Control of Green Apple Aphid (*Aphis pomi* De Geer) in Organic Apple Production

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SUMMARY

The efficacy of different methods for controlling populations of green apple aphid (*Aphis pomi* De Geer) in organic apple orchard was compared over three consecutive years. The following three control methods were tested: a) predator activity (*Coccinela septempunctata*), b) predator activity (*C. septempunctata*) + selective spraying of trees with infestation level exceeding 10% with a botanical insecticide (NeemAzal T/S), and c) predator activity (*C. septempunctata*) + total spraying of all orchard trees with the botanical insecticide (NeemAzal T/S). In terms of maintaining a biological balance within an orchard, the combination of natural regulation by *C. septempunctata* and selective spraying of individual trees with NeemAzal T/S proved to be the most efficient method.

Keywords: Azadirachtin; *Coccinella septempunctata*; Organic agriculture; Botanical insecticides; Spraying; Predators; Apples; *Aphis pomi*

INTRODUCTION

The green apple aphid, *Aphis pomi* De Geer (Homoptera: Aphididae) is a holocyclic and monoecious aphid species that is widespread in the northern hemisphere, particularly in the Western Palaearctic region. It is one of the most important pests in Serbian apple orchards with infestation occurring regularly each year both on globally popular and local apple cultivars. The species is especially harmful in nurseries and young orchards and it characteristically re-infests apple trees over the May-June period (Haley and Hogue, 1990; Kaakeh et al., 1993; Milenković, 2002;

van Emden and Harrington, 2007). A common strategy to control *A. pomi* in conventional apple orchards in Serbia is based on one or more applications of synthetic insecticides (Milenković, 2002; Stamenković et al., 2007; Tamaš et al., 2012).

Preventive practices, both mechanized and other physical measures, make the first choice in controlling harmful organisms in organic agriculture. An active ingredient permitted under the EC directive 889/2008, Anex II, may be applied only in case of necessity when such choice is fully justified and on condition of its consistency with relevant domestic legislation. Several insecticides of biological and

mineral origin have been approved for use in arthropod pest management programmes in organic crops. Azadirachtin has an important place among them as the main active ingredient of extracts, oils and other products derived from seeds of *Azadirachta indica*, the Indian neem tree (Milenković et al., 2005; Copping and Duke, 2007; Zehnder et al., 2007; Anonymous, 2011). Azadirachtin and/or other neem products have proved to be effective in controlling aphids on various host plants, including apples (Lowery et al., 1993; Kienzle et al., 1997; Karagounis et al., 2006; Milenković and Tanasković, 2010; Raudonis et al., 2009).

On the other hand, application of wide-spectrum bioinsecticides upsets natural biodiversity and affects population abundance of predators, which has a reverse negative effect on production sustainability and inevitability of repeated treatments (Fitzgerald, 2004; Jansen et al., 2010). The present study aimed to investigate the possibility of effective control of *A. pomi* on apple trees in organic production by minimal treatment with a bioinsecticide product in combination with the activity of an autochthonous predator population.

MATERIAL AND METHODS

The trial was conducted in an organic orchard of the autochthonous Kožara apple cultivar (rootstock M26), set up in 2004 and having 4 × 2.5 m row distance, and the trial had three replications on plots of 70 apple trees over three consecutive years (2008-2010). The orchard is located at 235 m altitude at Mršinci, Čačak, Serbia. It tested three control methods: 1) PR = an autochthonous population of the predator seven-spot ladybird (*Coccinella septempunctata*) as a regulator of aphid abundance on apple trees; 2) PR+S = the same autochthonous predator population + treatment of individual trees with the botanical insecticide (selective treatment); 3) PR+T = autochthonous predator population + treatment of all trees with the botanical insecticide (total treatment). The population density of green apple aphid (*A. pomi*) was assessed on all plots by inspecting 5 marked shoots per tree on 10 trees per replicate at 15-days intervals over the period April 30-June 30.

