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Optimized control of pear Psylla (*Cacopsylla pyri*) in function of their dynamics predicted by climate-driven phenological modelling

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Abstract

Pear suckers (Cacopsylla sp. or pear Psylla) (Hemiptera: Psyllidae) are a major pest of pear orchards worldwide. Both nymphs and adults of feed on pear tree phloem, with nymphs causing pronounced leaf curling, honeydew secretion, and sooty mold development, thereby reducing photosynthetic efficiency and fruit quality. Heavy infestations can lead to defoliation, reduced yields, and even tree decline due to the transmission of Candidatus Phytoplasma pyri, the causal agent of pear decline. A temperature driven model forecasting the dynamics and populations structure (subsequent generations of eggs/larvae/adults) of Pear Psylla was used to optimize timing of control sprayings targeting specific life stages of the pest. The outcomes of this study demonstrate that the treatment performances of kaolin clay and paraffin (mineral) oil are highly dependent on phenology (natural dynamics) of the first generation pear Psylla. By using the prediction phenology model's decision support (with weather forecasts for the near future), growers can determine in advance whether the pear Psylla phenology/dynamics are suitable for treatments with kaolin clay and/or paraffin oil, and if so, when optimal spraying times can be scheduled.

Keywords: pear psyllids, kaoline clay, paraffin (mineral) oil, phenology prediction model

Introduction

Pear suckers (*Cacopsylla* sp. or pear Psylla) (Hemiptera: Psyllidae) are one of the most economically important insect pests of pear (*Pyrus communis* L.) in temperate regions (Horton et al., 1992; Belien et al., 2017). Both nymphs and adults feed on the phloem, extracting assimilates and injecting phytotoxic saliva that interferes with normal physiological processes of the tree. Feeding causes leaf curling, chlorosis, and the excretion of honeydew, which fosters the development of sooty mold fungi, reducing photosynthetic activity and fruit marketability (Hodkinson, 2009). Severe or chronic infestations can result in reduced tree vigor, defoliation, and the transmission of '*Candidatus* Phytoplasma pyri', the causal agent of pear decline (Belien et al., 2013; Jarausch et al., 2019).

In organic production systems, management of pear Psylla is particularly challenging due to restrictions on synthetic insecticides. Consequently, control strategies emphasize ecological and preventive approaches, including the conservation and augmentation of natural enemies, such as predatory bugs (*Anthocoris/Orius* sp.), earwigs (*Forficula auricularia*), velvet mites (*Allothrombium* sp), lacewings (Chrysopidae), and lady beetles (Coccinellidae) (Dib et al., 2016; Daniels et al., 2017); and cultural practices such as pruning to improve canopy aeration and reduce overwintering sites (Horton et al., 2007). In addition, growers can intervene by spraying with kaolin clay and paraffin oil to prevent egg laying and egg hatching/nymphal survival, respectively (Markó et al., 2008, Nottingham et al., 2022). This requires continuous monitoring in order to time the interventions based on pest phenology, which is essential to maintaining psylla populations below economic thresholds while preserving orchard biodiversity (Belien et al., 2019; Reeves et al., 2025). Climate-driven phenological model predictions are a valuable decision support tool in this regard (Belien et al., 2017; Reeves et al., 2025), and therefore we investigated the impact of model-predicted

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dynamics of pear Psylla on the effectiveness of control sprayings with kaolin and paraffin oils.

Material and Methods

Pear psyllid phenology was predicted using the temperature driven model for forecasting the dynamics and populations structure (eggs/nymphs/adults) of pear Psylla based on the model earlier developed by Schaub et al. (2005), programmed in R software (Belien et al., 2017; R Core Team, 2023; Reeves et al., 2025). This model relies on a time distributed delay and uses hourly temperatures with a microclimate correction to predict egg, nymph and adult percentage abundance for the first two generations of pear psyllid, with a start date of 01 Jan. The termination of diapause in psyllid females was based on a Weibull distribution and was dependent on the time spent above the thermal threshold (3.5 °C) (Schaub et al., 2005). For winter-form females where diapause had been terminated, oviposition commenced thereafter. For summer-form females, a preoviposition period of 10 days was taking into account. Oviposition was age-specific, and the cumulative oviposition density reached a value of 1. The developmental rates of eggs and nymphs, as well as adult aging, exhibited a linear dependence on temperature, following the slopes and threshold values reported by Schaub et al. (2005).

