Cite as: Cahenzli, F., Boutry, C. (2022). Autumn kaolin treatments and early spring oil treatments against Myzus cerasi in Sweet cherries. *Proceedings of the 20th International Conference on Organic Fruit-Growing*, online 2022.02.21-23. Ed. FOEKO e.V. 2022: 175-179

Autumn kaolin treatments and early spring oil treatments against *Myzus cerasi* in Sweet cherries

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Abstract

The black cherry aphid Myzus cerasi *FABRICIUS (Hemiptera: Aphididae) is a major pest in low-stem cherry orchards with rain protective covering and hail nets. In autumn, winged aphids migrate from their secondary hosts back to the cherry orchards. We applied kaolin (Surround ® WP) in the autumn of 2019 (three applications) and 2020 (two applications) to young cherry trees to prevent the immigration and establishment of aphids, with the aim to reduce the number of fundatrices in the following spring. We compared the kaolin treatment with paraffin oil sprayed in spring, a combination of both treatments and an untreated control. In autumn 2019 with a denser kaolin residue and a higher assessment frequency than in autumn 2020, there were significantly less unwinged and winged aphids on trees treated with kaolin than control trees, whereas there was no significant difference in 2020. However, kaolin significantly reduced the number of aphid colonies in the following spring in both 2020 (95 %) and 2021 (77 %). Five days after the application, paraffin oil showed no significant effect in both years, but further assessments in 2021 revealed increasing efficacy up to 83 % 25 days after application. The combination of kaolin applications in autumn with a paraffin oil application in spring had an efficacy of 86-99 % and prolonged the effect of kaolin. As the white residue on leaves in autumn does not harm photosynthesis, assimilation or transpiration and since kaolin is not toxic to beneficial arthropods, kaolin applied in autumn is a promising tool to control* M. cerasi *in organic cherry production.*

Keywords: aphid control, crop protection, paraffin oil, Surround WP

Introduction

The black cherry aphid *Myzus cerasi* FABRICIUS (Hemiptera: Aphididae) is a major pest in low-stem cherry orchards with rain protective covering and hail nets (Lang et al., 2011). Rain protective covering can alter the microclimate in the cherry orchard and thereby promote *M. cerasi*. Sucking sap from buds and foliage during spring and early summer leads to severely curled and damaged leaves (Kepenekcí et al., 2015). Furthermore, black sooty fungus grow on honeydew secreted by the aphids. *Myzus cerasi* is also considered to be the most important vector of plant viruses worldwide (Blackman and Eastop, 2000). In autumn, winged females (gynoparae) migrate from their secondary hosts *Galium* spp. or *Veronica* spp. (CABI, 2019) back to the cherry orchards and produce wingless oviparae. Winged males, which migrate later, mate with oviparae that lay eggs at the base of buds, in crevices of the bark and on young shoots. Fundatrices hatch in the following spring and reproduce asexually. Due to asexual reproduction, every fundatrix reproduces exponentially, which makes early control crucial. In organic production, fundatrices are controlled with paraffin oil after bud swelling (BBCH 51) and later Pyrethrum, Neem oil and insecticidal soap after flowering (Häseli and Daniel, 2009). As an alternative, aphid control in the preceding autumn might interrupt the aphid cycle more effectively. In this study we tested whether white kaolin (Surround ® WP) residue on the leaves could prevent immigrating aphids in autumn from establishing the next generation and thus reduce the number of fundatrices in the following spring. The application of kaolin in autumn was compared to paraffin oil applied in spring,

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which targets the winter eggs and fundatrices. We also tested the combinations of the two treatments, i.e. kaolin application in autumn and paraffin oil application in spring.