The apple trees were treated with 0.1% concentration of the botanical insecticide NeemAzal T/S (a.i. azadirachtin 1%, Trifolio-M GmbH, Germany).

The bioinsecticide was applied by a motorized Stihl knapsack sprayer, using a spray volume of 1 litre per tree. On the PR+S plots, only trees with more than 10% infested shoots were treated after inspection of 10 shoots per tree. The number of treated trees was 3-6. On the PR+T plots, all trees were treated with the bioinsecticide. In 2008 and 2010, the treatments were conducted on May 30, and in 2009 on May 15.

The number of aphids per plot was subjected to ANOVA and the means were separated by Duncan's test ($\alpha = 0.05$). The data were transformed by $\sqrt{x}$ before analysis.

The relative abundance of aphids was calculated as follows:

$$R\% = (Ae/At) \times 100$$

where At is the mean number of aphids per plot at the time of spraying, and Ae is the mean number of aphids per plot at the end of trial. The percents were subjected to ANOVA and the means were separated by Duncan's test ($\alpha = 0.05$). The data were transformed by $arcsin\sqrt{x}$ before analysis.

RESULTS AND DISCUSSION

Tables 1-3 show changes in population density of *A. pomi* in the experimental apple orchard over three consecutive seasons. Treatments with azadirachtin in the first two seasons were conducted at the time when population density was not significantly different among the three trial variants, while population density in the PR plots during the third season was significantly higher at treatment time than it was in the other two variants. Fifteen days after treatment, the efficacy was 78-90% in the PR+T plots, and 69-83% in PR+S plots, depending on season. At the same time, predator activity reduced the population density of aphids in the PR plots by 58% (first season) and 26% (third season), while density increased 26% in the second season. At the end of our trial and the three seasons, population density of *A. pomi* in the PR plots was significantly higher than it was in the PR+S plots, and the PR+T plots in the second and third seasons. The difference between the PR+S and PR+T plots at the end of the first and second seasons was not statistically significant, while population density of *A. pomi* in the third season was significantly lower in the PR+S plots.

Table 1. Population densities of *A. pomi* on apple trees in 2008 [mean number of aphids per shoot (± SE), 5 shoots/tree, 10 trees/plot]

Control methods	30/04	15/05	30/05*	15/06	30/06
PR	26.0 a (± SE)	35.0 a (± SE)	57.7 a (± SE)	24.0 a (± SE)	20.7 a (± SE)
PR+S	28.0 a (± SE)	41.3 a (± SE)	65.0 a (± SE)	17.3 a (± SE)	6.7 b (± SE)
PR+T	34.7 a (± SE)	48.3 a (± SE)	79.3 a (± SE)	7.7 b (± SE)	11.7 ab (± SE)

The means within a column followed by the same letter are not significantly different (Duncan test, α = 0.05)

PR = Predator activity;

PR+S = Predator activity + Selective treatment

PR+T = Predator activity + Total treatment

* Date of treatment with NeemAzal T/S (PR+S, PR+T)

Table 2. Population densities of *A. pomi* on apple trees in 2009 [mean number of aphids per shoot (± SE), 5 shoots/tree, 10 trees/plot]

Control methods	30/04	15/05*	30/05	15/06	30/06
PR	49.0 a (± SE)	85.7 a (± SE)	108.3 a (± SE)	65.0 a (± SE)	36.3 a (± SE)
PR+S	44.7 a (± SE)	91.0 a (± SE)	28.3 b (± SE)	17.7 b (± SE)	12.0 b (± SE)
PR+T	30.0 a (± SE)	85.6 a (± SE)	10.3 c (± SE)	15.3 b (± SE)	17.7 b (± SE)

The means within a column followed by the same letter are not significantly different (Duncan test, α = 0.05)

PR = Predator activity;

PR+S = Predator activity + Selective treatment

PR+T = Predator activity + Total treatment

* Date of treatment with NeemAzal T/S (PR+S, PR+T)