Efficacy field trials were carried out in pear orchards (cultivar Conference) in the Belgian fruit growing area around Sint-Truiden, according to EPPO standards, following the guidelines as described in PP1/44(2) '*Cacopsylla* spp.'. All trials were set up in a fully randomized block design (within each block the different trial objects mixed in an aselect way), with 4 replicates (minimum 5 trees/plot) and the untreated control included. Trees were sprayed with a motorized knapsack sprayer (Type Stihl, model SR 420/430). Number of eggs, young larvae (1-3rd nymphal stages) and old larvae (4-5th nymphal stages) were assessed on at least 10 marked shoots or 25 random flower buds per plot, and assessments took place before, 1-3 days after and 7-14-21 to 24 days after application. Control efficacies were calculated according to the Abbott formula (Abbott, 1925) or Henderson-Tilton (when the initial population (precount) was considered not homogeneous) (Henderson & Tilton, 1955). For this study trials on the first generation (G1) pear Psylla were selected from 2016 until 2025, with spraying applications with kaolin clay (product Surround crop protectant 950 WP, 20.0 kg/ha LWA (=Leaf Wall Area) targeting the overwintering adults (preventing oviposition G1 eggs), and with paraffin oil (products Vernotex 850 EC/Oviphyt 817 EC, 6.2 l/ha LWA) targeting the hatching G1 eggs and G1 nymphs. For each trial year, the timing of treatment was analysed in relation to the simulated dynamics of pear Psylla. Here, we distinguished between years in which treatments were carried out on sharp G1 eggs-nymphs waves (with steep increases (≥10% within 3 days) of eggs-nymphs) on the one hand, and years with long flat G1 eggs-nymphs waves (without steep increases of eggs – nymphs) on the other hand.

To evaluate statistical differences between experimental years, efficacy data (percent control) were subjected to the non-parametric Kruskal–Wallis test using "year" as a factor. When a significant effect was detected ($p < 0.05$), efficacy data were further subjected to non-parametric analysis by performing the Kruskal–Wallis with the "G1 dynamics" considered as a grouping factor (group 1 consisting of years with sharp G1 egg-nymphs waves vs group 2 with years long flat G1 egg-nymphs waves), followed by Dunn's post-hoc test with Holm's correction. All statistical analyses were conducted using R software (R Core Team, 2023).

Results

Statistical comparison of control efficacy rates of treatments with kaolin clay and paraffin oil against the overwintering/first generation pear psyllids revealed a significant effect of the trial year on treatment efficacy ($\chi^2 = 59.33$, df = 8, $p = 6.30 \times 10^{-10}$), indicating that control effectiveness varied significantly among years. Subsequently, based on the G1 pear Psylla model simulated dynamics two types of years were distinguished (see Table 1):

- years with treatments just before steep increases of eggs-nymphs (≥10% within 3 days) and overall sharp G1 eggs-nymphs waves (see Figure 1A)
- years with overall long flat G1 eggs-nymphs waves in which treatments could not be applied just before steep increases of eggs-nymphs (see Figure 1B)

