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OPTIONS OF INTEGRATED PEST MANAGEMENT (IPM) OF DROSOPHILA SUZUKII

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Abstract

Globalisation and the export- import activities of foods contribute the expansion of invasive species in the world (Tait. et al., 2021). One of these species is the spotted wing drosophila (SWD) (Drosophila suzukii, Matsumara), which is a major threat to berries. Since it has a wide range of host plants and since it is an insect with several generations and a large population, it can cause enormous damage to berries (Wiman et al., 2016, Tait et al., 2021). Our experience shows that in Hungary it causes the most damage to blackberries, but it is also an increasingly common pest in our vineyards. Successful integrated pest management (IPM) can only be implemented by understanding the insect's biological cycle and ecological requirements. It is of paramount importance to strengthen the plants' defence system, avoiding diseases that give the green light to various pest organisms. By spraying salicylic acid, which induces resistance, the berry skin thickness can be increased in the case of thin-skinned grape varieties susceptible to rot (e.g., Rhine Riesling), thereby the insect damage rate can be reduced (Németh et al., 2020). The looser cluster structure by the treatments is also beneficial in preventing spread of the pest. In the current work, we present the results and experiences of the study series for the years 2021-2023.

1 Introduction

The appearance of Drosophila suzukii (Matsumura), the spotted wing drosophila (SWD), dates back to 1916 in Japan. As it is highly adaptable to adverse weather conditions, the species has expanded rapidly in Asia (Walsh et al., 2011, Kirschbaum et al., 2020). Worldwide, we can count on its damage from the 2000s. In Hungary, it has been a major threat in grapes and other berry crops, especially raspberries and blackberries, since 2016. However, it is important to note that Drosophila suzukii has a very large number of host plants, including several wild species.

Unlike the common fruit fly (Drosophila melanogaster), this species has a serrated ovipositor, which allows it to infect not only overripe, damaged fruits, but also damage the skin of completely intact fruits during oviposition, causing enormous economic damage (Lee et al., 2011).

Kanzawa (1939) found in his studies on cherries that up to 13 generations of Drosophila suzukii can develop during the ripening period, causing up to 75% fruit damage. The larvae become imago in about 3-13 days, the pupal stage lasts 3-15 days, usually in the fruit but sometimes in the soil. If crops are rotten or very immature, only 50 percent of the larvae survive to pupate. Experiments by

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Lee et al. (2011) demonstrated that the species is sensitive to fruit maturity. Fruits that were just beginning to colour were mostly infected. Their studies demonstrated that, in addition to different fruit species, cultivars also had a strong influence on where high damage could develop. Typically, the harder-skinned varieties, which are more resistant to fungal diseases, were less affected by SWD.

The basis of the control against Drosophila suzukii is to continuously obtain accurate datas of the presence of the pest and the swarming times during the ripening of the fruits. The most suitable method for this is to place traps with an attractant bait (apple cider vinegar) in the orchard.

The insecticide-based pest control (which can be used in field crop production) is often not safe to use in fruit plantations, because especially with perennial species, the food waiting period cannot be kept in many cases. Tai et al. (2021), Dam et al. (2019), Hussain et al. (2023) point out in their studies that it is an urgent issue to develop an environment-friendly and health-friendly control method against the spotted wing drosophila. They experimented with several methods, of which we will focus on salicylic acid treatment in the following.

Hypersensitive and other necroses trigger the production of salicylic acid in the surrounding plant cells. This is responsible for the activation of systemic acquired resistance. Salicylic acid accumulates in leaves with systemic acquired resistance. The resistance-causing effect of salicylic acid is actually based on the fact that the activity and quantity (glutathione) of antioxidants (superoxide dismutase, glutathione reductase, glutathione-S-transferase) increases in the tissues that accumulate salicylic acid and those treated with salicylic acid. (Király, 2004). Beyond their role in plant development, salicylic acid, jasminic acid and ethylene are also important in the regulation of primary defense responses. In many cases, infection by microbial pathogens and attacks by herbivorous arthropods are associated with increased production of the above-mentioned hormones (Maleck et al., 2000; Reymond et al., 2004; De Vos et al., 2005).

