Cite as: Siffert, A., Egger, B., Boutry, C., Baumgartner, F., Lucas-Barbosa, D., Suard, T. (2026). Evaluation of pyroligneous acid products as a potential repellent of *Drosophila suzukii* in Swiss organic cherry and raspberry production. *Proceedings of the 22nd International Conference on Organic Fruit-Growing*, Filderstadt 2026.02.23-25. Ed. FOEKO e.V. 2026: 235-240

Evaluation of pyroligneous acid products as a potential repellent of *Drosophila suzukii* in Swiss organic cherry and raspberry production

A. Siffert[1], B. Egger[2], C. Boutry[1], F. Baumgartner[1], D. Lucas-Barbosa[1, 3, 4] and T. Suard[1]

Abstract

Drosophila suzukii, commonly called spotted wing drosophila (SWD), is an invasive fruit fly that poses a major threat to red fruits crops in Switzerland. In organic farming, crop protection options against SWD are limited. Recently, pyroligneous acid, also commonly called wood vinegar (WV), has been proposed as a potential repellent against SWD. Here, we tested a bamboo-derived product (Karrikin®) and a mixed-wood product (PyGrow®), for their repellent activity against SWD under laboratory and field conditions. PyGrow® showed no repellent effect in either laboratory or field tests. Karrikin® repelled flies in laboratory tests but showed insufficient field efficacy and will therefore not be pursued further by FiBL[1].

Keyword: *Drosophila suzukii*, wood vinegar, pyroligneous acid, raspberry, cherry.

Introduction

SWD is an invasive fruit fly spreading from Asia since 2011, that oviposits in ripening fruits leading to fruit collapse. SWD aims undamaged fruits, whereas Switzerland native *Drosophila* species typically lay eggs in an already damaged fruit. This behavior results from ovipositor differences, with only SWD females having the dented structure that cuts through the fruit epidermis (Atallah et al., 2014). SWD arrival in Switzerland caused significant economic losses in berry and stone fruit production (Knapp et al., 2021). Although anecdotal evidence has suggested that WV may have repellent effects on SWD, scientific validation has been lacking so far. WV is a by-product of pyrolysis of lignocellulosic biomass (Tiilikkala et al., 2010). It contains mainly organic acids, phenolics, and alcohol, all contributing to potential biocidal activity. According to Walse et al. (2018), wood vinegar at concentrations between 0.001-1% can repel pests such as *Amyelois transitella* and *Diaphorina citri*. The repellent effect is attributed to volatile organic acids and phenolics interfering with host-finding and oviposition cues. This trial evaluates the potential use of WV to reduce SWD infestation in red fruit production.

Materials and Methods

Insect rearing: A banana-based oviposition medium was used (1300 g organic peeled bananas, 3087 ml tap water, 65 g agar, 162.5 g yeast, 97.5 g wheat flour, 65 g sugar, 13 g Nipagin, 100 ml 70% ethanol). Adults were supplied with honey and water. Flies were maintained at 25°C and 60% relative humidity under a 16:8 h light/dark cycle. SWD adults were obtained from CABI (Delémont, Switzerland), and subsequent

[1] Research Institute of Organic Agriculture (FiBL), CH-5070 Frick, thierry.suard@fibl.org
[2] Agroscope, Extension Obstbau, CH-8820 Wädenswil
[3] Institute of Parasitology, National Centre for Vector Entomology, Vetsuisse and Medical Faculty, University of Zürich, CH-8006 Zürich
[4] Department of Environmental Sciences, Plant Ecology and Evolution, University of Basel, CH-4001 Basel

rearing was carried out at the Research Institute of Organic Agriculture (FiBL, Frick, Switzerland).

Test products**:** Two commercial WV were evaluated: Karrikin® (pyrolysis temperature 340°C, DeNatura Ltd. Bockhorn, Germany) and PyGrow® (pyrolysis temperature 280°C, Carbonzero, Seneca Farms Biochar LLC New York, USA).