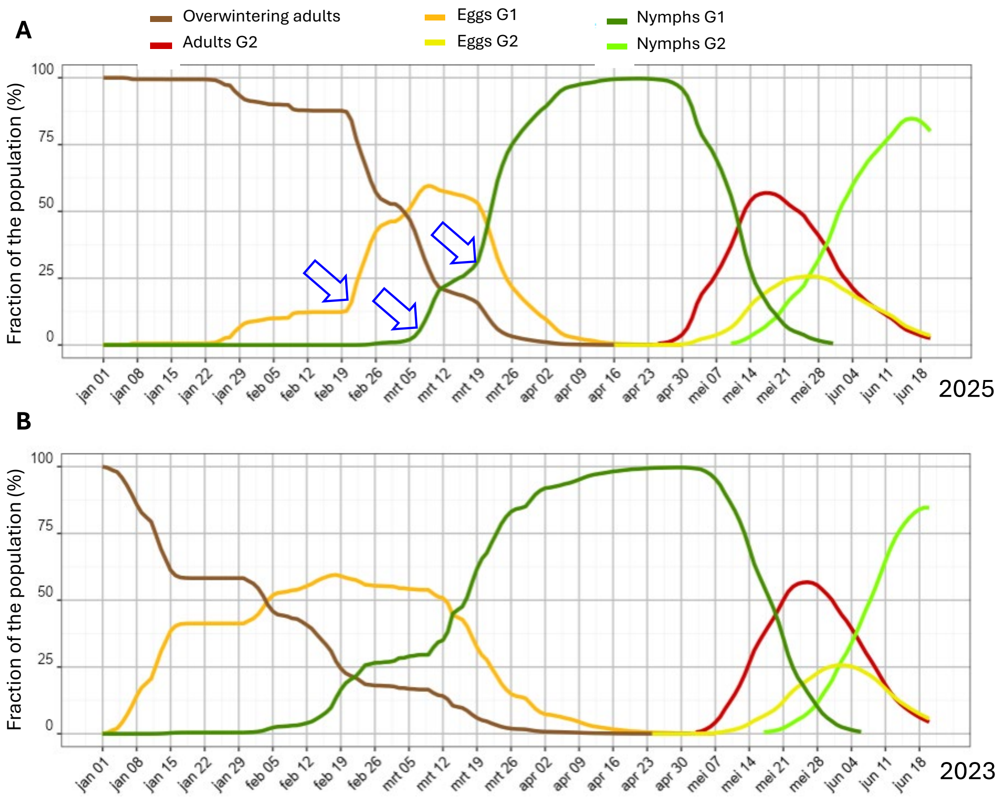

Figure 1: Simulated dynamics of pear Psylla based on temperature data of weather station at pcfruit trial orchard in Sint-Truiden in 2025. The different coloured lines represent different life stages in the first (G1) and second (G2) generation, as indicated in the legend on top of the graph. A) 2025: sharp waves with steep increases of G1 eggs-nymphs. The blue arrows point to the steep increases of eggs-nymphs in the overall relatively sharp waves. B) 2023: long flat waves of G1 eggs-nymphs without steep increases.

Further comparative analysis between both group of years (2019–2020–2022–2024–2025 vs. 2016–2018–2021–2023) showed a highly significant difference between the groups ($\chi^2 = 44.05$, df = 1, $p = 3.19 \times 10^{-11}$).

Kaolin clay treatments resulted in a mean assessed control efficacy of 77.5 % in years with sharp G1 eggs dynamics, which was 24% higher than the mean efficacy of 53.4 % reached in years with a long, flat G1 eggs wave, and this difference was statistically significant ($p = 0.00242$) (Figure 2A). In case of paraffin oil treatments, more than 38% higher control efficiency was achieved in years with steep eggs hatching increases (relatively sharp G1 nymphs wave) (80.3 % vs 42.0 %, respectively), which also differed significantly from years characterised by a long flat G1 nymphs wave ($p = 4.95 \times 10^{-8}$) (Figure 2B).

Table 1: Overview of field trial treatments with kaolin clay or paraffin oil on the first generation (G1) pear Psylla, with indication of the G1 eggs-nymphs dynamics as simulated by the prediction model.

Year	Number of G1 trial-treatments with efficacy results	Sharp G1 eggs-nymphs waves with steep increases of eggs-nymphs	Long flat G1 eggs-nymphs waves without steep increases of eggs-nymphs
2016	8		x
2018	35		x
2019	2	x	
2020	5	x	
2021	8		x
2022	10	x	
2023	2		x
2024	11	x	
2025	3	x	

