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Feeding ants with sugar: control of rosy apple aphid

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Abstract

*Rosy apple aphid (*Dysaphis plantaginea *Pass.; RAA) and ants (*Lasius niger *L.) maintain a mutualistic relationship in which aphids receive protection and help in migration across the tree in exchange for aphid-excreted honeydew (sugars) as food for ants. Offering an alternative sugar solution was investigated as a possible method to break the defensive mutualism between ants and RAA, thereby potentially reducing damage caused by RAA. Applying sugar dispensers in 2021 and 2023 at a density of 1 dispenser on every other tree, showed a positive effect by reducing RAA populations and, in particular, their expansion to young shoots. At lower dispenser densities (1 dispenser per 4 trees or 10 trees) the effect was still observed, but less pronounced and the difference with the reference was no longer significant. Further research is recommended to resolve practical issues in terms of reducing labour and material costs, as well as on optimization of strategies in which pest-ant interactions can be targeted in ways that enhance control of pests and diseases in organic fruit growing.*

Keywords: Rosy apple aphid, ants, sugar dispensers, insect interactions

Introduction Rosy apple aphid is a pest in apple which can cause severe damage to leaves and fruits. In spring, foundatrices settle themselves in cluster leaves and form colonies by asexual reproduction. RAA has multiple generations per year. When colonies grow, some aphids migrate to younger parts of the tree and form new colonies. RAA colonies cause curling of the leaves and impede the growth of young shoots. Additionally, infested fruits become malformed and remain small, thus being unsellable.

Ants maintain a mutualistic relationship with several honeydew producing insects, including RAA. In exchange for sugar, ants protect the honeydew producers against their natural enemies and facilitate migration of RAA to young shoots in the tree (Offenberg, 2001). Disruption of the relationship between RAA and ants may inhibit the expansion of RAA across the tree (Stewart-Jones, Pope, Fitzgerald & Poppy, 2008). Without the help of ants, RAA cannot easily spread through the trees and are more vulnerable to natural enemies.

Offering alternative sugar to ants is a possible way to decrease the dependency of ants on the honeydew excretion of aphids. Several studies have demonstrated this principle for multiple aphid-ant combinations. Examples are *D. plantaginea* and green apple aphid *Aphis pomi* De Geer with wood ant *Formica polyctena* Förs. (Jensen, Hansen, Damgaard & Offenberg, 2023) or common black ant *L. niger* (Nagy, Cross & Markó, 2013), *Aphis spiraecola* Patch and the ant *Lasius grandis* (Wäckers, Alberola, Garcia Marí & Pekas, 2017) and mealybug *Planococcus citri* Risso with *Lasius grandis* Forel (Pérez-Rodríguez, Pekas, Tena & Wäckers, 2021).

In 2021 and 2023 experiments were performed in the Netherlands to investigate the effectiveness of offering alternative sugar sources to *L. niger* in reducing damage caused by RAA. After positive results in 2021, the trial was extended with multiple densities of sugar dispensers, to find the minimum required number of sugar dispensers to control RAA. The results are presented in this paper.

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Material and Methods

The experiments were performed in the Netherlands (51.653401 N, 4.007165 E) in a biodynamic apple orchard (cultivar Natyra). The orchard had been planted in 2015 at a tree density of 2462 trees/ha (1.25 m x 3.25 m). In both 2021 and 2023, one application of NeemAzal-T/S (3 l/ha) was applied on the entire experiment, also being the reference treatment in this paper. The sprayings were performed on 26 April 2021 and 19 April 2023.

In 2021, a treated object in which additional sugar dispensers had been placed at every other tree (1231 dispensers/ha) was compared to the reference treatment with NeemAzal-T/S spraying only. Each plot consisted of a single row of 14 trees, the central 10 trees of which were used for observations. The trial consisted of five replicates per treatment.