Kraeva et al. (1998) draw attention to the fact that salicylic acid (SA) is a phenolic plant growth-regulating compound that can also be formed endogenously, which can also be considered a growth promoter and is important in the mechanisms for eliminating biotic and abiotic stress effects. It is an important secondary metabolite in grapes and plays an essential role in quality of the grape berry such as colour, flavour, elasticity and bitterness. On the positive side, salicylic acid prevents fruit decay by affecting the activity of key cell wall-degrading enzymes such as cellulase, polygalacturonase and xylanase. Dweck et al. (2021), highlight that Drodophila suzukii has lost 20% of its bitter taste receptors during evolution. If, however, Drosophila suzukii is less sensitive to bitter tastes compared to other Drosophila species, this may explain why it oviposits its eggs in fruits that are in the process of colouring. This is because the levels of certain bitter compounds are higher in the early stages of ripening than later. These results suggest that taste plays an important role in the egg-ovipositing preferences of the pest. Dweck and Carlson (2020), Crava et al (2016), French et al. (2015), Wang et al. (2022) also confirm this. Harindra-Champa et al. (2014) sprayed the grapes with different concentrations of salicylic acid solution in different ripening stage (when the berries were green pea size and when they were in veraison). As a result of the treatment, the clusters became looser, the berries became bigger, and the skin of the berries thickened.

2 Methods

In 2015, National Center for Agricultural Research and Innovation (NAIK), Viticulture and Winery Research Institute in Kecskemét, legal predecessor of the Hungarian Universtity of Agriculture and Life Sciences (MATE), Istitute of Viticulture and Oenery, was contacted by an Austrian-owned company with the request that Hungarian grape growers would also like to learn about their preparations based on plant active ingredients and they would need examinations also in vineyards.

Tests were started in 2016 in treated and control plots of 0.5-0.5 ha. The experimental plot was given ecological plant protection. Traditional plant protection technology was used in the control area.

The primary goal of the study is to examine the effect of a plant conditioning agent (Plantonic) with 3% methyl salicylate, containing only plant active ingredients, on the growing and resistance of grapes. The tests were carried out with Rhine Riesling and Kerner grape varieties. Both grape varieties are also susceptible to gray rot (Botrytis cinerea), powdery mildew (Erysiphe necator), and downy mildew (Plasmopara viticola), so cluster damage caused by pests also occurs more frequently.

The age of the plantations are 27 years. The method of cultivation is medium height Guyot. The growing conditions are made difficult by the loose, structureless, sandy soil with a humus content of less than 1%.

The Plantonic treatments were applied 4 times (3-5 leaf stage, pre-flowering, post-flowering, cluster closure and just before tillering) as part of the plant protection treatments. From 2017, only organic plant protection was applied in the experimental plot. Plantonic was the main component of the plant protection treatments, supplemented with copper, sulphur, potassium bicarbonate and other plant conditioning products.

The control plantation received conventional plant protection treatment. Insects were not controlled in any of the areas. In the vegetation, ratings were carried out continuously to determine the presence of pathogens and traps were set to monitor the occurrence of pests. To trap Drosophila sp., apple cider vinegar was used as bait. Traps were collected weekly, then filtered the Drosophila species were identified by microscopy. Male and female SWD individuals were also separated.

The degree of Botrytis cinerea infection was determined at harvest. In both the treated and control plantations, 20-20 vines were harvested. 10 clusters from the samples were selected, weighed them individually, counted the number of berries per cluster, separated healthy, infected and rotten berries, and then calculated the percentage frequency of infection. The total number of berries per cluster were weighted. The weight of 100 berries, and separately also the weight of the vine stems was also measured. After that, the contents of the berries were analyzed (acid, sugar content, pH value of grape juice).

Data was entered into a spreadsheet and then evaluated statistically. A correlation calculation was made in the treated and untreated stands of each variety, where the data on cluster weight, number of berries per cluster, and clusters infected with botrytis were examined. A regression analysis was made of the different parameters of the treated and untreated varieties.