Two-choice assays with PyGrow® and Karrikin®: "No-choice" assays were conducted to test the residual toxicity of the 2 WV products on fruit fly survival. Bioassays were performed in Plexiglass cylinders (10 × 15 cm) containing either 4 banana-medium cubes (0.5 × 0.5 × 0.5 cm) or blueberries sprayed with undiluted WV or water, plus a water pad to maintain humidity. SWD (5 males, 5 females) were introduced into each cylinder, and mortality was recorded daily for 4 days, with 6 replicates per treatment (for blueberries). 7 days later, offspring were counted (eggs in blueberries and adults emerging from the banana medium).

Two "choice assays" were conducted to assess the repellence or attraction of the products. A rearing cage (45 × 45 cm) contained two plastic trap cups filled with an attractant mixture (apple vinegar 1/3, water 3/4, wine 2 tbsp, sugar 2 tbsp) and was placed inside a PhotoBox (PULUZ Technology Limited, Shenzhen, China) to avoid behavioral bias. Before releasing 20 starved SWD (mixed sexes) for 4 h, the cup rims were dipped in either WV or water (control). After 1 h, the number of SWD on the cups, inside the liquid, or within 10 cm of the cup was recorded as their preferred choice. Cup positions were rotated between repetitions. Each treatment had 8 replicates.

PyGrow® and Karrikin® treated fields**:** 3 experimental sites on organic and IP farms were selected for high-stem cherries, low-stem cherries, and raspberries. The following treatments were applied:

<u>High-stem cherries:</u> To test the repellent effect of Karrikin® under field conditions, trees were sprayed with Karrikin® 0.3% (300 l/ha spray mixture or 3 l per tree), with untreated trees as controls. Applications were made with an air-blast sprayer 2-3 times to 8 trees per variety during ripening (21.05.2025 and 04.06.2025 for Kordia, Langstieler, Weber Sämling, Schauenburger, Star, Dollenseppler (DE/CH), and additionally on 16.06.2025 for Dollenseppler (DE/CH) and Schauenburger). 8 trees remained untreated. 50 fruits were collected on 20.06.2025 and 27.06.2025 and subjected to a salt test (10% salt solution, 4 h incubation at RT (25-28°C). Larvae emerging from fruits were recorded for each variety. This assay was conducted at Alpbad Farm, Sissach (CH; 47.480043 N, 7.807211 E).

<u>Raspberries:</u> To test the repellent effect of PyGrow® under field conditions, PyGrow® 1-10% (333 l/ha spray mixture), Whitewash 3% ($Ca(OH)_2$) (500 l/ha spray mixture), and a control were applied. 3 raspberry rows were treated weekly from July to September 2025 following a 3-treatment rotation (1 = control, 2 = PyGrow®, 3 = Whitewash). Each treatment plot (8.3 m) was replicated 6 times along all rows (18 plots total; ~18 ares). 50 fruits per plot were collected each round. When fewer fruits were available, counts were scaled up. Fruits were incubated for 25 days at RT (25-28°C), and emerging adults were counted to determine infestation. Samples were taken only from the middle row to avoid edge effects. This assay was conducted at Kugelhof Farm, Steinebrunn (CH; 47.534541 N, 9.339477 E).

Low-stem cherries: To test Karrikin® as an insecticide against SWD, low-stem cherry trees (var. Kordia) were sprayed with Karrikin® 0.3% (400 l/ha spray mixture), with untreated controls. 2 applications were made starting at BBCH 81, 7 days apart. The assay was repeated 4 times with 5-8 trees per replicate. 7 days after the last application, 50 fruits were collected. SWD eggs were counted under a stereomicroscope. Fruits were then immersed in 10% salt water and incubated 14 h at RT (25-28°C), and emerging larvae were counted. This assay was conducted at Breitenhof Farm, Wintersingen (CH; 47.49713 N, 7.81330 E).

