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Kaolin against *Scaphoideus titanus* as an alternative to natural pyrethrins in Swiss vineyards?

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Abstract: In Switzerland, natural pyrethrins are currently the only registered insecticide to control the leafhopper *Scaphoideus titanus*, the main vector of grapevine Flavescence dorée, in commercial vineyards. In order to find alternative products against this insect, we tested the effectiveness of kaolin, a white inert aluminosilicate mineral, in 11 independent field trials over four consecutive years from 2018 to 2021. The use of kaolin at rates between 20 and 40 kg/ha applied two to three times at the beginning of hatching resulted in an average reduction in leafhopper densities of 36.8 % with efficacy values ranging from 0 to 88.9 % for the 18 different interventions. Overall, the efficacy of the different kaolin dosages and application strategies did not equal those commonly recorded for natural pyrethrins, which showed a mean efficacy of 74.8 % in 6 independent field trials with reduction values ranging from 41.3 to 97.4 %. In view of the highly variable efficacy levels of kaolin observed in our assays, we conclude that the use of kaolin to control *S. titanus* in Swiss vineyards does not provide an efficient alternative to natural pyrethrins in compulsory control areas.

Key words: *Vitis vinifera*, Cicadellidae, grapevine yellows, elm yellows group (16SrV), transmission, IPM, alternative control

Introduction

The leafhopper *Scaphoideus titanus* is the main vector of grapevine flavescence dorée (FD). This phytoplasma is classified as a quarantine disease. When the insect and the disease are present in the same vineyard, the only direct control method, apart from uprooting diseased vines, is the use of insecticides to combat the vector in order to limit transmission of the disease to healthy vines. Currently insecticides based on natural pyrethrins are the only active ingredient registered in Switzerland. They are used in all production schemes, but present risks to bees, aquatic organisms and a range of beneficials. To overcome these nontarget effects as well as reducing the risk of the emergence of resistance, various alternative products were tested in France and Italy (Constant and Lernould, 2014; Tacoli et al., 2017 a; Prazaru et al., 2023). In particular, kaolin, an inert white aluminosilicate stone powder, showed an interesting potential.

Referring to a recent scientific publication (Linder et al., 2023), we present here the main results obtained by Agroscope with this stone powder in the diverse field trials conducted in Switzerland between 2018 and 2021.

Materials and methods

The trials were conducted in the cantons of Vaud and Valais (Tab. 1). Dosages of kaolin (Surround WP®) varied between 20 and 40 kg/ha. In 2018, treatments targeted the N1 to N2 stages of the vector. From 2019 to 2021, the first treatment targeted the peak of hatching, i. e., the emergence of third nymphal instar. The treatments were applied using backpack sprayers or turbo diffusers, on blocks of 180 to 1700 m^2 without any repetitions at spray volume of 1000 to 1600 l/ha. Visual controls were carried out before the first application and five to ten days after the last. Three to four series of 100 leaves per variant were observed. The *S. titanus* densities of the kaolin variants were compared with those of the untreated controls and/or treatments with natural pyrethrins (Parexan N® or Pyrethrum FS®).

Table 1. Main characteristics of kaolin trials conducted between 2018 and 2021 in Switzerland against *S. titanus.*

Sites (canton)	Varieties	No. of trials	No. of Kaolin treatments	Kaolin applied/ treatment	Kaolin applied/ season
Gland (VD)	Chasselas / Merlot	4	1 to 3	20 to 40 kg/ha	40 to 80 kg/ha
Morges (VD)	Chasselas	3	1 to 3		
Duillier (VD)	Pinot Noir	2	1 to 2		40 to 60 kg/ha
Grône (VS)	Pinot Noir	2	2 to 3		56 to 80 kg/ha

Results and discussion

In 2018, kaolin applied twice showed no sufficient efficacy against *S. titanus* with an average reduction of *S. titanus* of 49.9 % compared to the nontreated control (Figure 1). Three applications, with an average reduction of 46.7 %, were not more effective than two. Overall, two to three applications of kaolin at the start of hatching resulted in an average reduction in leafhopper densities of 48.6 % (min. 13.2 %; max. 84.6 %). In 2019, kaolin applied twice resulted in an average reduction in *S. titanus* populations of 52.9 %. An additional application generally resulted in higher efficacy of 69.1 %. Overall, efficacy ranged from 37.7 % to 88.9 %. In comparison, the efficacy of two applications of pyrethrins reached 80.6 % (Figure 1). In 2020, nearly all interventions did not reach an effective reduction of the vector populations with a mean efficacy of 18.0 %. However, two applications of natural pyrethrins achieved an average vector reduction of 62.8 %, with values ranging from 41.3 % to 77 %. In 2021, two additional trials with kaolin showed no efficacy after two applications (Figure 1), while the average value of natural pyrethrins was 89.6 %.

