Apple scab susceptibility and necessary plant protection input of "Topaz" after scab resistance breakdown

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Abstract
Since at least 2013 widely spread apple scab infestation occurred in the vf-resistant apple variety "Topaz" in Lake Constance Area if reduced plant protection input was applied. This article summarizes the results from three trials that investigate the question whether there still is potential to save fungicides in apple scab management compared to susceptible cultivars. Managed without any fungicides, "Topaz" shows a higher level of scab susceptibility compared to other vf-resistant varieties, but still performs better than susceptible cultivars "Elstar" and "Jonagold". Compared to "Jonagored" over six years, scab incidence on "Topaz" remained below "Jonagored" in untreated control. Under a customary fungicidal plant protection management, scab was reduced below 5% infested leaves in five out of six years for "Topaz" but only in two years for "Jonagored". Thus, the same intensity of fungicidal input lead to a higher reduction of scab on "Topaz" than on "Jonagored". In a further trial, different fungicide reduction strategies were tested over three years on "Topaz". A reduced number of applications during primary season appeared sufficient when focussing on the anticipated main infection periods.

Keywords: Apple scab, Venturia inaequalis, resistance breakdown, Topaz

Introduction

At the latest since 2013, apple scab on vf-resistant apple varieties has widely been observed in the Lake Constance Area. Particularly "Topaz" being one of the most commonly grown varieties in organically managed orchards in this area was noticed to show severe scab symptoms under reduced plant protection management. Thus the question of handling the new circumstance emerged from farmers and advisers. Especially the intensity of fungicidal treatment needed to control apple scab in the formerly resistant cultivar "Topaz" was unclear. Different trials were conducted at Competence Centre for Fruit Production at Lake Constance (KOB) to investigate if there is still potential to reduce fungicidal input to "Topaz" compared to susceptible cultivars.

Material and Methods

Trial A: For the evaluation of scab susceptibility, several scab resistant or tolerant varieties as well as the susceptible varieties „Elstar" and „Jonagold" were planted in an orchard, where trees remain without any fungicide input over several years. A number of 3 x 3 trees per variety were planted by randomised dispersal within the orchard. Scab infestation was visually assessed yearly in July on a 0-9-scale adapted from Lateur and Populer (1994) with 9 being the highest level of infestation with nearly all organs infected.
Trial B: In a six year trial the level of susceptibility of „Topaz" and „Jonagored"; both with and without customary fungicidal treatment, was compared. The trial was set out in an organically managed orchard at the Competence Centre for Fruit Production at Lake Constance (KOB) located in Ravensburg, Germany. Trees were planted with distance 3,2m x 0,8m on rootstock M9, each treatment included four repetitions with 25 trees per repetition. Plant protection treatments were applied only during primary scab season, i.e. between start of ascospore disposal and appearance of first conidia on infested leaves. Control trees

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remained untreated during the whole primary season, while the customary plant protection treatment received adequate fungicide applications at every infection event. „Topaz" was treated with the same fungicide input as „Jonagored"in this treatment. After primary season, both treatments and varieties received customary plant protection management following the guidelines for organic production.

Trial C: In an additional trial we differentiated the plant protection input necessary to control scab infestation in „Topaz". The trial started 2014 in an organically managed orchard at KOB, where extensive scab infestation occurred in the variety „Topaz" in 2013. Four different plant protection treatments applied during primary scab season were compared, each different in number and timing of fungicide applications. Each treatment contained four repetitions with 15 trees per repetition. For preventative applications, a copper product (Cuprozin progress) and wettable sulfur (Netzschwefel Stulln) was used according to product guidelines and concessions. In case of high infection pressure lime sulfur (Curatio) was additionally applied in the window of germination. An overview of the application details is given in Table 1. In treatments 2 and 3 every single infection date was treated, independently from infection intensity. In treatment 2 only preventative applications were conducted, while in treatment 3 both preventative and additional applications with lime sulfur into the window of germination were applied. Treatments 4 and 5 were set up correspondingly, however only anticipated major infection dates were considered (Tab. 1). In 2017 and 2018 customary plant protection management was applied after the end of primary season in every treatment. In 2019 every treatment remained untreated for the rest of the season.