In 2023, the trial had three treated objects and the reference treatment, each in four replicates. Different densities of sugar dispensers were tested, namely 1231 dispensers/ha (every other tree; 1-in-2); 615 dispensers/ha (one dispenser on every fourth tree; 1-in-4) and 246 dispensers (one dispenser on every tenth tree; 1-in-10). The sugar dispensers were again additional to the NeemAzal-T/S treatment. The plot size was 60 trees (4 rows x 15 trees), but for the 1-in-2 and 1-in-4 treatments the treated plot size was only 24 trees (3 rows x 8 trees). Observations were performed on the central 8 trees in the middle row of each plot.

The sugar dispensers were placed on 20 April 2021 and 20 April 2023 (BBCH 57-59). They were attached circa 1 m above the ground to the trees with Treefix. The sugar dispensers were not refilled during the growing season. In 2021, the sugar dispensers consisted of plastic, in contrast to the glass bottles used in 2023 to prevent leakage as the result of wood pecker picking. The sugar solution in the dispensers was provided by Biobest.

The degree of RAA infestation was assessed on 17 June 2021 and 15 June 2023 respectively. Assessments were grouped according to the following categories: foundatrice (not in 2021), occupied colony, empty colony, occupied young shoots and empty young shoots (not in 2021). Empty colonies and shoots had previously been occupied by aphids, but the aphids had disappeared, for example due to predation.

Data were analysed using RStudio (version 4.3.0). For 2021, t-tests were performed. In cases where the data did not meet the assumptions for a t-test, the non-parametric Mann-Whitney U-test was performed. For 2023, the data were analysed using a one-way ANOVA or the non-parametric Kruskal-Wallis test, in case where assumptions for ANOVA were not met.

Results

Initial infestation of RAA on cluster leaves was higher in 2021 as compared to 2023. In 2021, on average 2.92 colonies with RAA on cluster leaves were found in the reference treatment, whereas the number of colonies with RAA was significantly reduced by 96% to 0.12 colonies per tree in the plots containing a sugar dispenser on every second tree (table 1). In 2023, a comparable reduction (88%) as in 2021 was observed for the 1-in-2 treatment as compared to the reference (0.50 colonies/tree). However, in this trial the result was not significant due to variation in the field. The 1-in-10 and the 1-in-4 treatment also showed a reduction in the number of occupied colonies in cluster leaves as compared to the reference treatment, but reductions were smaller than for the 1-in-2 treatment. The number of empty colonies was similar among all treatments in 2023, but was elevated by a factor 2.7 in 2021 for the plots with sugar dispensers.

Table 1: Infestation level of RAA on cluster leaves and corresponding efficacy as a result of applying sugar dispensers at multiple densities in 2021 and 2023.

	2021			2023		
	Occupied (colonies/ tree)	Efficacy (%)	Empty (colonies/ tree)	Occupied (colonies/ tree)	Efficacy (%)	Empty (colonies/ tree)
Reference	2.92 a		0.38	0.50		1.16
Ref. + 1-in-10				0.38	25	1.16
Ref. + 1-in-4				0.13	74	1.14
Ref. + 1-in-2	0.12 b	96	1.04	0.06	88	1.13
p-value	0.02		0.20 (n.s.)	0.32 (n.s.)		1.00 (n.s.)

Spreading of RAA infestation to shoots was significantly reduced in both years for the plot with the highest density of sugar dispensers (1-in-2), resulting in fewer shoots as well as fewer empty colonies (table 2). The reduction in the number of infested shoots was on average 97% (2021) and 98% (2023). Decreasing the density of sugar dispensers increased the number of infested shoots as compared to the highest density of sugar dispensers, but infestation of shoots was still reduced (69-88%) as compared to the reference treatment. However, for the 1-in-4 and 1-in-10 treatments, the effect was not significantly different from the reference treatment for both occupied and empty colonies.

Table 2: Infestation level of RAA on young shoots (spreading of RAA) and corresponding efficacy as a result of applying sugar dispensers at different densities in 2021 and 2023.

