varied and smaller effect on the mortality of aphids, which ranged from 8.2% to 37.63%. At harvest, samples of fruit were collected randomly from each combination and assessed in terms of the occurrence of deformation resulting from the rosy apple aphid feeding on fruitlets. The fruits were divided into three groups depending on the extent of deformation (severe, moderate, slight). In 2013, there were from 4.5 to 7% of deformed fruits, the fewest after the application of extracts from garlic (4.5%) and white mustard (4.8%), and in 2014 from 9.3 to 16.8%, the fewest after using the neem extract (9.3%) and potassium soap (9.8%).

**Key words:** *Dysaphis plantaginea*, *Aphis pomi*, plant extracts, plant decoctions, control of aphids, organic apple growing

## MOŻLIWOŚĆ OGRANICZANIA LICZEBNOŚCI MSZYC (Homoptera: Aphidoidea) W EKOLOGICZNEJ UPRAWIE JABŁONI Z WYKORZYSTANIEM EKSTRAKTU, WYWARU I NAPARÓW ROŚLINNYCH

### Streszczenie

W latach 2013 – 2014 oceniano skuteczność preparatów roślinnych w zwalczaniu mszycy jabłoniowo-babkowej *Dysaphis plantaginea* (Passerini) i mszycy jabłoniowej *Aphis pomi* (Degeer) w ekologicznym sadzie jabłoniowym. Zastosowano przygotowane we własnym zakresie napary ze skrzypu polnego *Equisetum arvense* (L.), czosnku *Allium sativum* (L.), nasion gorczycy białej *Sinapis alba* (L.) i sarepskiej *Brassica juncea* (L.) (2014), wywar z gorzkiej właściwej *Quassia amara* (L.), ekstrakt z miodli indyjskiej *Azadirachta indica* (L.) oraz mydło potasowe z wrotyczem, z dodatkiem alkoholu etylowego. Zabiegi ochronne wykonano trzykrotnie w siedmio dniowych odstępach. Po upływie ok. 6 dni od ostatniego zabiegu pobrano próby pędów oraz liści i oceniono wpływ zastosowanych preparatów na śmiertelność mszyc. W obydwu latach najwyższą redukcję liczby kolonii mszyc obu gatunków zanotowano po zastosowaniu wywaru z gorzkiej właściwej (81,8% - 2013 i 52,9% - 2014, wyciągu z czosnku (77,3% - 2013) oraz ekstraktu z miodli indyjskiej (59,1% - 2013 i 66,2% - 2014). Zastosowane mydło potasowe ograniczało liczbę kolonii mszyc w mniejszym stopniu ale uzyskane wyniki dla obu lat były powtarzalne (31,8% - 2013 i 30,9% - 2014). Wyrównany, w obu latach, odsetek śmiertelności mszycy jabłoniowej i jabłoniowo-babkowej zanotowano po zastosowaniu ekstraktu z miodli indyjskiej (34,1% - 2013 i 35,1% - 2014). Pozostałe preparaty wykazały zdecydowanie bardziej zróżnicowany i mniejszy wpływ na śmiertelność mszyc, która wyniosła od 8,2% do 37,63%. W okresie zbioru pobrano losowo próby owoców w każdej kombinacji i oceniono je pod kątem wystąpienia deformacji będących wynikiem żerowania mszycy jabłoniowo-babkowej na zawiązkach. Zebrane owoce podzielono na trzy grupy w zależności od stopnia deformacji (silnie, średnio, słabo). W roku 2013 zanotowano od 4,5 do 7% zdeformowanych owoców, najmniej po zastosowaniu wyciągu z czosnku (4,5%) i gorczycy białej (4,8%), a w roku 2014 od 9,3 do 16,8%, najmniej po zastosowaniu ekstraktu z miodli indyjskiej (9,3%) i mydła potasowego (9,8%).

**Słowa kluczowe:** *Dysaphis plantaginea*, *Aphis pomi*, ekstrakty roślinne, wywary roślinne, zwalczanie mszyc, ekologiczna uprawa jabłoni

### 1. Introduction

In the organic growing of apple trees there is a number of pests that reduce the size and quality of the fruit crop, and aphids are the most common of them. Apple orchards have been reported to be inhabited by 9 species of aphids,

of which the green apple aphid and the rosy apple aphid are the most numerous, and have the greatest negative impact on fruit yield and quality [8].