In trials B and C scab infestation was measured both on leaves and fruits after the end of incubation period. 25 shoots of each repetition (100 shoots per treatment) were examined to assess the scab infestation on leaves. The leaves were classified in 4 categories: 0= no visible infestation; 1= 1 infested spot; 2= 2 infested spots; 3= 3 infested spots. Scab on fruits was documented by examining 600 fruits per treatment in the following categories: 0= no visible infestation; 1= 1-3 infested spots; 2= 3 and more infested spots.

Table 1: Overview of application details for Trial C.

No.	Treatment / strategy	Fungicide and dosage per hectare (2 m crown high)	Number of applications		
			2017	2018	2019
1	untreated	-	-	-	-
2	**all infections** preventative + infection*	**Preventative:** until flowering: copper (Cuprozin progress 0,8 l - 1,2 l after flowering: wettable sulphur (Netzschwefel Stulln 5 kg) **Infection:** lime sulphur (Curatio till flowering 16 l, after flowering 12 l)	15	14	10
3	**all infections** preventative*		10	9	6
4	**only main infections** preventative + infection*		9	7	7
5	**only main infections** infection*		5	3	4

*Preventative means directly before rain event, infection means application during window of germination

Results and Discussion

In cooperation with Fördergemeinschaft Ökologischer Obstbau e.V. (FÖKO) the yearly scab infestation of several scab resistant or tolerant varieties was documented in the years 2017 to 2019 in an orchard managed without fungicidal input (see Fig. 1). A scale 0-9 adapted from Lateur and Populer (1994) was used to assess scab infestation. In this scale 1 means "no visual symptoms" and 9 "tree completely affected".

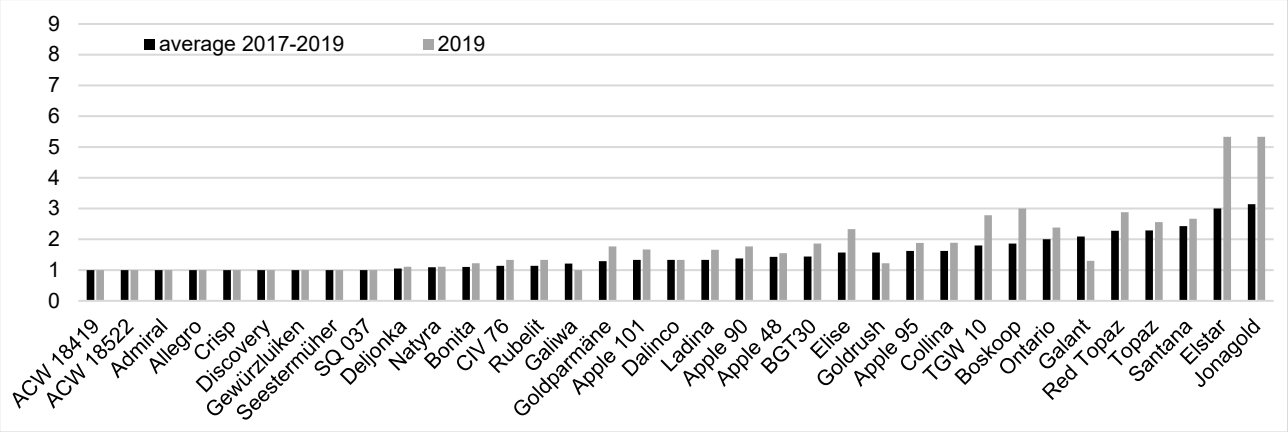

Figure 1: Trial A. Average infestation of different varieties with apple scab 2017-2019 in July. Visually graded on a 0-9-scale adapted from Lateur and Populer (1994).

Compared with other scab resistant varieties, untreated „Topaz“-trees showed the highest average infestation level in the three years of observation together with the variety „Santana“. Although the former vf-resistance of „Topaz“ has clearly been lost, its infestation level was still lower than that of „Elstar“ and „Jonagold“. Especially in the year 2019 with high infection pressure, “Topaz” showed considerably less scab symptoms than the susceptible varieties.

In trial B the scab susceptibility of „Topaz“ and „Jonagored“ was compared under different plant protection intensities over six years. Fig. 2 states the amount of infested leaves of both varieties measured in the untreated control. Within the six years of observation, the amount of infested leaves in „Topaz“ ranged on a level from 18% - 28%. With amounts between 39% and 85% of infested leaves, the level of scab infestation in the untreated „Jonagored“ was distinctively higher. This observation implies that „Topaz“ still has a certain robustness against apple scab.