Statistical analysis

SWD adult counts from field and lab assay were submitted to standard two samples and Welch's t-tests ($\alpha = 0.05$).

Results

Residual toxicity has a repellent effect on SWD

In the lab, we performed 3 "no-choice" assays to monitor the toxicity and the repellent effect of both WV. In the toxicity test, none of the WV had a toxicity effect as flies survived for five days without any significant abnormal death rate (2.2%) (data not shown).

To get further information about SWD egg deposition, we exposed them to two additional different "no-choice" assays. In the first one, the number of SWD flies that emerged from the Karrikin® treated banana-medium decreased in comparison to the control (water) and the PyGrow® treatments (Fig. 1a). In the second assay, in which blueberries were used, we could not see any decrease or increase (Fig. 1b).

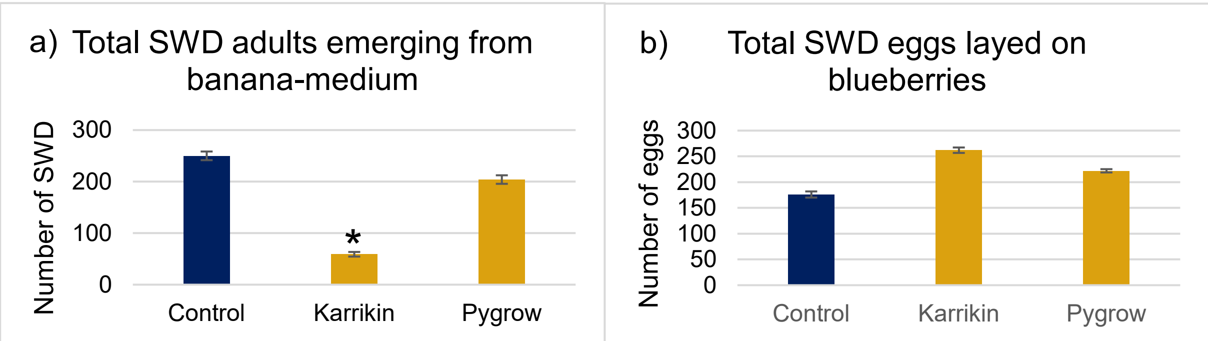

Figure 1: Number of SWD that resulted from a) banana-medium as adults, b) blueberries as eggs across 6 replicates. Error bars represent ± standard error. Standard T-test compared to control treatment for PyGrow® and Karrikin® ($P < 0.01$).

In choice assays, Karrikin® showed a repellent effect with 43.75% (± 0.72%) of flies gathering on or near the untreated cup and 21.87% (± 1.18%) gathering on the WV treated cup (*P* = 0.008) (Fig. 2a). Other flies were non-responsive or died during the assay. For PyGrow®, no difference between treated and untreated cups (*P* = 0.763) could be observed, the flies being more distributed between the treated and untreated cups (Fig. 2b).