Material and Methods

The trial was performed in an organic cherry orchard in Frick AG Switzerland (47°31’4’’ N 08°01’33’’ E) on trees of the variety Kordia grafted on G6 rootstocks and standing in the fourth vegetation in 2020. The planting distance is 2.4 m with 4.6 m distance between tree rows (900 trees / ha). Insecticide treatments were randomly assigned to different fertilizer blocks (Figure 1). Each insecticide-fertilizer-combination was repeated three times. Kaolin (2 %, 32 kg/ha product for 1600 L/ha water for 10,000 m^3 tree volume; Surround ® WP: 95 % kaolin, Stähler Suisse SA, LOT # AL 161208) was applied three times in 2019 (27.9, 11.10 and 23.10) and two times in 2020 (30.9 and 8.10). The broth was sprayed with a motorized Honda stroke sprayer type WJR 2525 with a single Yamaha-nozzle, type 20-10. Half of the spray broth was applied, left to dry and then the second half was sprayed. This approach was chosen to ensure an even and dense white coverage on the top and bottom of the leaves. Paraffin oil (Weissöl EC: 830 g/l, EC, Schneiter AGRO AG, Lot.-Nr 11.2017, BN 30000625104) was applied with a spray gun with 10 bar pressure on 11.3.2020 and 26.2.2021. To ensure a good wetting, we used a high water volume and sprayed the paraffin oil in two runs (1.75 %, 56 L/ha product for 1600 L/ha water per run for 10,000 m^3 tree volume) with a pause for drying. This approach is common practice in organic farming to achieve the same amount of active ingredient on the crop as applying a paraffin oil concertation of 3.5 %, which is permitted against various stone fruit pests requiring early season pest control.

In autumn, the top and bottom side of 25 randomly selected leaves per tree side were assessed (50 leaves per tree in total) for winged and unwinged aphids. Assessments were performed five times in 2019 (1.10, 4.10, 15.10, 22.10. and 31.10) and twice in 2020 (7.10. and 20.10). In spring 2020 (16.3) and 2021 (3.3., 8.3, 23.3), ten randomly selected bunches of buds per side were assessed for each tree (20 bunches of buds per tree in total) for aphid fundatrices.

Generalized linear mixed models (GLMM) with Poisson distributed errors and the fixed effects year, assessment date, treatment (kaolin vs. control) and an offset for the number of assessed leaves were used to analyse the number of winged and unwinged aphids in autumn. Both models also included the random effect individual tree, with random slopes for the two years in unwinged aphids and an observational random effect level to account for overdispersion. Fertilizer block explained no variance. The R-package lme4 with the optimizer “bobyqa” was used to analyse the number of winged aphids and the R-package glmmTMB, accounting for zero inflation, for unwinged aphids. The number of colonies in spring was analysed with a GLMM with Poisson distributed errors and the fixed effects assessment date and treatment (control, kaolin, paraffin oil, paraffin oil plus kaolin). The model also included the random effects individual tree and fertilizer block and used the optimizer “bobyqa” for better model conversion.

Results

There was a significant interaction between year and treatment on the number of unwinged aphids in autumn ($\chi^2_{1,315}$ = 5.350, P = 0.021). In 2019, the number of unwinged aphids per 50 leaves was significantly lower on trees treated with kaolin (mean ± SE: 3.1 ± 0.5) than on untreated trees (8.2 ± 1.0), whereas there was no significant difference in 2020 (kaolin: 2.0 ± 0.4, untreated: 2.5 ± 0.4). The number of unwinged aphids significantly increased over the assessment period ($\chi^2_{4,315}$ = 88.740, P < 0.001). There was a significant interaction between year and treatment on the number of winged aphids in autumn ($\chi^2_{1,325}$ = 7.078, P = 0.008). In 2019, the number of winged aphids per tree was significantly lower on trees treated with kaolin (1.9 ± 0.2) than on untreated trees (4.1 ± 0.3), whereas there was no significant difference in 2020 (kaolin: 0.4 ± 0.1, untreated: 0.3 ± 0.1). The number of winged aphids significantly increased over the assessment period ($\chi^2_{4,315}$ = 49.228, P < 0.001). There was a significant interaction between assessment date and treatment on the number of fundatrices in spring ($\chi^2_{9,174}$ = 30.197, P < 0.001; Figure 2).

Treatment	Fertilizer		Treatment	Fertilizer
kaolin	1		kaolin	1
paraffin oil	1		kaolin + oil	1
untreated	1		untreated	1
kaolin	2		kaolin	2
paraffin oil	2		untreated	2
kaolin + oil	2		kaolin	2
kaolin + oil	3		paraffin oil	3
paraffin oil	3		untreated	3
kaolin + oil	3		kaolin	3
kaolin + oil	4		kaolin	4
untreated	4		kaolin + oil	4
paraffin oil	4		kaolin + oil	4
paraffin oil	1		untreated	1
kaolin + oil	1		kaolin + oil	1
paraffin oil	1		kaolin	1
untreated	2		kaolin + oil	2
untreated	2		paraffin oil	2
kaolin + oil	2		paraffin oil	2
paraffin oil	3		kaolin	3
untreated	3		kaolin + oil	3
kaolin	3		untreated	3
paraffin oil	4		paraffin oil	4
untreated	4		untreated	4
kaolin	4		kaolin	4

Figure 1: Map of the orchard with low-stem cherry trees. Kaolin applied in autumn was compared with paraffin oil sprayed in spring, a combination of both treatments and an untreated control. Each combination of the insecticide fertilizer blocks was repeated three times.