The green apple aphid *Aphis pomi* (de Geer) is a holocyclic and single-host species, a vector of viral diseases [22]. This species is widespread in Europe in the cul-

tivation of apple, pear, quince and other plants of the family Rosaceae (Juss.); its presence has also been recorded in North America [3]. In Poland, the green apple aphid is present *en masse* in most apple orchards and is very harmful throughout the growing season [15]. During the growing season, 9-15 generations of the green apple aphid develop, and females of this species lay overwintering eggs at the turn of September and October [25]. The larvae hatch during the flower bud-break stage, and the colonies develop on the apical parts of young shoots and the underside of leaves. The young shoots and leaves on which individuals of the green apple aphid feed become twisted and bent [3].

The rosy apple aphid *Dysaphis plantaginea* (Pass.) is a holocyclic and multi-host species. It migrates from apple trees (*Malus domestica*) onto the leaves of the ribwort plantain (*Plantago lanceolata*), greater plantain (*P. major*), and the hoary plantain (*P. media*). This species, like the green apple aphid, is a vector of viral diseases [22]. It occurs commonly in apple orchards in Europe, and its presence has also been recorded in Africa, North and South America, and Asia [3]. The rosy apple aphid has the highest inherent rate of population growth, which is a result of high fertility and a short pre-reproductive period [26]. This species feeds on the leaves, floral rosettes, and fruitlets. During warm and humid summers, which are conducive to the development of this species, it can cause significant damage to the fruit, leaves and shoots, which curl up, turn yellow prematurely, and fall off. The most serious effect of feeding of this pest is its considerable impact on the diameter and weight of fruit, manifesting itself in extensive deformation and inhibited development [8, 25, 27]. A measurable effect of the presence of large populations of this pest in apple orchards is a reduction in yield by as much as 50-70% [16]. Studies on the occurrence of the rosy apple aphid conducted in Poland have shown a varied extent of colonization of different apple cultivars by this species [9, 19, 24]. The risk threshold for the green apple aphid in apple orchards is 15 shoots with colonies of this species in a sample of 150 shoots [5], and for the rosy apple aphid it is 2 larvae in a sample of 100 rosettes [25], or 1 tree with colonies in a sample of 50 trees [5].

In Polish organic farming there are currently no approved plant protection products designed for controlling aphids [23]. An additional problem in organic apple growing consists in the lack of effective reduction in aphid populations by beneficial organisms [20]. Worldwide research has been conducted for many years on obtaining plant-derived insecticides [1, 6]. Numerous studies on the use of substances of plant origin to control the rosy apple aphid and the green apple aphid have investigated the effects of, among others, extracts of the sweet flag (*Acorus calamus* L.), arnica (*Arnica* sp.), garlic (*Allium sativum* L.), hellebores (*Helleborus* sp.), black poplar (*Populus nigra* L.) [4], comfrey (*Symphytum officinale* L.), marigold (*Calendula officinalis* L.), cinnamic acid [18], essential oil from hemp seed [14], azadirachtin, fungal preparations containing *Beauveria bassiana* and *Paecilomyces fumosoroseus*, natural pyrethrins [2, 17], kaolin clay [7], potassium soap, and a starch-based plant extract [9]. Natural essential oils derived from geranium (*Geranium* L.), lavender (*Lavandula officinalis* L.), peppermint (*Mentha piperita* L.), pine (*Pinus sylvestris* L.), thyme (*Thymus vulgare* L.) [13], and also coriander and petitgrain oils have been used to study their influence on the mortality of the glasshouse potato aphid (*Au-*

*lacorthum solani* Kalt.) in tobacco crops [12]. On the other hand, infusions of the field horsetail (*Equisetum arvense* L.), garlic (*Allium sativum* L.), white mustard (*Sinapis alba* L.) and Indian mustard (*Brassica juncea* L.), and decoctions of *Quassia amara* (L.) and extracts from the seeds of the Indian neem tree *Azadirachta indica* (L.) have been studied: as regards the possibility of controlling the black cherry aphid (*Myzus cerasi* F.) in the cultivation of sweet cherry [11]. Other studies have examined the possibility of using extracts from *Quassia amara* (L.) and *Azadirachta indica* (L.) for controlling the bird cherry-oat aphid (*Rhopalosiphum padi* L.) and rose-grass aphid (*Metopolophium dirhodum* Wlk.) in cereal crops [21].

