REPORT

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Susceptibility of different grape varieties to *Drosophila suzukii* oviposition

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1 Aim of the study

Aim of this study was to assess the susceptibility of different grape varieties to oviposition of spotted wing drosophila *Drosophila suzukii* Matsumura (Diptera: Drosophilidae).

2 Summary

In laboratory no-choice trials, we found significant differences in susceptibility of eleven different grape varieties to oviposition of *D. suzukii*. However, there was no obvious effect of berry color on oviposition, since varieties with dark berries ranked among the most susceptible varieties (Cabernet Cortis and IRAC 1999), but also provided the three least susceptible varieties (Chambourcin, Prior and Blauburgunder). All varieties with white berries (Solaris, VB 32-7, Seyval Blanc, Johanniter, Prior, Bronner) and one blue variety (VB 91 26 04) ranged in between. Furthermore, sugar content and harvest date had no significant effect on oviposition. We hypothesize that fruit skin firmness affects susceptibility to oviposition of *D. suzukii* and suggest to evaluate it in future studies. Nevertheless, choosing the right grape variety might prevent fruit damage and economic loss due to *D. suzukii.*

3 Introduction

The spotted wing drosophila *Drosophila suzukii* Matsumura (Diptera: Drosophilidae), a devastating pest of soft-skinned fruit crops, is originally native to Southeast Asia (Kanzawa, 1939), but has been introduced into Europe (Calabria et al., 2010; Cini et al., 2012) and North (Beers et al., 2011; Walsh et al., 2011) and South America (Depra et al., 2014). Female spotted wing drosophila possess a serrated ovipositor to cut through the epicarp of their host fruit and thus can feed and oviposit on previously undamaged, ripening fruits (Kaneshiro, 1983; Mitsui et al., 2006; Calabria et al., 2010). The invasion into new regions and the high population increase has led to significant financial losses to European and American farmers of soft-skinned fruits (Walsh et al., 2011; Cini et al., 2012) such as cherries, grapes and various berries (Beers et al., 2011; Walsh et al., 2011; Lee et al., 2011a). In addition to cultured fruits, soft-skinned fruits of various wild, non-crop plants serve as alternative hosts, particularly when crop hosts are not available. Wild hosts might also provide source populations and potentially increase pest pressure during crop growing season (Lee et al., 2015). Due to short reproduction cycles of about 10 days. rapidly increasing populations are often observed, which makes monitoring and management strategies of *D. suzukii* challenging (Harris et al., 2014). Since *D. suzukii* attacks ripening fruits shortly before harvest, only insecticides with short preharvest intervals can be applied (Bruck et al., 2011). Alternative and additional approaches to protect crops are therefore needed.
Although *D. suzukii* preferes other soft-skinned fruits such as blackberries, blueberries, cherries, raspberries and strawberries over grapes (Lee et al., 2011b; Bellamy et al., 2013), grapes are also at risk to infestation because high population levels of *D. suzukii* occur in autumn. Susceptibility of different grape varieties to *D. suzukii* oviposition depends on various variety-related factors such as skin firmness, color, ripening status etc. (Maiguashca et al., 2010; Saguez et al., 2013). Some grape varieties are therefore relatively secure from infestation by *D. suzukii*. In the present study, we evaluated the susceptibility of different grape varieties used in organic farming to *D. suzukii* oviposition in order to differentiate between vulnerable and relatively resistant varieties.

4 Material and Methods

Blue and white grape varieties from the variety testing vineyard in Frick (47°30' N, 8°1' E) were exposed in no-choice-laboratory exteriments to *D. suzukii*.
25 randomly chosen berries of each variety (table 1) were carefully removed with a short stem using small scissors from two rows in the vinyard. Three samplings in weekly intervals before harvest were planned, but due to the warm weather conditions in summer 2015 that led to an exceptionally early harvest, some varieties could only be sampled once (table 1). Picked berries were assessed under the binocular for *D. suzukii* oviposition and damage.
Two undamaged berries (without skin damage and undamaged stem base) per variety were placed in a cup (diameter: 10 cm, height 6.5 cm) and five females (5-10 days old) were allowed to oviposit for 24 hours. In total, 6 cups (=replicates) per variety and date were set-up, resulting in a total sample size of N = 150. During the experimental period, temperatures varied between 23-25.5ºC and relative humidity between 33-50%.
Sugar content of berries (Brix) was determined at each sampling date of a mixed sample of 19 smashed berries with a refractometer. Sugar content of one versus two weeks before harvest was compared with a linear model with the fixed factor evaluation date and the random factor row. The variety Seyval Blanc was excluded from this analysis, since it was only measured once.
The number of oviposition holes in the fruit skin was counted under the binocular. The number of oviposition holes per replicate (two berries) was analyzed with a mixed effects model with negative binomial distributed errors, with the fixed factor grape variety, the covariate sugar content and the random factor row with different slopes for time to harvest. The interaction between variety and sugar content or variety and harvest date were not significant and therefore removed from the model.

Table 1:Grape Varieties and sampling dates.

Variety	Colour	3 weeks before harvest	2 weeks before harvest	1 week before harvest
Solaris	White	20.08	27.08	03.09
VB 32-7	White	-	27.08	03.09
IRAC 1999	Blue	-	03.09	10.09
VB 91 26 04	Blue	-	03.09	10.09
Seyval Blanc	White	-	-	10.09
Johanniter	White	03.09	10.09	17.09
Cabernet Cortis	Blue	10.09	17.09	24.09
Bronner	White	-	17.09	24.09
Prior	Blue	-	17.09	24.09
Blauburgunder	Blue	17.09	24.09	01.10
Chambourcin	Blue	-	01.10	08.10

5 Results & Discussion

Due to the hot and dry summer 2015, we did not find any *D. suzukii* damage in the vineyard.