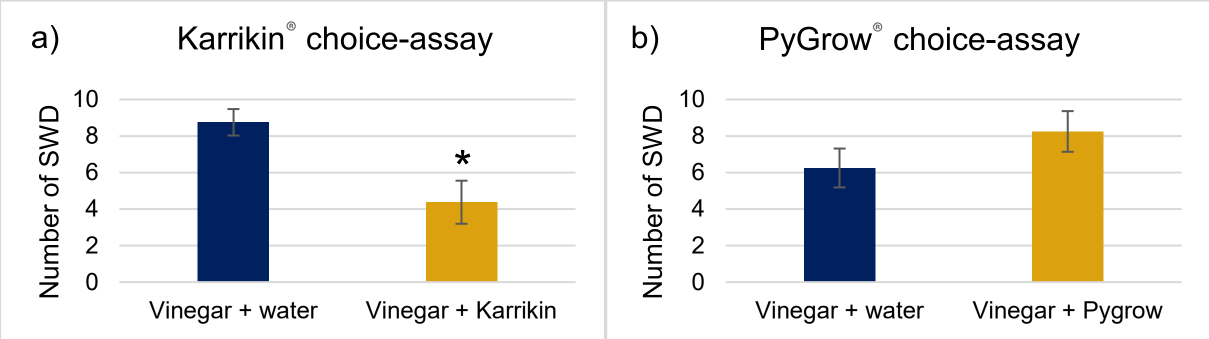

Figure 2: Mean number of SWD that choose a vinegar mix untreated or treated across 8 replicates. a) Karrikin® treatment, b) PyGrow® treatment. Error bars represent ± standard error. Standard T-test compared to control treatment for PyGrow® (*P* > 0.05) and Welch's T-test for Karrikin®, *P* < 0.01).

Efficacy in the field

For field assays, Karrikin® was used on cherries and PyGrow® on raspberries, as the two VW products have different reported properties. In the first cherry collection, larval numbers were low (0–20), whereas the second collection showed higher infestation (81–100). A trend toward reduced infestation was observed in Karrikin®-treated high-stem cherry trees, but the number of replicates was too small to determine statistical significance (Fig. 3).

For low-stem cherries, similar patterns were observed. Seven days after the final Karrikin® treatment, larval numbers were lower in treated trees than in controls (Fig. 4a), but high variance across the four repetitions prevented statistical significance (P= 0.219). The proportion of infested fruits remained unaffected, 100% contained SWD larvae (Fig. 4b).

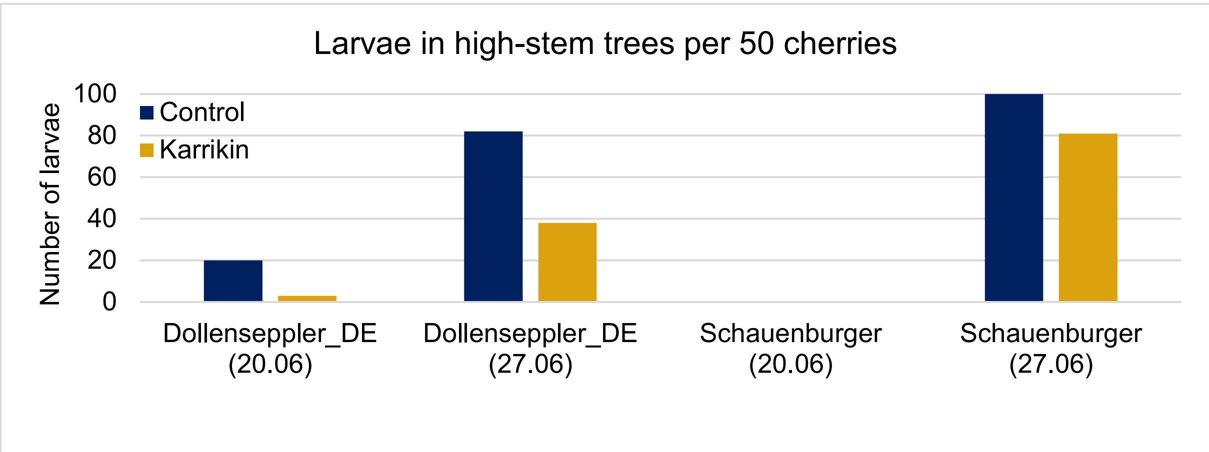

Figure 3: Number of larvae of SWD in cherries after sampling round 1 (20.06.2025) and 2 (27.06.2025) for the high-stem trees. DE: German variety. As only one tree per variety and treatment was available, no repetition was possible, and statistical testing could not be performed.