The aim of the experiment was to estimate the possibility of reducing the occurrence of aphids in organic cultivation of apple trees, using the decoction, extract and plant infusions.

## 2. Material and Methods

The experiment was conducted in an organic orchard in the years 2013-2014, on eight-year-old fruiting apple trees of the cultivar 'Topaz'. The experiment was established in a system of experimental blocks with four replicates of 4 trees each. Protective treatments were performed three times at seven-day intervals using an infusion of the field horsetail (*Equisetum arvense* L.) obtained from the dried greens (2.5 kg/ha), an infusion of garlic bulbs (*Allium sativum* L.) obtained from fresh bulbs (6.5 kg/ha), an infusion of white mustard (*Sinapis alba* L.) obtained from ground seeds (15 kg/ha), an infusion of Indian mustard (*Brassica juncea* L.) obtained from ground seeds (15 kg/ha), a decoction of the wood of *Quassia amara* (L.) obtained from wood chips (4 kg/ha), an extract from the seeds of the neem tree *Azadirachta indica* (L.) (3.5 l/ha), and the horticultural potassium soap with tansy (15 l/ha), with the addition of 96% ethanol (7.5 l/ha).

The treatments were performed using 750 litres of working liquid per 1 ha. The number of colonies of both aphid species was determined prior to carrying out the protective treatments and 6 days after the last treatment. During the inspection, the mortality of individuals of both aphid species was assessed using a stereoscopic microscope, on twenty apple shoots with aphid colonies from each combination. The results of the mortality of individuals and the percentage of reduction in the number of colonies in comparison with the control combination are presented jointly for the green apple aphid and the rosy apple aphid because of the simultaneous colonization of the leaves and shoots by the two species of aphid.

At harvest, the fruits were collected and assessed as regards damage caused by the rosy apple aphid in samples of 400 fruits from each combination. The extent of damage was assessed on a three-point scale: severely damaged – undersized and very deformed fruits (up to 5.5 cm in diameter), moderately damaged – fruits with visible deformities, of average size (from 6 to 7 cm in diameter), slightly damaged – fruits of normal size with traces of damage around the calyx (above 7 cm in diameter). Slightly damaged fruits are suitable for retail sale, moderately damaged fruits are suitable for use in the processing industry, whereas severely damaged fruits constitute a non-marketable crop.

The results of aphid mortality and damage to apple fruit were statistically analyzed using the variance method for numerical data transformed with the Bliss formula. The resulting numerical data were compared using the Duncan test, in the program Statistica 10, at a significance level of  $p = 0.05$ .

### 3. Results and Discussions

The effectiveness of the preparations used varied depending on the year. One of the assessment criteria was the reduction in the number of colonies of both species of aphid in relation to the control combination. In 2013, this reduction was from 31.8% to 81.8%, while in 2014 it was lower, ranging from 10.3% to 66.2%. In both years, the group of preparations with the strongest effect on reducing the number of colonies included the Quassia wood decoction (2013, 2014), the neem extract (2014), the garlic infusion (2013), the horsetail infusion (2013), and potassium soap (2013). In 2014, there was a much smaller reduction in the number of colonies by the applied preparations. In 2013, the average percentage of reduction in the number of aphid colonies was 59.85%, and in 2014 – 32.14%. In both years of the experiment, a reproducible result of a marked effect on reducing the number of colonies of aphids was obtained only with the decoction of Quassia wood (Tab. 1).