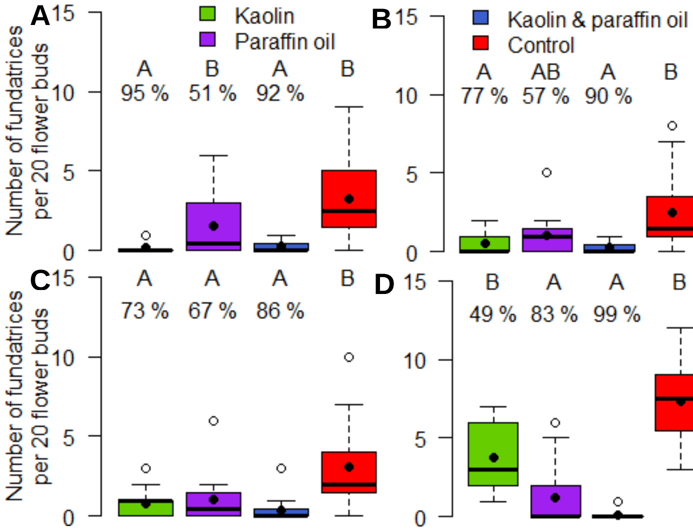

Figure 2: Mean number of fundatrices per 20 flower buds 5 days after the application of paraffin oil in 2020 (A) and 2021 (B) and 10 (C) and 25 days (D) after the application in 2021. Kaolin applied in autumn was compared with paraffin oil sprayed in spring, a combination of both treatments and an untreated control. Different letters indicate significant differences between treatments (P < 0.05). Effectiveness (%) is calculated according to Abbot. The boxes represent the interquartile range from the first to the third quartile, bold lines the median, whiskers the quartiles ± 1.5 × the interquartile distance, open circles outliers and black circles the arithmetic mean.

Discussion

In three consecutive years, the economic threshold of 2 % infestation of trees (Danelski and Rozpara, 2015) was exceeded on 28.9.2018, 23.09.2019, 30.09.2020. For the timing of the first application of kaolin, we suggest to start protecting the trees in mid or late September. To prevent the immigration and establishment of the next generation, two to three applications until leaves have fallen are necessary, depending on precipitation. Kaolin has different modes of action on aphids. The white residue alters light reflection, which could affect host detection and selection (Cottrell et al., 2002; Döring, 2014), an accumulation of particle film on aphid body parts and especially on tarsi occurs, suggesting restricted aphid mobility (Cottrell et al., 2002) and repellency (Barker et al., 2007). The particle film can even increase mortality and reduce oviposition (Glenn et al., 1999; Cottrell et al., 2002; Burgel et al., 2005). In autumn 2019 with a denser kaolin residue and a higher assessment frequency than in autumn 2020, there was a significant difference in unwinged and winged aphids between trees treated with kaolin and control trees. However, in both assessment years, trees treated with kaolin in autumn had significantly less aphid colonies in the following spring than control trees (Figures 2A&B). The effectiveness early in the season was 77-95 %, but further assessments in 2021 revealed a decline as the aphid colonies continued to reproduce (Figure 2D).

Five days after the application, paraffin oil showed no significant effect in both years (Figures 2A&B), but further assessments 10 to 25 days after application in 2021 revealed increasing efficacy up to 83 % (Figure 2D). The mode of action of paraffin oil is due to a thin oil coating over the winter eggs shortly before hatching, when the embryos have an increased oxygen demand because of enhanced metabolism. The embryos suffocate under the thin oil coating (Cranshaw, 2005). Paraffin oil could also block the young aphid's syphons. Therefore, the right timing of application is crucial. The effect of the spring oil application is not immediate, but rather takes a couple of days. The combination of kaolin applications in autumn with a paraffin oil application in spring had an efficacy of 86-99 % and prolonged the effect of kaolin (Figure 2). As the white residue on leaves in autumn does not harm photosynthesis, assimilation or transpiration (Glenn et al., 1999; Glenn and Puterka, 2005) and since kaolin is not toxic to beneficial arthropods, kaolin applied in autumn is promising to control *M. cerasi* in organic cherry production.

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