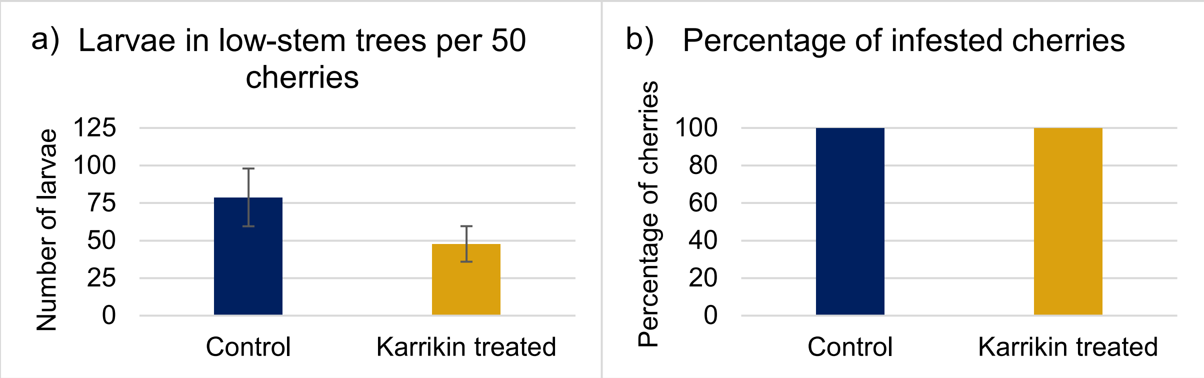

Figure 4: a) Number of larvae of SWD per 50 fruits seven days after the last Karrikin® treatment. n=50, T-test (*P* > 0> 0.05). b) Percentage of infested cherries seven days after the last Karrikin® treatment n=50.

In the raspberry field, PyGrow® (*P* = 0.346) nor higher concentration of PyGrow (*P* = 0.571 for 5%, *P* = 0.478 for 7.5%, and *P* = 0.559 for 10%) nor whitewash (*P* = 0.851) reduced adult SWD numbers compared with the untreated control (Fig. 5).