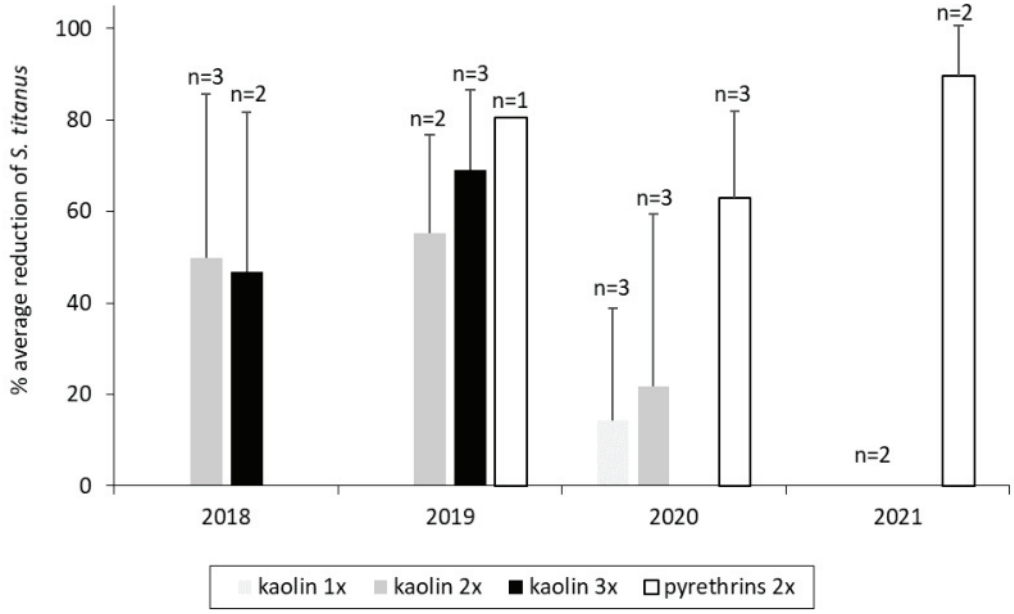

Figure 1. Average efficacy of kaolin and natural pyrethrins in trials conducted from 2018 to 2021 in Switzerland and standard deviation. n = number of trials.

Out of 18 independent interventions conducted between 2018 and 2021, only two showed a satisfactory control higher than 80 %. This level corresponds to the one usually recorded with natural pyrethrins (Gusberti et al., 2008; Constant and Lernould, 2014; Prazaru et al., 2023). However, these results were obtained for low *S. titanus* populations. At higher vector densities, such efficiencies were not any longer achieved (Figure 2). Overall, the efficacy of kaolin decreased with *S. titanus* density (r = -0.60, P = 0.008).

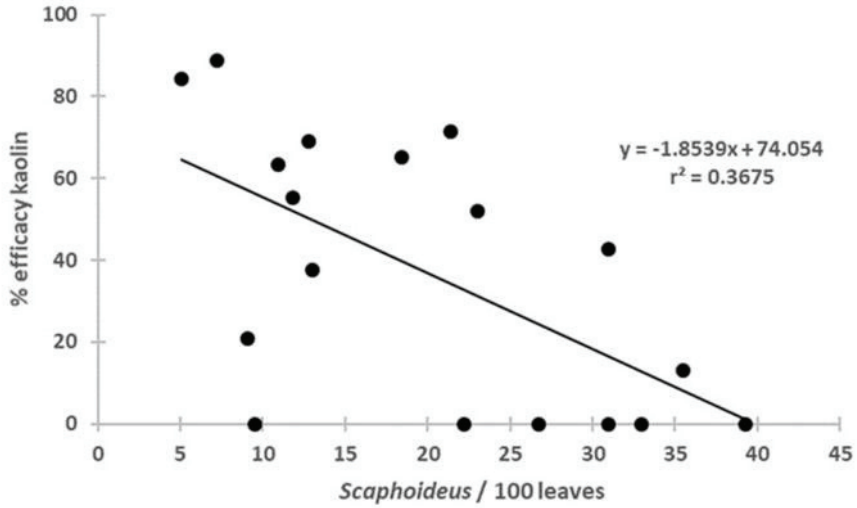

Figure 2. Average efficacy of kaolin in trials conducted in Switzerland from 2018 to 2021 in relation to *S. titanus* density.

Our results agree with those of Constant and Lernould (2014) who also published efficacy values between 0 and 83 % for kaolin. In their trials, four applications of kaolin at 50 kg/ha resulted in a similar control than those of natural pyrethrins. However, in three field trials and with three applications of kaolin at 20 kg/ha, Tacoli et al. (2017a) obtained insufficient efficacy to control the insect. Based on two trials, Prazaru et al. (2023) concluded that among natural insecticides, natural pyrethrins were the most effective with 74 %, while kaolin, with 54 % efficacy, could be used as a complementary active ingredient against *S. titanus* in organic vineyards. Feeding inhibition, which is the main mode of action of kaolin on *S. titanus* nymphs (Tacoli et al., 2017b), therefore appears to be significantly less effective than direct intoxication of individuals with traditional insecticides such as natural pyrethrins. There is a general consensus that the modalities and conditions of application of kaolin must be optimal to ensure a good coverage of the vegetation thereby affecting the feeding of *S. titanus* nymphs. Under the conditions of our trials, and despite careful application, we observed a high variability in efficacy levels. Natural pyrethrins produced, however, more regularly satisfactory results with just two applications. Three applications of kaolin can sometimes achieve this level. However, the lack of efficacy recorded after two treatments means that we cannot rule out the possibility of FD being transmitted before the third application. Overall, the extreme variability in the efficacy recorded for kaolin means that it cannot be considered as an alternative to natural pyrethrins in the mandatory control areas of Swiss vineyards. Yet, there could be fields of application for the use of kaolin. For example, it could help to limit the presence of vectors in regions where the population density of *S. titanus* is low. In addition, kaolin could provide a 'low-risk' alternative in situations where the use of natural pyrethrins, which are toxic to aquatic organisms, is prohibited, such as in buffer zones near to watercourses. Overall, the development of alternative control methods remains a major challenge and must be pursued.

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