Table 3. Population densities of *A. pomi* on apple trees in 2010 [mean number of aphids per shoot (± SE), 5 shoots/tree, 10 trees/plot]

Control methods	30/04	15/05	30/05*	15/06	30/06
PR	39.7 a (± SE)	64.7 a (± SE)	129.7 a (± SE)	95.3 a (± SE)	33.7 a (± SE)
PR+S	22.3 b (± SE)	35.5 b (± SE)	66.7 b (± SE)	11.3 b (± SE)	7.3 c (± SE)
PR+T	43.3 a (± SE)	66.0 a (± SE)	93.7 b (± SE)	20.7 b (± SE)	14.0 b (± SE)

The means within a column followed by the same letter are not significantly different (Duncan test, α = 0.05)

PR = Predator activity;

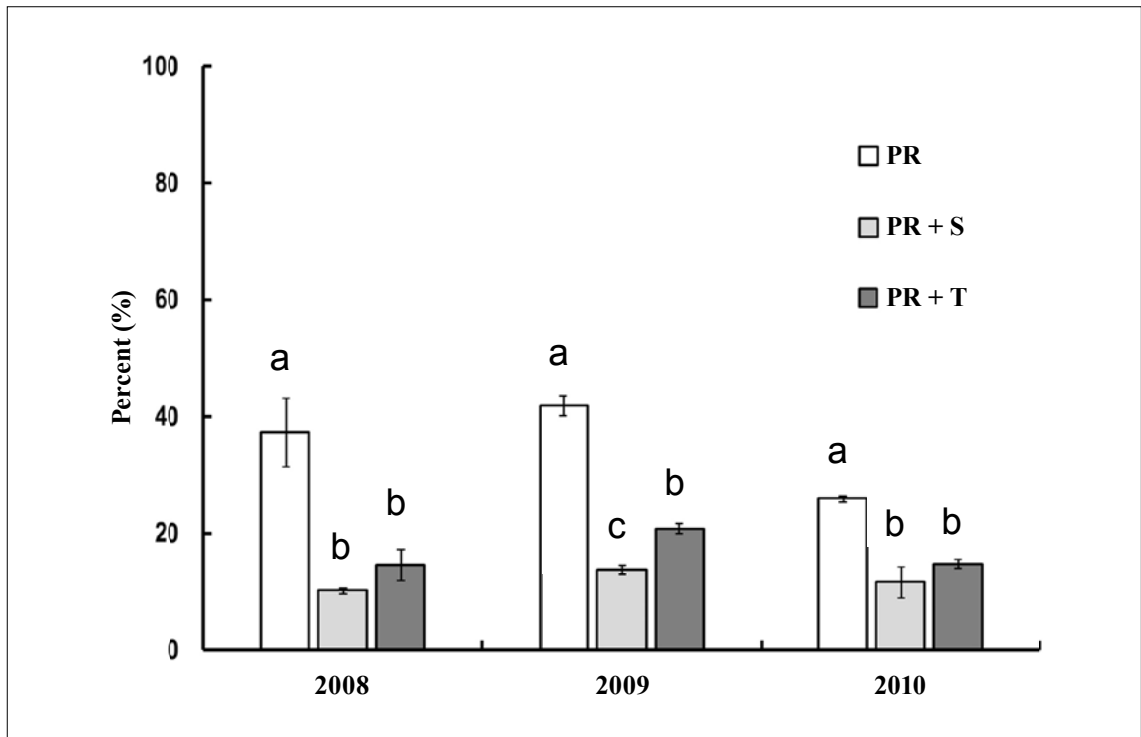PR+S = Predator activity + Selective treatment

PR+T = Predator activity + Total treatment

* Date of treatment with NeemAzal T/S (PR+S, PR+T)

Figure 1 shows the relative abundance of green apple aphids at the end of the trial, compared to their abundance at the time of treatment. In all three seasons, relative abundance in the PR plots was significantly higher statistically than it was in the other two treatment variants, which showed no significant mutual difference in the first and third seasons. In the second season, the relative abundance of *A. pomi* in the PR+S plots was significantly lower than in the PR+T plots.