	2021		2023		
	Infestation (shoots/ tree)	Efficacy (%)	Infestation (shoots/ tree)	Efficacy (%)	Empty (colonies/ tree)
Reference	2.46 a		1.09 a		1.13 a
Ref. + 1-in-10			0.34 ab	69	0.47 ab
Ref. + 1-in-4			0.13 ab	88	0.80 ab
Ref. + 1-in-2	0.04 b	98	0.03 b	97	0.19 b
p-value	0.01		0.02		0.03

Discussion

The results showed significant, positive effects on reducing RAA when sugar dispensers are applied at every second tree (1231 dispensers/ha). In particularly, the expansion of RAA to young shoots is strongly suppressed (97-98%) relative to the reference treatment when expressed in the number of colonies with RAA in this experiment. When the density of sugar dispensers was decreased, the efficacy of the method decreased, but the treatment effect was still visible.

The focus for this experiment was on reduction of shoot damage, whereas fruit damage was not assessed. It is not likely that fruit damage can be prevented in the year of application, as fruit damage is caused early in the growing season. Applying sugar dispensers mainly acts on preventing expansion of RAA to shoots later on in the season. Therefore, the application of sugar dispensers seems particularly useful for young trees or weak-growing trees where shoot growth should be promoted. It remains to be seen, whether the current results obtained in a full-grown orchard can be extrapolated to young orchards, for example because of different levels of abundance of natural enemies.

In both years, the RAA infestation was at a tolerable level for full-grown trees and consequently the RAA reduction was not directly related to economic benefits. The low infestation levels may also be the result of the NeemAzal-T/S application early in spring, thus lowering the RAA pressure in the orchard.

A disadvantage of the 1-in-2 treatment are the costs. Currently, filling and installing of the bottles is labour-intensive. Additionally, material costs should be considered. Attention needs to be paid to these aspects to make the method user-friendly and cost-effective. Density reduction represents a proportional cost reduction, but resulted in this trial also in a reduced efficacy. The minimum application density at which tree damage is still acceptable is likely situation dependent.

Applying sugar dispensers to control aphids is an interesting example of a system's approach to deal with pests and diseases. Building on this, it is important to get a better understanding of the relationships between aphids, ants and natural enemies in order to find ways to optimize these relationships. Offenberg (2001) found evidence under lab conditions that ant predation on aphids is increased when an alternative sugar source is added. Also, literature suggests that ants provide many services to fruit crops (Offenberg, Nielsen & Damgaard, 2019; Jensen, Hansen, Damgaard & Offenberg, 2023). This stresses that further research towards species interactions in orchard systems in general is needed to design optimal organic fruit orchards.

References

Jensen, I. C., Hansen, R. R., Damgaard, C., & Offenberg, J. (2023). Implementing wood ants in biocontrol: Suppression of apple scab and reduced aphid tending. *Pest Management Science* **79**: 2415-2422.

Nagy, C., Cross, J. V., & Markó, V. (2013). Sugar feeding of the common black ant, *Lasius niger* (L.), as a possible indirect method for reducing aphid populations on apple by disturbing ant-aphid mutualism. *Biological Control* **65**: 24-36.

Offenberg, J. (2001). Balancing between mutualism and exploitation: the symbiotic interaction between Lasius ants and aphids. *Behavioral Ecology and Sociobiology* **49**: 304-310.

Offenberg, J., Nielsen, J. S., & Damgaard, C. (2019). Wood Ant (*Formica polyctena*) services and disservices in a danish apple plantation. *Sociobiology* **66**: 247-256.

Pérez-Rodríguez, J., Pekas, A., Tena, A., & Wäckers, F. L. (2021). Sugar provisioning for ants enhances biological control of mealybugs in citrus. *Biological Control* **157**: 104573.

Stewart-Jones, A., Pope, T. W., Fitzgerald, J. D., & Poppy, G. M. (2008). The effect of ant attendance on the success of rosy apple aphid populations, natural enemy abundance and apple damage in orchards. *Agricultural and Forest Entomology* **10**: 37-43.

Wäckers, F.L., Alberola, J.S., Garcia Marí, F., Pekas T. (2017). Attract and distract: Manipulation of a food-mediated protective mutualism enhances natural pest control. *Agriculture Ecosystems & Environment* **246**:168-174