Since there was obtained normal distribution of the cluster weight and number of berries data, the two-factor analysis of variance was examined for them at the $P_{5\%}$ probability level.

3 Results

The number of berries per cluster (Figure 1) in the treated plots was less for both varieties, but the weight of 100 berries increased compared to the control. Despite the larger berries, the clusters did not become denser. The rate of grey rot infection is reduced (Figure 2).

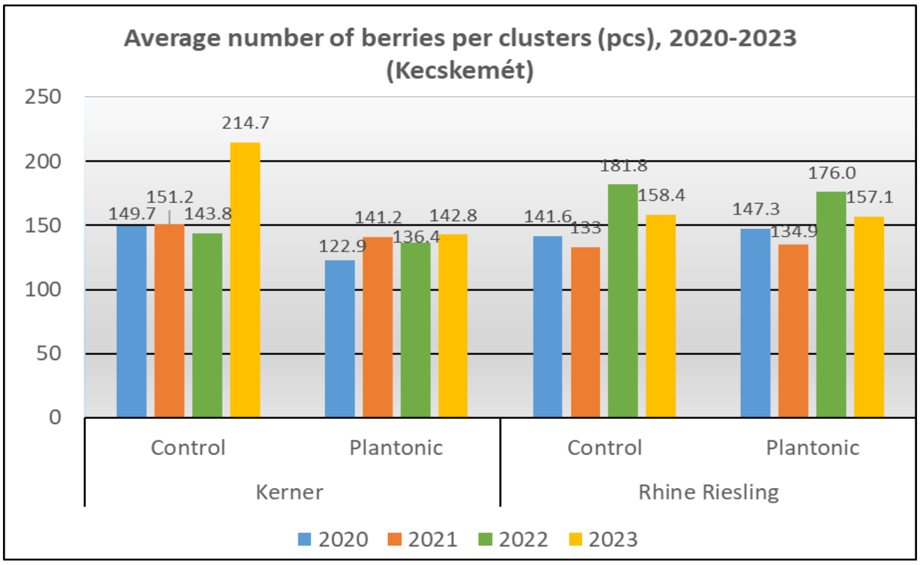

Figure 1. Average number of berries per cluster in treated and control plots (Kecskemét,2020-2023)