Comparing the PR+S and PR+T plots, we found the selective azadirachtin treatment to be equally good or even more effective than total treatment when population abundance of the predator species was insufficient to reduce prey abundance significantly. The period of conversion from conventional to organic fruit production is three years and it serves also to establish a dynamic balance between predators and prey by applying preventive control measures. The most important preventive measure aimed at reducing plant aphid populations is the preservation of their natural enemies (ladybirds, green lacewings, hoverflies, etc.) by installing shelters for them and forming corridors of flowering plants inside and around orchards (Fitzgerald, 2004; Milenković, 2010; Milenković et al., 2010). Biopesticides are applied only when preventive measures have proved insufficient.

Figure 1. Relative abundance of *A. pomi* (Ms ± SE) at the end of the trials (PR = predator activity (*Coccinela septempunctata*); PR + b = predator activity (*C. septempunctata*) + selective treatment with NeemAzal T/S; PR + B = predator activity (*C. septempunctata*) + total treatment with NeemAzal T/S)

The means followed by the same letter are not significantly different (Duncan test, α = 0.05)

Azadirachtin and other neem-derived insecticides are regarded as generally compatible with insect natural enemy conservation. However, azadirachtin causes various toxic and/or harmful sublethal effects on Coccinellidae species (Banken and Stark, 1997, 1998; Bernardo and Viggiani, 2002). In view of a risk of harming predator populations, bioinsecticide use needs to be restricted to a necessary minimum. Another important aspect of organic farming-compatible biopesticides is their cost effectiveness. As the required amount of bioinsecticide was up to 90% lower in the selective treatment than in total treatment, while the same or better effect was achieved in the former, selective treatment was found to be the more effective control measure both from the aspects of economy of organic production and protection of agro-ecosystem.

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REFERENCES

Anonymous (2011). Pravilnik o kontroli i sertifikaciji u organskoj proizvodnji i metodama organske proizvodnje. *Službeni glasnik RS*, br. 48/11.

Banken, J.A.O. & Stark, J.D, (1997). Stage and age influence on the susceptibility of *Coccinella septempunctata* (Coleoptera: Coccinellidae) after direct exposure to Neemix, a neem insecticide. *Journal of Economic Entomology*, 90:1102–1105.

Bernardo, U. & Viggiani, G. (2002). Effects of Oikos (a. i. Azadirachtin A) on the vedalia ladybeetle *Rodolia cardinalis* (Mulsant) (Coleoptera: Coccinellidae). *IOBC/wprs Bulletin*, 25: 81-88.

Copping, L.G. & Duke, S.O. (2007). Natural products that have been used commercially as crop protection agents – a review. *Pest Management Science*, 63:524-554.

Fitzgerald, J. (2004). Best practice guide for the production of organic apples and pears. Revision funded by EU INTERREG-Transorganic 2. http://www.emr.ac.uk/PDF/FinaOrganicAppleandPearGuidlines.pdf (Accession date: 2/10/2013)

Haley, S. & Hogue, E. (1990). Ground cover influence on apple aphid, *Aphis pomi* De Geer (Homoptera: Aphididae), and its predators in a young apple orchard. *Crop Protection*, 9, 225-230.

Jansen, J.P., Defrance, T. & Warnier, A.M. (2010). Effects of organic-farming-compatible insecticides on four aphid natural enemy species. *Pest Management Science*, 66: 650-656.

Karagounis, C., Kourdoumbalos, A.K, Margaritopoulos, J.T., Nanos, G.D. & Tsitsipis, J.A. (2006). Organic farming-compatible insecticides against the aphid *Myzus persicae* (Sulzer) in peach orchards. *Journal of Applied Entomology*, 130: 150-154.