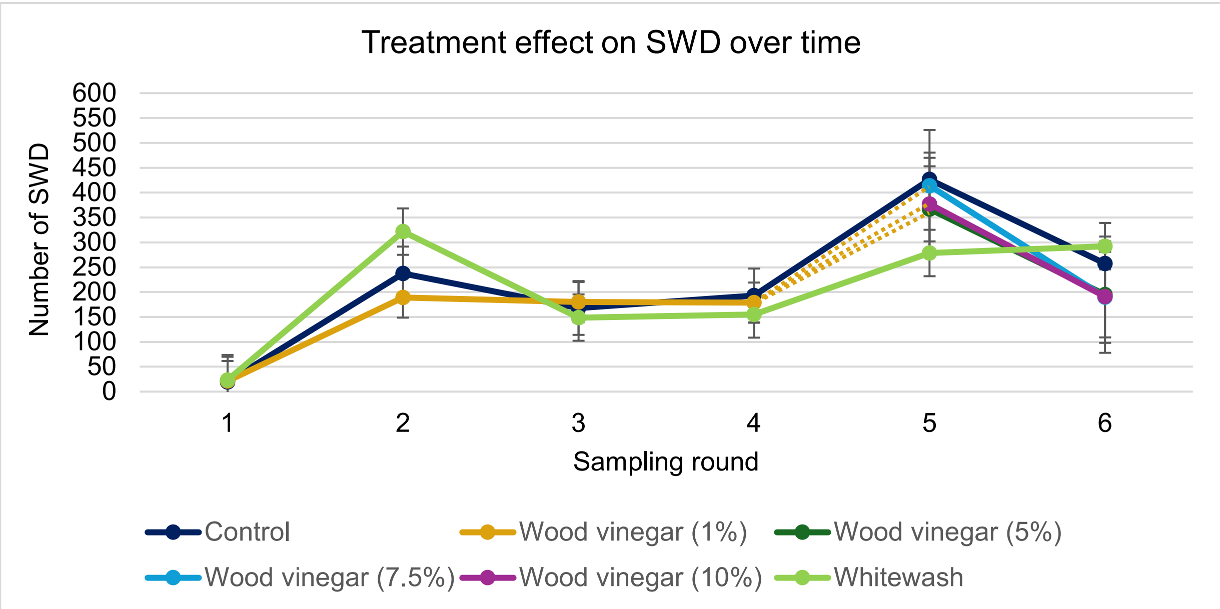

Figure 5: Mean of SWD adults per 50 raspberry fruits after incubation under different treatments (control, whitewash, and WV (PyGrow®) 1 to 10%) across 6 sampling rounds. The dotted yellow line represents the putative line between sampling 4 and 5. Error bars represent ± standard error. T-test compared to control treatment, *P* > 0.05.

Discussion

The trials provide comparative evaluations of bamboo (Karrikin®) and mix wood-based (PyGrow®) WV against SWD under Swiss organic production conditions and in laboratory conditions. PyGrow® showed no repellent effect in the lab as in the field. Karrikin® showed repellent effect in the lab whereas in the field only a trend toward reduction was observed. These results contrast with previous reports of pyroligneous acid efficacy in other crops (Walse and Woelk, 2018). Species differences and growing conditions may explain the discrepancy. The trial in the low stem cherry was designed to test for insecticidal activity of the product. It is still to be tested if Karrikin® may exhibit higher repellence efficacy under low SWD pressure and in larger cherry plots, that might be more suitable to test for repellent effects by respecting SWD mobility between differently treated trial plots. WV composition is highly variable, influenced by pyrolysis temperature, feedstock, and condensation method (Tiilikkala et al., 2010). It is likely that PyGrow® promotes microbial balance and plant vigor rather than acting as a repellent. Phenolic and organic acid fractions may degrade under field conditions, reducing activity. Nevertheless, Karrikin®'s repellence could relate to karrikinolide volatile molecules (Kirchberger 2024).

According to literature, WV has a phytotoxic effect when applied at dosage up to 5% (Leifeld and Walz, 2025). The used concentration was 0.3% in cherry orchards. We can imagine applying a higher concentration and potentially reaching higher efficacy without necessarily damaging the plants. However, higher concentrations mean higher costs too. In summary, Karrikin® shows insufficient field efficacy and will therefore not be pursued further by FiBL.

Acknowledgements

We kindly thank the farmers Michael Kugler and Johannes Hostettler, who provided their orchards and participated in the trials. We thank Francis Mulligan and the Agroscope Steinobstzentrum Breitenhof team for their help in the field. We appreciate the collaboration with DeNatura and Carbonzero which provided the two different wood vinegars.

References

Atallah, J., Teixeira, L., Salazar, R., Zaragoza, G., Kopp, A., 2014. The making of a pest: the evolution of a fruit-penetrating ovipositor in Drosophila suzukii and related species. Proc. R. Soc. B Biol. Sci. 281, 20132840. https://doi.org/10.1098/rspb.2013.2840

Knapp, L., Mazzi, D., Finger, R., 2021. The economic impact of Drosophila suzukii: perceived costs and revenue losses of Swiss cherry, plum and grape growers. Pest Manag. Sci. 77, 978–1000. https://doi.org/10.1002/ps.6110

Leifeld, J., Walz, I., 2025. Pyroligneous Acid Effects on Crop Yield and Soil Organic Matter in Agriculture—A Review. Agronomy 15, 927. https://doi.org/10.3390/agronomy15040927

Tiilikkala, K., Fagernäs, L., Tiilikkala, J., 2010. History and Use of Wood Pyrolysis Liquids as Biocide and Plant Protection ProductHistory and Use of Wood Pyrolysis Liquids as Biocide and Plant Protection Product. Open Agric. J. 4, 111–118. https://doi.org/10.2174/1874331501004010111

Walse, S.S., Woelk, M.R., 2018. Pyroligneous acid insect repellent. US20180184652A1.