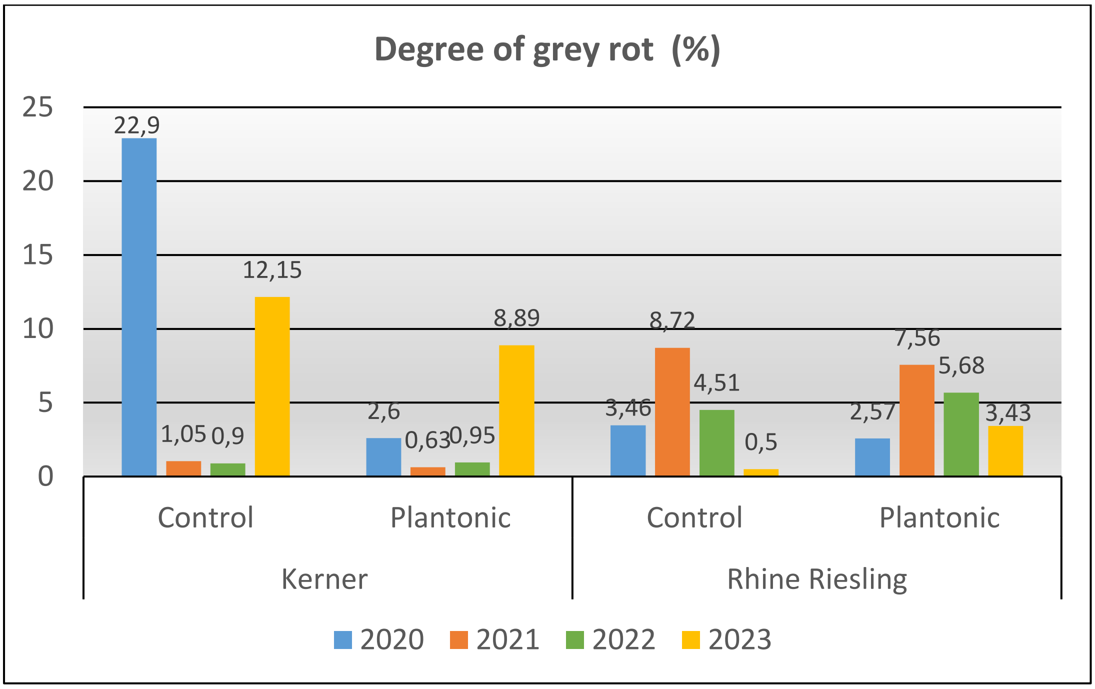

Figure 2 Extent of grey rot in treated and control plots (Kecskemét,2020-2023)

A statistical correlation test was made, which established that there was a close or moderate relationship between cluster weight and number of berries in both treated and untreated plants. However, in the treated areas, cluster weight was somewhat less dependent on the number of berries, which suggests that the treated plants had larger berries, especially in the case of the Rhine Riesling variety. A strong negative correlation was found between the number of berries with botrytis and the number of berries in the case of the treated Rhine Riesling. So, it was proven that the fewer berries with botrytis found within a cluster, the higher the number of berries was.

The regression analysis proved that the Kerner variety shows a closer relationship between the changes of the parameters than the Rhine Riesling. In the control Kerner variety - because of the strong positive interaction between the variables - 84% of the variables explaining cluster weight were explained by the variables of number of berries and number of botrytis berries. However, for the control Rhine Riesling, only a moderate relationship (R^2 = 0.57) was found for the above-mentioned parameters. In both cases, however, there is evidence that a higher number of berries implies a higher cluster weight. However, as the number of botrytis berries increases, cluster weight decreases. On the contrary, in both the treated Kerner and the treated Rhine Riesling varieties it was observed that the increase in the number of botrytis berries did not affect the yield: weight of clusters increased.

A two-factor analysis of variance on the cluster weight data at the $P_{5\%}$ probability level concluded that salicylic acid treatment significantly affected the cluster weight of the plants. Different yields were observed for treated and untreated plants. There was no significant difference between the two varieties tested at the $P_{5\%}$ probability level. In terms of interaction, it can be stated that the treatment does not affect the cluster weight of each variety to the same extent, there is no significant difference, i.e., in this case there is a probability of 87.18% that if there is no interaction, then incidence is the cause of the difference in the sample.

The same test was also carried out for berry number, and at the $P_{5\%}$ probability level, it was found that salicylic acid treatment significantly affected the berry number of the plants. There was a significant difference in berry number between the two varieties studied at the $P_{5\%}$ probability level. When the interaction was examined, it could be stated that the treatment affected the berry number to the same extent for each variety.

The infestation rate of drosophila did not reach the economic damage threshold, so no control was applied. Figure 3 shows the distribution of Drosophila suzukii in treated and control plots.