Table 1. Effect of plant-derived preparations on the reduction in the number of aphid colonies in relation to the control combination in 2013 and 2014

Tab. 1. Wpływ zastosowanych preparatów roślinnych na redukcję liczby kolonii mszyc w odniesieniu do kombinacji kontrolnej w latach 2013 i 2014

Preparation	Reduction in number of aphid colonies [%]	
	2013	2014
Infusion of field horsetail	68.2	10.3
Infusion of garlic bulbs	77.3	17.6
Potassium soap	31.8	30.9
Infusion of white mustard seeds	40.9	26.5
Decoction from Quassia wood	81.8	52.9
Extract from neem seeds	59.1	66.2
Infusion of Indian mustard seeds	–	20.6

Source: own work / Źródło: opracowanie własne

Table 3. Damage to apple fruits caused by the feeding of the rosy apple aphid in 2013

Tab. 3. Uszkodzenia owoców jabłoni w wyniku żerowania mszycy jabłoniowo-babkowej w roku 2013

Preparation	Percentage of damaged fruits [%]							
	Severely		Moderately		Slightly		Overall	
Infusion of field horsetail	0.6	a	5.5	b	0.9	ab	7.0	d
Infusion of garlic bulbs	1.0	ab	2.9	ab	0.6	ab	4.5	a
Potassium soap	2.0	b	3.7	ab	1.2	b	6.9	d
Infusion of white mustard seeds	0.9	ab	3.1	ab	0.8	ab	4.8	a
Decoction from Quassia wood	1.8	b	4.1	ab	0.0	a	5.9	c
Extract from neem seeds	1.9	b	2.7	a	0.5	ab	5.1	ab
Control / no treatment	2.7	b	3.0	a	0.0	a	5.7	bc

Source: own work / Źródło: opracowanie własne

The rate of mortality of the green apple aphid and the rosy apple aphid varied in both years. In 2013, the mortality of the two aphid species ranged from 8.8% to 37.6%, and in 2014 from 8.2% to 35.1%. In 2013 and 2014, the highest aphid mortality was observed after the application of the Quassia wood decoction, neem extract (37.6% and 34.1%, and 20.5% and 35.1%, respectively), and in 2014 – potassium soap (33.7%). The other used preparations had a smaller and varied effect on the mortality of individuals of both aphid species, which ranged from 8.8% to 24.3% in 2013, and from 8.2% to 15.5% in 2014 (Tab. 2).

Table 2. Mortality of aphids following the use of plant-derived preparations in 2013 and 2014

Tab. 2. Śmiertelność mszyc po zastosowaniu preparatów roślinnych w latach 2013 i 2014

Preparation	Aphid mortality [%]			
	2013		2014	
Infusion of field horsetail	9.4	b	15.5	cd
Infusion of garlic bulbs	17.2	c	14.7	c
Potassium soap	8.8	b	33.7	e
Infusion of white mustard seeds	24.3	c	8.6	b
Decoction from Quassia wood	37.6	d	20.5	d
Extract from neem seeds	34.1	d	35.1	e
Infusion of Indian mustard seeds	–		8.2	b
Control / no treatment	2.3	a	2.2	a

Source: own work / Źródło: opracowanie własne

At harvest, the fruits were assessed as regards damage caused by the rosy apple aphid. In 2013, there were much fewer damaged fruits than in 2014. The percentage of severely damaged fruits was from 0.6% to 2.7% (2013), and from 6.0% to 11.6% (2014), and of moderately damaged fruits from 2.7% to 5.5% (2013), and from 2.0% to 3.5% (2014). In 2013, the lowest percentage of severely damaged fruits was recorded after the application of the infusions of field horsetail and white mustard, and in 2014 of the neem extract and potassium soap (Tab. 3 and 4). The evidence of severe and moderate damage to fruits in 2013 did not coincide with the effect of the preparations on reducing the increase in the number of new colonies of aphids and their mortality. In 2014, however, the effectiveness of the neem extract and potassium soap in reducing the number of new colonies of aphids and their mortality correlated with the lower percentage of severely damaged fruits.

