

Susceptibility of scab-resistant apple cultivars to various fungal diseases

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Abstract

*Between 2017 and 2024, a yearly increasing number of new scab-resistant apple cultivars were tested for their susceptibility to apple scab (*Venturia inaequalis*), sooty blotch and flyspeck disease (SBFS) and apple blotch (*Diplocarpon coronariae* syn. *Marssonina coronaria*) in an organically managed orchard in Lake Constance Area without any fungicide input. Within this eight-year period, several cultivars remained without any apple scab symptoms, while none of the tested cultivars showed resistance or at least pronounced robustness to sooty blotch and *Diplocarpon coronariae* in this trial.*

Keywords: Apple scab, *Venturia inaequalis*, sooty blotch, *Diplocarpon coronariae*

Introduction

The use of resistant apple cultivars plays a major role in the control of apple scab particularly in organic fruit production. Especially in Lake Constance region, where annual rainfall exceeds 900 mm, the use of scab-resistant cultivars on organic farms is currently around 60%. The most important vf (Rvi6)-resistant cultivars are 'Topaz' and 'Santana', but in the last years also new cultivars like 'Natyra' have been frequently planted on organically managed farms. Primarily vf (Rvi6)-resistant cultivars of the first generation, e.g. 'Topaz' and 'Santana', showed regionally increasing infestation with apple scab especially in the years 2022 – 2024 with very favourable infection conditions. In recent years, there has been much progress in breeding scab-resistant apple cultivars. In addition to the vf- resistance (Rvi6), some newer cultivars already have two or different resistance genes. To evaluate the susceptibility of these new scab-resistant cultivars to several diseases in an early stage, Förderverein Ökologischer Obstbau (Föko e.V.) initiated and coordinated the planting of an on-farm cultivar testing orchard in Lake Constance Area. In this orchard, cultivars remained without any fungicide input during the years 2017-2024. Under these conditions, first estimations on resistance or robustness of newly bred cultivars can be generated within a short period of time.

Material and Methods

Trial design. Investigations were carried out in an organically managed apple orchard on a commercial farm in 88697 Bermatingen, Germany (47.717865, 9.327035). Each test cultivar was planted randomly in the trial orchard with at least 3 x 3 trees. A maximum of one missing tree was accepted, leading to a minimum number of eight values. To rate the resulting infestation level of the new cultivars, the four scab-susceptible established cultivars 'Gala', 'Golden Delicious', 'Jonagold' and 'Elstar' were also included in trial to serve as a reference. However, these reference cultivars were only planted with a small number of two to three trees per cultivar. Some cultivars were planted and others grafted directly on site, but all on rootstock M9. No fungicidal plant protection measures were carried out during the entire observation period.

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Disease ratings. Trees were visually observed from two sides and assigned a rating based on the most common infestation level found. For apple scab, a scale adopted from Lateur & Populer (1994) ranging from 1 (no symptoms) to 9 (tree completely affected) was used to assess infestation annually in July. Infestation by sooty blotch and flyspeck disease (SBFS) was rated annually in August/September using a scale from 0 to 5 based on percentage of fruit surface covered with symptoms of SBFS was used with 0 = no symptoms, 1 = very small spots, still marketable, 2 = up to 10%, 3 = 10-25 %, 4 = 25-50 %, 5 = more than 50 %. All cultivars were rated at one point in time, disregarding their individual harvest date. Thus, the data represents a snapshot at a certain point in time rather than the infestation level at harvest, which is expected to further increase due to rainfall and dew especially for later-maturing cultivars. Infestation with apple blotch (*Diplocarpon coronariae* or formerly *Marssonina coronaria*) was rated yearly in September or October using a scale from 0 (no visible lesions) to 9 (tree almost bare, few leaves left) derived from Bohr et al. (2018). For all three diseases, the exact dates of the assessments varied between the years, but all cultivars were rated at the same date of the respective year by trained observers.

Display of data. First, the simple arithmetic mean for each cultivar and disease was calculated for each year. Second, to summarise the data in an understandable way, from these yearly averages again the simple arithmetic mean was calculated across the observation years. As new apple cultivars are incorporated into the trial every year, the observation periods for the individual cultivars vary in length. However, years differ in general disease pressure due to differing weather conditions. Thus, only cultivars with the same available years of observation can be accurately compared with each other. To approach this, cultivars are grouped according to their individual observation periods in the figures shown below.

Results

The evaluation of the resulting apple scab infestation in Figure 1 shows clear, cultivar-specific differences.