Kienzle, J., Schulz, C. & Zebitz, C.P.W. (1997). Two years of experience with the use of NeemAzal in organic fruit orchards. In: *Proceedings of the Fifth Workshop Practice oriented results on use and production of neem-ingredients and pheromones*, Wetzlar, Germany, 27–31.

Lowery, D.T., Isman, M.S. & Brard, N.L. (1993). Laboratory and field evaluation of neem for the control of aphids (Homoptera: Aphididae). *Journal of Economic Entomology*, 86: 864-870.

Milenković, S. (2002). Jabukina zelena vaš, *Aphis pomi* De Geer - štetnost i suzbijanje. *Zbornik naučnih radova Instituta PKB Agroekonomik*, 8, 61-68.

Milenković, S.,Tanasković Snežana, Lazić Tatjana (2005). Azadirahtin - mogućnosti primene u zaštiti bilja. Jugoslovensko voćarstvo; vol. 39, br. 149, (2005/1) 61-69.

Milenković, S. (2010). Organska proizvodnja jabuke. Zbornik XV savetovanja o biotehnologiji, Čačak, pp. 883-886.

Milenković, S. & Tanasković, S. (2010). Biological Efficacy of Botanical Insecticides in Controlling Green Apple Aphid (*Aphis pomi* De Geer). *IOBC/wprs Bulletin* 54: 367-370.

Milenkovic, S., Snežana Tanasković, Dušica Sretenović (2010). Organic Raspberry Production in Serbia. IOBC/wprs Bulletin, Vol. 54. Part 1 [xviii + 318 pp.], Part 2 [viii + 350 pp.]., 415-418.

Raudonis, L., Valiuškaite, A., Duchovskiene, L. & Surviliene, E. (2010). Toxicity of biopesticides to green apple aphid in apple-tree. *Sodininkyste ir daržininkyste*, 97: 49-54.

Stamenković, S., Gudžić, S., Perić, P., Marčić, D. & Ilić, N. (2007). Štetni insekti voćaka i vinove loze. *Zbornik radova savetovanja „Proizvodnja i zaštita voćaka i vinove loze", Požarevac, Zbornik radova Više tehničke škole,* Požarevac, 2/2007, 103-117.

Tamaš, N., Miletić, N. & Elezović, I. (2012). Efikasnost insekticida različitih mehanizama delovanja u suzbijanju zelene vaši jabuke (*Aphis pomi* De Geer) na jabuci. *Biljni lekar*, 45, 489-497.

van Emden, H.F. & Harrington, R. (2007). *Aphids as Crop Pests*. Wallingford, UK: CAB International.

Zehnder, G., Gurr, G.M., Kühne, S., Wade, M.R., Wratten, S.D. & Wyss, E. (2007). Arthropod pest management in organic crops. *Annual Review of Entomology*, 52: 57-80.

Suzbijanje zelene vaši jabuke (*Aphis pomi* De Geer) u organskoj proizvodnji

REZIME

Upoređivana je efikasnost različitih metoda suzbijanja populacija zelene vaši jabuke (*Aphis pomi* De Geer) u organskom zasadu jabuka tokom tri godine. Ispitane su tri metode suzbijanja: a) aktivnost predatora (*Coccinela septempunctata*), b) aktivnost predatora (*C. septempunctata*) + selektovno prskanje stabala sa preko 10% zaraženosti botaničkim insekticidom (NeemAzal T/S) i c) aktivnost predatora (*C. septempunctata*) + prskanje svih stabala u voćnjaku botaničkim insekticidom (NeemAzal T/S). Sa stanovišta održavanja biološke ravnoteže u voćnjaku, najefikasniji metod predstavljala je kombinacija prirodne regulacije putem vrste *C. septempunctata* i selektivnog prskanja pojedinačnih stabala preparatom NeemAzal T/S.

Ključne reči: Azadirahtin; *Coccinella septempunctata*; organska poljoprivreda; botanički insekticid; prskanje; predatori; jabuka; *Aphis pomi*