The number of oviposition holes differed significantly between grape varieties (χ^2 = 39.75, P < 0.001; figure 1). Color had no effect on the oviposition rate in these laboratory no-choice tests: Cabernet Cortis and IRAC 1999 blue berries were the most susceptible varieties, Chambourcin, Prior and Blauburgunder, also with blue berries, were the least susceptible varieties. All white varieties ranged in between. Generally, *D. suzukii* prefers red and black fruit over bright colors (Basoalto et al., 2013; Renkema et al., 2014) and Saguez et al. (2013) found only oviposition on dark grape varieties rather than on white ones. Choice experiments or field evaluations are necessary.

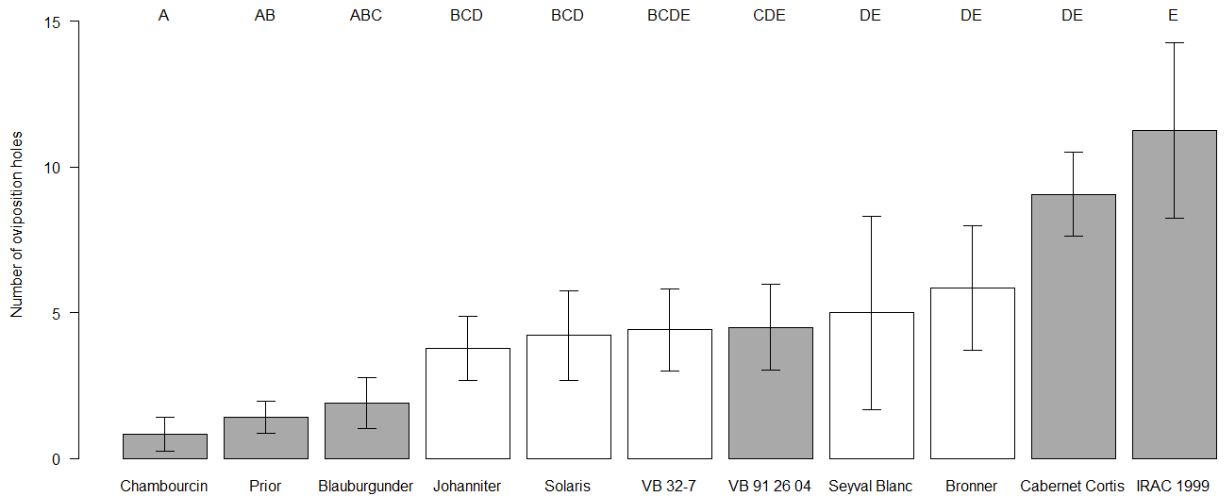

Figure 1: Number of oviposition holes in different grape varieties. Different letters show significant differences among grape varieties. Mean ± SE.

Sugar content and oviposition of *D. suzukii* usually is positively correlated (Ioriatti et al., 2015; Hamby et al., 2016; Lee et al., 2016), whereas also negative relationshps have been found (Little et al., 2017). In the evaluated varieties in this study, Brix levels were significantly higher one week than two weeks before harvest (t = 3.64, P = 0.002). However, Sugar content had no significant effect on oviposition (χ^2 < 0.001, P = 0.92). The required Brix levels in the hot and dry summer 2015 were reached about 2-3 weeks earlier than in average seasons. This suggestion is emphasized since also evaluation date had no significant effect on oviposition (χ^2 = 2.84, P = 0.09). It seems that sugar content was not a limiting factor and therefore may had no big influence on oviposition close to harvest.

Since we tested oviposition rate in “no-choice” tests, factors like color, sugar content and acidity level may have been of reduced importance for oviposition decisions. Females had only the choice between laying eggs in given berries and or stopping oviposition completely. We therefore consider varieties that showed only low oviposition susceptibility under these conditions, to be at low risk under field conditions. One factor influencing oviposition susceptibility might be skin thickness and penetration force needed for oviposition (Hamby et al., 2016; Lee et al., 2016). Ioriatti et al. (2015) evaluated a penetration force of 40 cN (with a 2mm blunted needle) as a critical limit for oviposition. Varieties with tougher fruit skins may therefore be physically less accessible to *D. suzukii* than varieties with softer fruit skins. Further experiments are needed to test influence of skin firmness on oviposition susceptibility.

Similar to our results, Maiguashca et al. (2010) found no oviposition in certain grape varieties. Choosing the right grape variety might therefore prevent fruit damage and economic loss due to *D. suzukii.* However, verified information is necessary before farmers will take the risk and make the long-tern decision to change their range of varieties.

6 Conclusions

The grape varieties Chambourcin, Prior and Blauburgunder were the least susceptible to oviposition of *D. suzukii* in our no-choice experiments. Cabernet Cortis and IRAC 1999 were highly susceptible. This finding needs to be proven in field trials under high pest pressure. Under the hot and dry weather conditions in 2015, no *D. suzukii* damage was observed in the vineyard. Furthermore, a potential correlation between fruit skin firmness and susceptibility to oviposition needs to be evaluated, since this might be one crucial factor for oviposition and since it could be a good indicator for field susceptibility to *D. suzukii* attacks. Choosing the right grape variety might prevent fruit damage and economic loss due to *D. suzukii.* However, verified information is necessary before farmers will take the risk and make the long-tern decision to change their range of varieties.

7 Literature

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