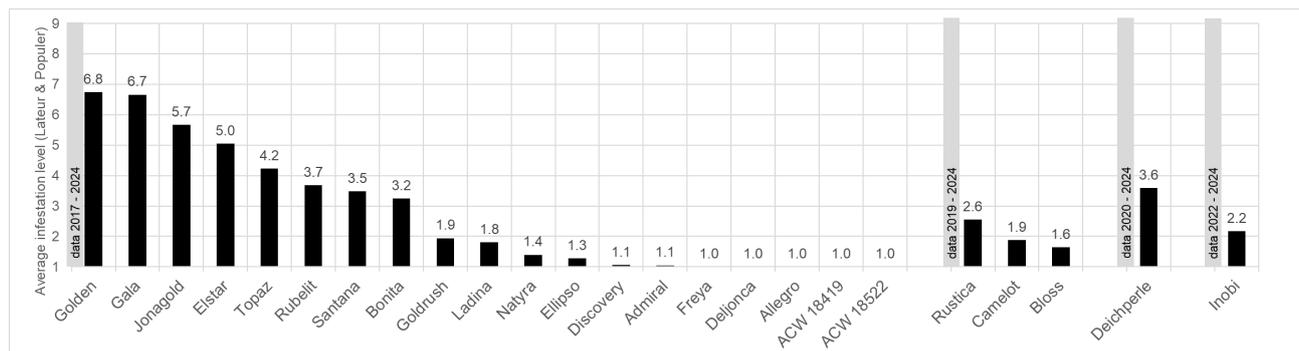


Figure 1: Infestation with **apple scab** rated on scale 1-9 (1 = no symptoms, 9 = tree completely affected). Average of the years given. N = 8-9 trees for new cultivars and 2-3 trees for reference cultivars ('Golden Delicious', 'Gala', 'Jonagold', 'Elstar').

Within the group of cultivars with 8-year data (2017-2024), the scab-susceptible commercial cultivars Golden Delicious (6.8), Gala (6.7), Jonagold (5.7) and Elstar (5.0) showed a high level of apple scab infestation, as expected, given no fungicidal plant protection measures were used. A medium level of infestation was observed in scab-resistant cultivars such as

'Topaz' (4.2), 'Santana' (3.5) and 'Bonita' (3.2). In contrast, several newer cultivars and breeding lines showed low to very low susceptibility: Average infestation values below 2.0 were observed in the cultivars 'Goldrush', 'Ladina', 'Ellipso' and 'Natyra'. The cultivars 'Freya' (1.0) and 'Deljonca' (1.0) among others, remained without apparent scab infestation over eight years, indicating that they remain completely resistant to scab. Cultivars with fewer years of observation will be further examined.

Figure 2 gives the average incidence level of sooty blotch and flyspeck disease (SBFS) at the time of assessment. The values shown are based on multi-year averages, with the respective evaluation period ranging from two to six years depending on the cultivar. Overall, the average infestation values vary in a range from 0.6 to 3.2.

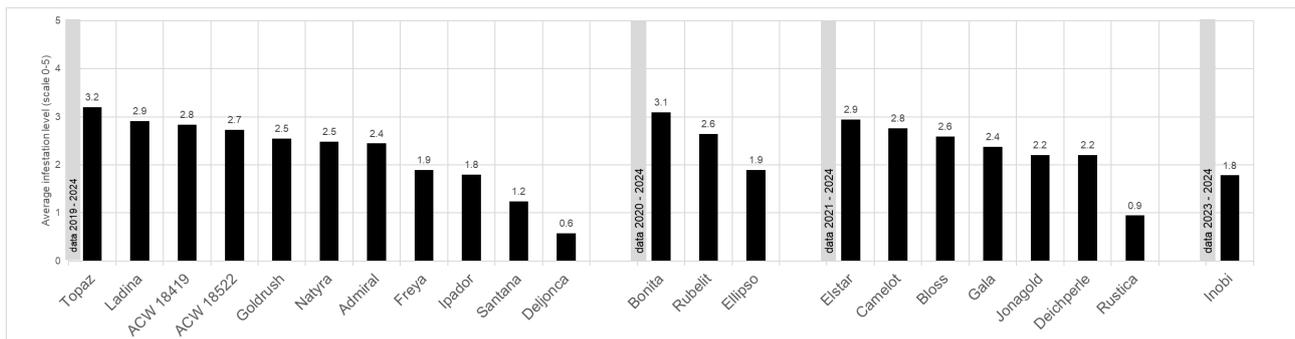


Figure 2: Average infestation with **sooty blotch and flyspeck disease (SBFS)** rated on scale 0 - 5 (0 = no symptoms, 5 = more than 50% of fruit surface covered with symptoms) of the years given. Average infestation level of the fruit of N = 8-9 trees for new cultivars and 2-3 trees for reference cultivars ('Golden Delicious', 'Gala', 'Jonagold', 'Elstar').