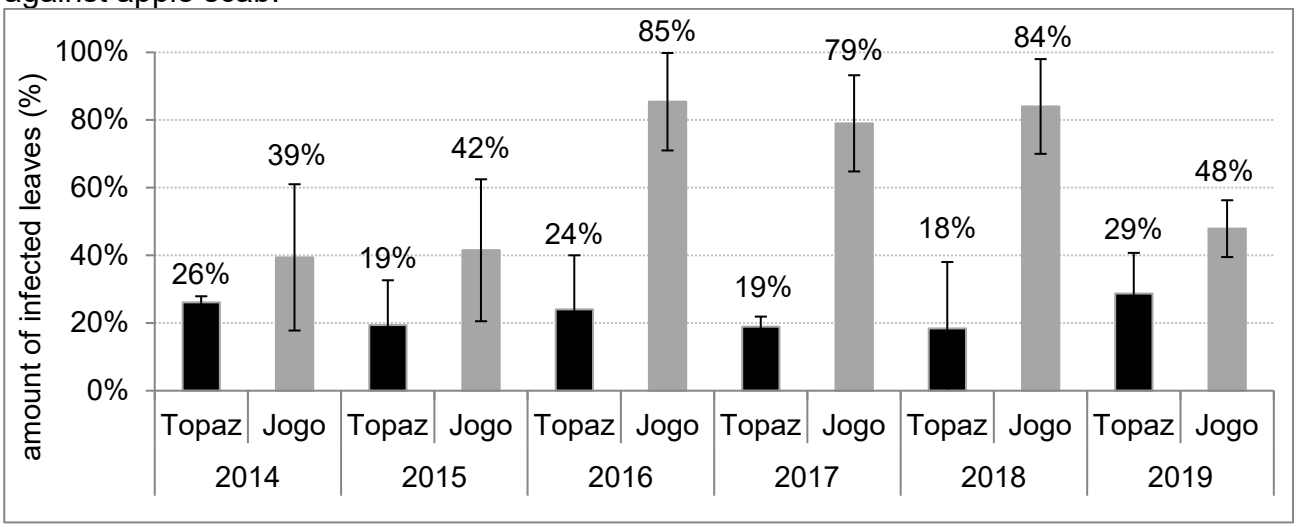

Figure 2: Trial B. Control, untreated during primary season. Percentage of scab infected leaves at the end of June/early July. Error bars represent standard deviation.

With the application of a customary plant protection management, scab infestations in „Topaz“ were yearly reduced to a level lower 5% except in the year 2016, when the amount of infested leaves reached 16,9% (Fig. 3). In contrast, adequate control of scab infestations in „Jonagored“ has only been possible in the years 2014 and 2015. In the years 2016 to 2019 high amounts of infested leaves between 18% -53% indicate an insufficient impact of the regular plant protection management in this variety. The level of scab infestation

resulting from the same intensity of fungicidal input was distinctively lower in „Topaz“ than in the susceptible variety „Jonagored“ in every year.