Table 4. Damage to apple fruits caused by the feeding of the rosy apple aphid in 2014

Tab. 4. Uszkodzenia owoców jabłoni w wyniku żerowania mszycy jabłoniowo-babkowej w roku 2014

Preparation	Percentage of damaged fruits [%]							
	Severely		Moderately		Slightly		Overall	
Infusion of field horsetail	9.8	ab	2.9	a	1.9	a	14.6	ab
Infusion of garlic bulbs	9.1	ab	2.8	a	2.3	a	14.2	ab
Potassium soap	6.5	ab	2.1	a	1.2	a	9.8	ab
Infusion of white mustard seeds	10.6	ab	3.5	a	1.6	a	15.7	ab
Decoction from Quassia wood	8.2	ab	2.8	a	1.4	a	12.4	ab
Extract from neem seeds	6.0	a	2.0	a	1.3	a	9.3	a
Infusion of Indian mustard seeds	10.2	ab	3.1	a	1.5	a	14.8	ab
Control / no treatment	11.6	b	3.3	a	1.9	a	16.8	b

Source: own work / Źródło: opracowanie własne

The study resulted in obtaining varied effectiveness of plant-derived preparations in controlling the green apple aphid and the rosy apple aphid (8.2-37.6%). Similarly, varied results had been obtained in another study on controlling the black cherry aphid, in which the same plant-derived preparations were used (7.1-63.4%) [11]. The highest and reproducible efficacy of reducing the populations of both species of aphids was obtained using the decoction of Quassia wood and the extract from neem seeds. However, in the case of controlling the black cherry aphid, the effectiveness of these preparations had been considerably higher [11]. Other field experiments conducted over several years in Europe have also produced a positive effect of the application of azadirachtin in terms of reducing the number of the rosy apple aphid, and a varied effect on the green apple aphid [17]. Experiments conducted in the laboratory have demonstrated 100% mortality of the rosy apple aphid after 24 h [2], and of the rose-grass aphid (*Metopolophium dirhodum* Wlk.) and the bird cherry-oat aphid (*Rhopalosiphum padi* L.) 48 h after the application of extracts from *A. indica* and *Q. amara* [21].

In a study by Cross et al. (2007), conducted under field conditions, protective treatments with azadirachtin, garlic extract, and potassium soap were performed in the autumn against the last generations of the rosy apple aphid in order to control its number and reduce the population of the first generation in the spring. However, the applied measures did not reduce the number of this aphid [9]. In a study by Bürgel et al. (2005), in which use was made of kaolin as a deterrent in the autumn, the treatments did not result, in the spring of the following season, in a decrease in the number of the rosy apple aphid below the risk threshold despite observing fewer females laying overwintering eggs on the trees [7]. Promising results in controlling the rosy apple aphid have been obtained under laboratory conditions using essential oils of industrial hemp (80.34-95.52%) [14], extracts from the black poplar (100%) [4], and marigold (51.35%) in the case of the green apple aphid [18]. In other laboratory tests, after the application of plant oils, satisfactory results have been obtained in the control of the glasshouse potato aphid (*Aulacorthum solani* Kalt.). The efficacy of the treatments after 72 h reached 100% for the essential oil of geranium, 100% for lavender, 98.85% for peppermint, 97.64% for pine, 100% for thyme [13], and 81.2-99.47% for coriander and 89.8-99.5% for petitgrain [12].

In field experiments on the control of aphids, the effectiveness of plant-derived preparations is much lower than the effectiveness of the same preparations obtained in laboratory tests. The conditions in the laboratory experiments are stable and controlled, in contrast to variable and unpre-

dictable weather conditions outdoors, which often have a negative effect on biologically active substances.

#### 4. Conclusions

The results of the use of plant-derived preparations are not satisfactory. The low and varied effectiveness of controlling the rosy apple aphid and the green apple aphid disqualifies the infusions of garlic, field horsetail, white mustard and Indian mustard as plant-derived aphicides. Potassium soap, due to its varied efficacy, can be applied as an auxiliary means, an adjuvant, when using other, more effective, plant-derived preparations. Only with the decoction of *Q. amara* wood and the extract from *A. indica* seeds the results were satisfactory enough to allow further research on using them for controlling other aphid species. Because of the unavailability of effective aphicides for organic farming in Poland, research should continue in order to obtain effective means, of plant origin, intended for controlling aphids in organically grown crops.

#### 5. References

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