In contrast to apple scab, none of the cultivars examined remained completely free from infestation with SBFS. Lower infestation levels were observed particularly in the cultivars 'Deljonca' (0.6) and 'Santana' (1.2) given six-year data and Rustica (0.9) given four-year data. 'Inobi', 'Ellipso', 'Freya' and 'Ipador' also showed lower infestation levels compared to their respective groups with values below 2.0 and thus a maximum of 10% of the fruit surface affected. In contrast, numerous cultivars showed a medium level of susceptibility. These included 'Gala' (2.4), 'Bloss' (2.6) and 'Natyra' (2.5). The highest infestation values were observed in 'Topaz' (3.2) for six-year data and 'Bonita' (3.1) for five-year data.

The results of the assessments of infestation by *Diplocarpon coronariae* are shown in figure 3. None of the tested cultivars remained without any symptoms and the overall level of infestation was relatively high. Infestation values were predominantly in the upper range of the scale used (0-9) and varied between 3.3 and 7.7. High susceptibility with average infestation values > 6.0 was found for most of the cultivars tested. 'Elstar' (3.3) showed the lowest infestation value over five years, followed by 'Jonagold' (4.5).

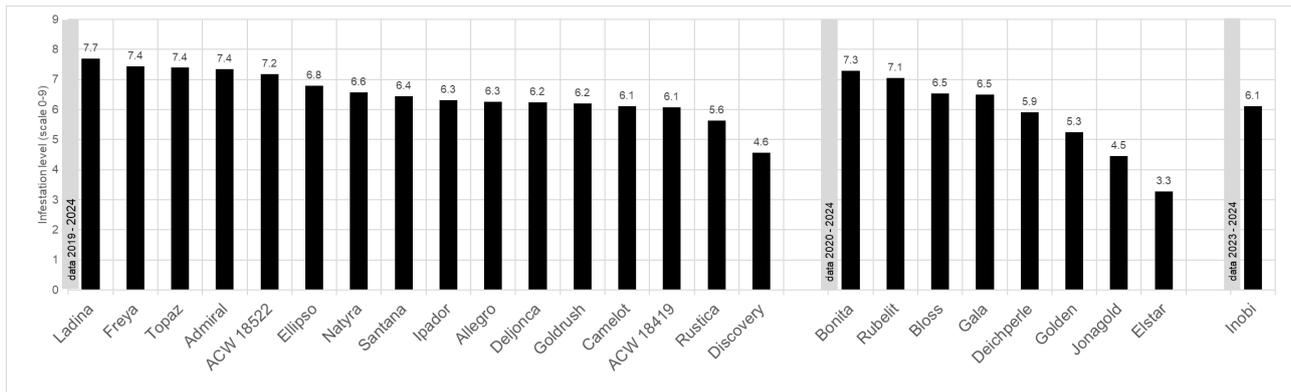


Figure 3: Average infestation with **apple blotch** (*Diplocarpon coronariae* syn. *Marssonina coronaria*) rated on scale 0 - 9 (0 = no symptoms, 9 = nearly no leaves left) of the years given. N = 8-9 trees for new cultivars and 2-3 trees for reference cultivars ('Golden Delicious', 'Gala', 'Jonagold', 'Elstar').

Discussion

The results show that the apple cultivars tested are susceptible to apple scab to varying degrees, despite often having identical resistance genes. While traditional, susceptible commercial cultivars show a high level of infection without plant protection, many newer, scab-resistant cultivars and breeding lines prove to be much more robust towards apple scab. During the eight-year study period, no scab symptoms were observed in several scab-resistant apple varieties without fungicidal plant protection and despite high infection pressure in the Lake Constance region. These cultivars currently offer high potential for reducing the input of fungicidal plant protection products. The present results underline the central importance of variety selection as a preventive measure, especially in organic plant protection, and confirm the breeding progress made in the development of scab-resistant apple varieties.

In contrast, the picture was different for sooty blotch and flyspeck disease. Unlike for apple scab, none of the cultivars examined was completely free of infestation. Most of the cultivars examined already showed a medium to high level of infestation at the time of assessment in late August to early September. Particularly for late-ripening cultivars, it can be assumed that the symptoms will continue to develop until harvest. The results underscore the importance of considering susceptibility to SBFS as a separate evaluation criterion in breeding and cultivar selection.

Regardless of their breeding background and scab resistance, many modern cultivars and breeding lines showed a high susceptibility to *Diplocarpon coronariae*. Only a few cultivars showed moderate susceptibility, although even these cultivars were not found to be completely free from infestation.

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