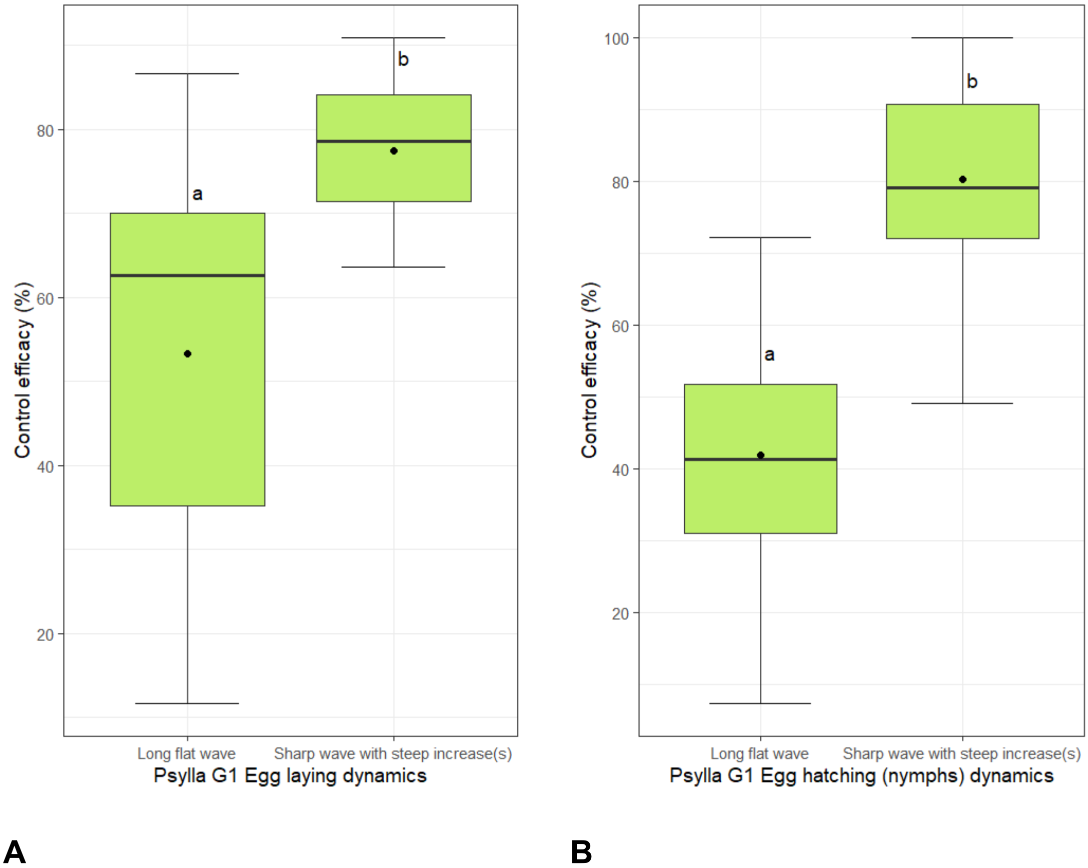

Figure 2: Boxplots showing the control efficacy (%) of kaolin clay (A) and mineral oil (B) treatments under different G1 pear Psylla dynamics. Boxes display the interquartile range (IQR) with medians and means indicated by black horizontal lines and dots, respectively. Whiskers displayed as error bars extend to 1.5×IQR.

Discussion

The outcomes of this study indicate that the treatment performances (control efficacy rates) of kaolin clay and paraffin oil are highly dependent on phenology (natural dynamics) of the first generation pear Psylla. Kaolin clay is most effective against pear Psylla when applied before the peak oviposition period (Puterka et al., 2005; Nottingham et al., 2022). Its primary mode of action is to deter egg-laying in pear trees rather than directly kill adults (Belien et al., 2013). Therefore, in years with relatively short periods with steep increases of egg-laying activity, clearly higher impact on the psyllid population can be achieved by utilising these optimal treatment times. In years with long flat egg laying dynamics such optimal spraying moments are lacking, and consequently lower overall control effects are achieved. Likewise, horticultural paraffin oil treatments are considerably more effective in years when the egg-hatching period of pear psyllids is relatively short and intense, because their primary mode of action is the prevention of egg-hatching (suffocation of eggs and young nymphs) (Puterka et al., 2005), making timing just prior to or at the onset of (intense) egg-hatching periods critical for optimal efficacy. In conclusion, by using the prediction phenology model's decision support (with weather forecasts for the near future), growers can determine in advance whether the pear Psylla phenology/dynamics are suitable for treatments with kaolin clay and/or paraffin oil, and if so, when optimal spraying times can be scheduled.

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