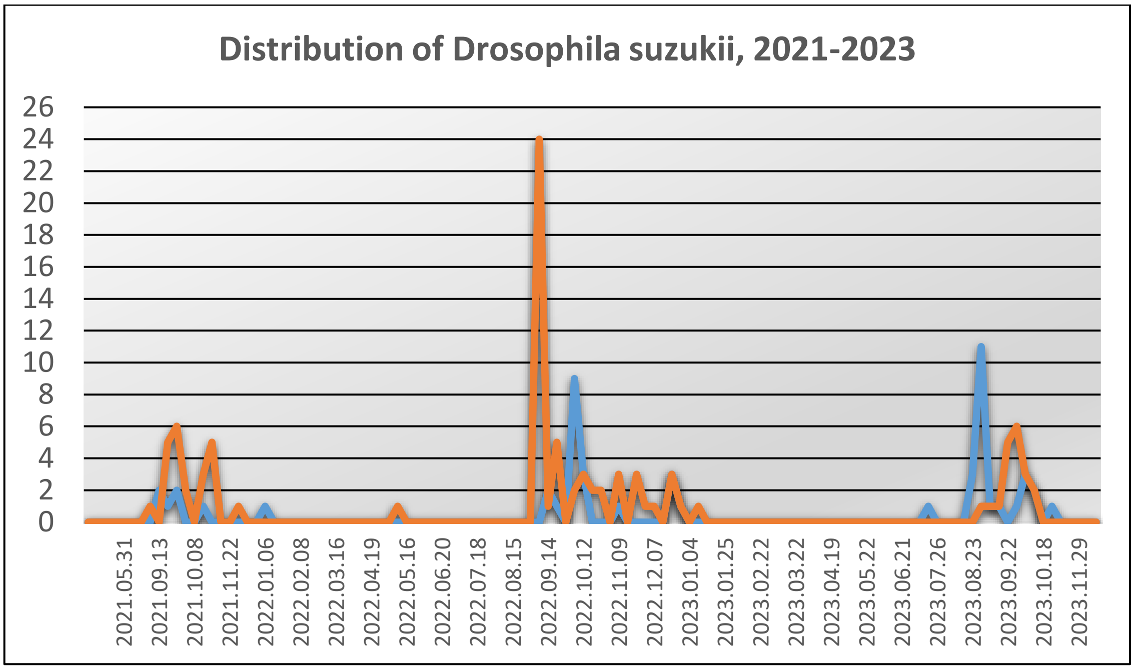

Figure 3 Swarming number of Drosophila suzukii in treated and control plots within years (Kecskemét, 2021-2023) (blue= treated; orange=control)

In 2021 and 2022 there were fewer individuals in the trap compared to the control plot, in 2023 there were more, but not significant, individuals in the trap compared to the control. It was unable to detect the presence of Drosophila suzukii in the clusters that had begun to rot, nor it was not possible to grow it.

4 Conclusions

Based on the experience of previous years, Plantonic was considered as a formulation to enhance the natural resistance of the plant, given that it contains salicylic acid, which is also produced by the plant in increased quantities to prevent stressful situations. Therefore, it was used as a supplementary formulation to fungicides (copper + sulphur + potassium bicarbonate) in the plant protection technology. In the treated plantations, both vine varieties showed thickening of the leaf epidermis, and in the first third of the growing season, plant growth was significantly reduced. As a consequence, the most susceptible period to fungal diseases, from flowering to fruit setting and cluster closure, resulted in an airy, easily drying, less humid microclimate, in contrast to the control plantation

On average over the four years, the percentage of rotten berries in the grape varieties Kerner and Rhine Riesling, which are susceptible to grey rot, decreased significantly, which is a very significant result in terms of harvestability and ripening parameters. The treatment resulted in looser clusters, larger berries, thicker skins, increased weight per 100 berries and significantly reduced rot. The thickening of the berry skin may also have provided physical protection against Drosophila suzukii damage.

In the treated plantation, the intensity of shoot growth was also reduced by salicylic acid treatment. The clusters developed freely in the airy foliage, were not threatened by humidity, conditions were less favourable for the fungal diseases and infestation was reduced. In addition, it could be observed that the leaves became leathery and stronger, the skin of the berries thickened, and their physical resistance moved in a favourable direction.

The statistical studies have also shown that salicylic acid treatment has a positive effect on yield and quality. After performing a two-factor analysis of variance, it can be stated that there was a significant increase in cluster weight of the plants in the treated stand.

Since there is seasonality in the swarming of this species, it is very important to determine when to make pest control against it. Although present days mainly insecticidal methods are used worldwide, it is important to focus on monitoring, prevention and avoiding or at least reducing pesticide use, taking advantage of other natural repellents or natural enemies of Drosophila suzukii, in order to protect the environment and to consider sustainability. For this purpose, researchers are trying to develop several methods. Experiments have been going on in Hungary for several years. Based on the positive results of the trials on grapes since 2015, it can be assumed that salicylic acid treatment may also have a beneficial effect on other berry crops, so from 2024 it will be started trials on other species (raspberry, blackberry, currants), with which we hope will successfully combat spotted wing drosophila in these plantations as well.

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