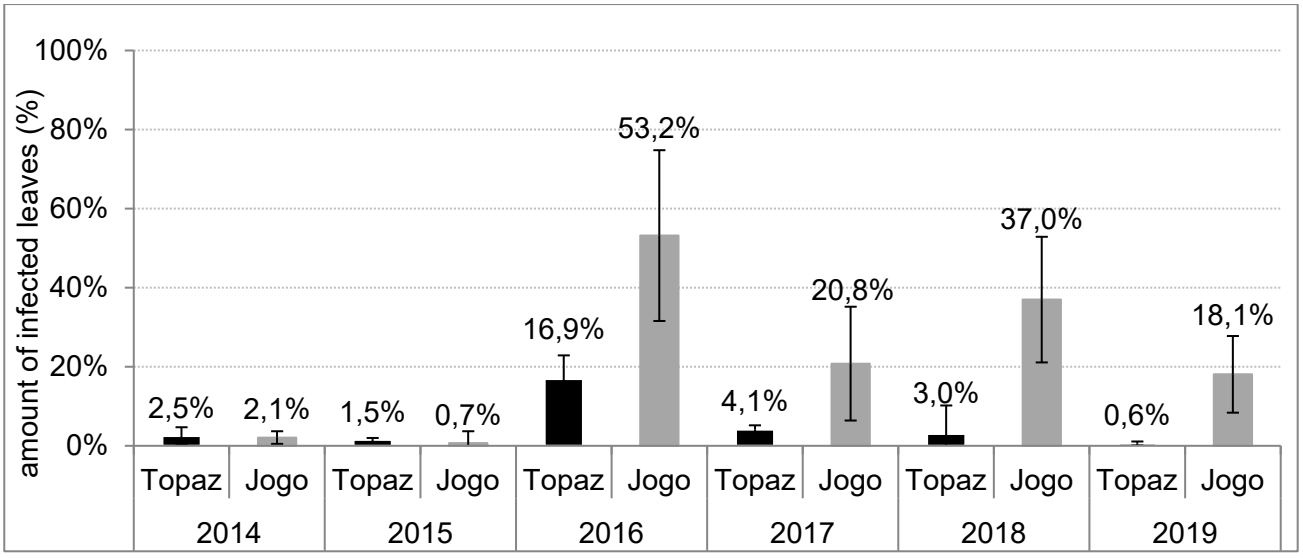

Figure 3: Trial B. Customary plant protection treatment. Percentage of scab infected leaves at the end of June/early July. Error bars represent standard deviation.

In Trial C the necessary plant protection input to regulate scab during primary season on „Topaz“ was investigated more detailed. The amount of infested leaves measured in every treatment is represented in Fig. 4 for the years 2017 till 2019. Regarding apple scab infestation on leaves it is obvious, that in the year 2019, when all treatments remained untreated after primary season, untreated control showed a higher amount of scab compared to 2017 and 2018. However, efficiency of all the treatments with plant protection input was comparable to those of the years 2017 and 2018, when regular plant protection management was applied after primary season in every treatment. It is evident that the reduction of fungicide input tends to result in increasing infestation, but compared with the untreated control, infestation levels were still lower in all treatments in every year. Even extensively reduced plant protection input in treatment 5 resulted in obviously lower infestation levels compared to the untreated control in every year. With treatment 4, promising results were achieved in 2 out of 3 years, when infestation levels were comparable with those resulting from the highest intensity of fungicide input applied in treatment 2. Therefore it can be stated that scab regulation on „Topaz“ can be successful by focusing only on major infection dates if both preventative and additional applications in the window of germination are applied. In our trial, the possible saving of fungicidal plant protection input was between three and seven applications depending on the weather conditions of the certain year (compare tab.1).

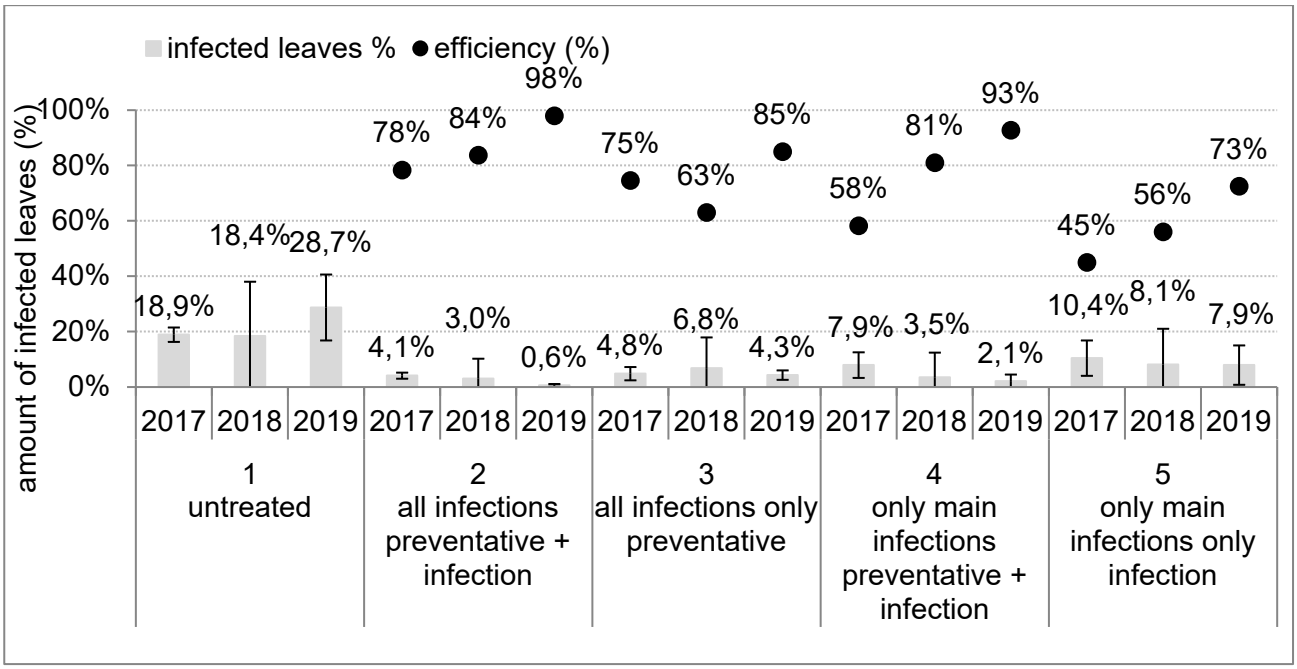

Figure 4: Trial C. Different application strategies during primary season 2017-2019. Percentage of scab infected leaves at the end of June/early July. Error bars represent standard deviation.

Concerning scab on fruit, data is not fully available due to losses caused by heavy frost during bloom in 2017. In 2018, when all treatments received the same fungicidal program after the primary season, all treatments resulting in a very low level of fruit infestation < 1%. This results indicate, that scab on fruits can be prevented sufficiently when commonly plant protection management, necessary to control sooty blotch and/or Marssonina coronaria, was applied after primary season till harvest. In contrast to 2017 and 2018, all treatments remained without fungicide input after the primary season until harvest in 2019. This resulted in an amount of 25% infested fruits in the untreated control in 2019. Similar as for scab on leaves, all fungicidal strategies led to a lower incidence of scab on fruits compared to the control in 2019 (Fig. 5). In treatment 5 with only four fungicide applications in 2019, efficiency was lower than in the other treatments but still reached 73%.

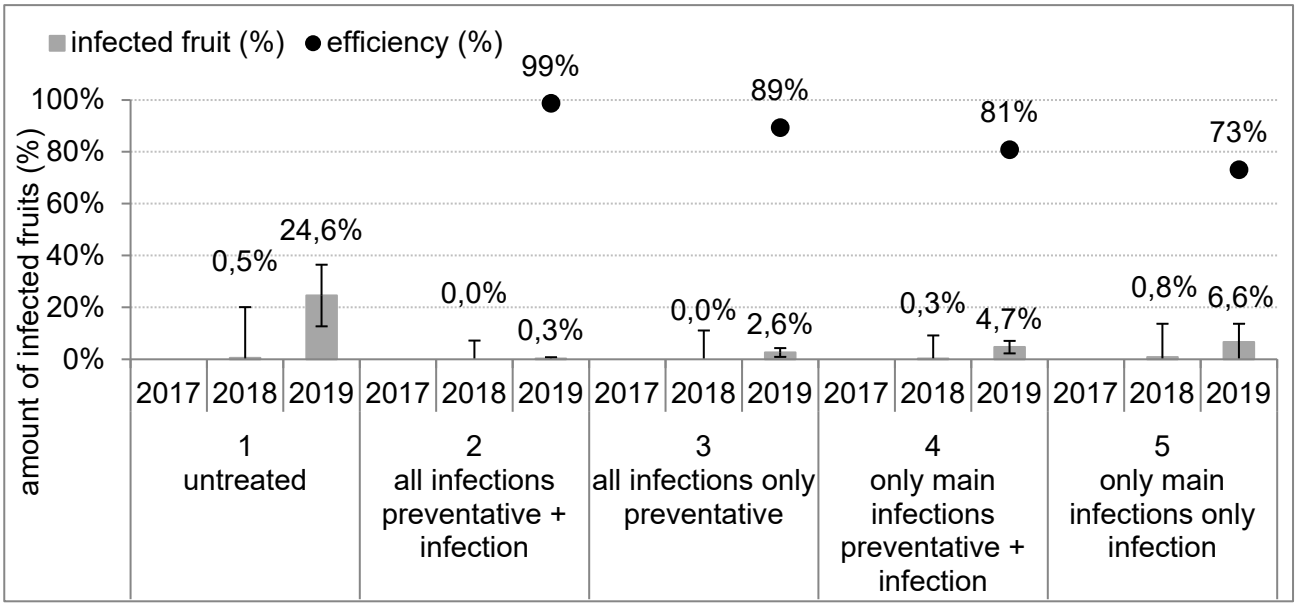

Figure 5: Trial C. Different application strategies/intensities during primary season 2017-2019. Percentage of scab infected fruit by middle of July / early August. Error bars represent standard deviation.

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