Swiss apple genetic resources under disease pressure: Results from a multi-year field trial

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Abstract

Robust varieties and new sources of resistance to major fungal apple diseases are needed. Genetic resources are one possible source. We present the interim results of a multi-year field trial without fungicide application. Over 600 Swiss apple genetic resources were assessed for susceptibility to scab (Venturia inaequalis), powdery mildew (Podosphaera leucotricha), and Marssonina leaf blotch disease (Diplocarpon coronariae). Infestation levels of powdery mildew and Marssonina leaf blotch allowed the identification of potentially robust genotypes. Scab infestation was rather low but sufficient to identify susceptible genotypes. The findings can be useful for breeding purposes and organic cultivation.

Keywords: Swiss apple genetic resources, powdery mildew, scab, Marssonina leaf blotch

Introduction

In apple growing, there is a demand for robust varieties and reliable sources of disease robustness. As one potential valuable source, fruit genetic resources have been screened in different countries (Lateur & Populer, 1994; Fischer & Duneman, 2000; Kellerhals *et al.,* 2012; Höfer *et al.,* 2021).

In Switzerland, around 1,200 apple genetic resources have been inventoried and are since preserved. A first portion of around 600 accessions had already been assessed for susceptibility to scab and powdery mildew (Hunziker *et al.,* 2015). The same orchard was replanted in 2016 with another 700 accessions corresponding to over 600 genotypes. In addition to traditional varieties, a few modern varieties were included, such as 'Topaz' and breeding selections. These accessions have since been assessed for scab, powdery mildew and Marssonina leaf blotch. Some interim results of this multi-year scoring will be presented (partially already reported in Hänni *et al.,* 2022).

Material and Methods

The 1,600 trees have been planted in spring 2016 in the trial plot in Horgen, Switzerland (annual precipitation around 1,300 mm). 1-year old trees on M9 rootstock with interstem 'Golden Delicous' or 'Schneiderapfel' were used, planting distance was 3.5 by 0.7 metres. The two trees per accession were randomly distributed in two diagonally opposite quadrants. Trees of the susceptible control varieties 'Golden Delicious' (for scab) and 'Gravensteiner' (for powdery mildew) were distributed alternately in the 16 rows (approx. 60 trees of each). Fungicides were applied till 2017, insecticides and other measures sparingly according to IP standards. Scab and powdery mildew were assessed annually in early summer (mid-June to beginning of July) using a 9-step scale (1: 0% infestation, 3: 1-5%, 5: 25%, 7: 50%, 9: >90%, by Lateur & Blazek, 2004, as reported in Kellerhals *et al.*, 2012). Primary infestation of shoot tips was assessed for powdery mildew, spring leaf infestation for scab. Due to low disease incidence, scab assessment was omitted in 2020 and 2021, in 2022 a reduced scoring was performed (only clearly infested trees, score 3 or more).

To assess susceptibility of the genotypes to powdery mildew and scab, the highest score per genotype over the scoring years was determined. Genotypes with fewer than two trees and trees with fewer than three scoring years were excluded. To reflect general infestation

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pressure and variance in the field, the annual mean score and standard deviation of the control varieties were calculated.

To increase Marssonina leaf blotch pressure, 800 net bags with infested foliage were suspended between the trees from autumn 2020 till summer 2021 (as in Szalatnay & Bettschart, 2025). An adapted version of the 9 step-scale was used for infestation assessment (infestation=leaf symptoms or leaf drop). The first regular scoring was performed end of September 2022. Since 2023 two scorings per year were made: one in late August/beginning of September and another around four weeks later. Since 2023 leaf drop was additionally assessed. Some scorings were excluded due to unclear symptoms or leaf fall. In 2025, incidence and severity of infestation were assessed separately.

Results

Powdery mildew

The susceptible control variety 'Gravensteiner' showed middle to high infestation in all five scoring years (Tab. 1). Mean incidence in the tested accessions (except the two control varieties) was overall lower.

Table 1: Average powdery mildew score (1-9) per year (primary infestation of shoot tips), sd=standard deviation, n=number of scored trees.

	2018	2019	2020	2021	2022
'Gravensteiner'	**8.0** sd=1.0 n=53	**6.9** sd=1.6 n=51	**6.5** sd=1.5 n=53	**6.1** sd=1.6 n=53	**5.7** sd=1.3 n=55
Mean incidence	**4.8** n=1416	**3.2** n=1418	**3.4** n=1464	**2.8** n=1468	**3.2** n=1460

Around 10% of the genotypes with sufficient scoring data never showed more than 5% powdery mildew infestation (score 3, Fig. 1). Twelve of those genotypes didn't show any infestation (score 1), all of them genetic resources e.g. 'Allensberger Mostapfel', 'Berghof Lederapfel'; 'Jahrapfel von Steckborn' and 'Voidjatte'.

Scab

The infestation of the control variety 'Golden Delicious' varied considerably between years, with high infestations levels found in 2019 and 2023. Mean incidence in the tested accessions was remarkably lower compared to 'Golden Delicious' for all years except 2018, when infestation was generally very low (Tab. 2).

Table 2: Average scab score (1-9) per year (spring scab on leaves), sd=standard deviation, n=number of scored trees.

	2018	2019	2022	2023	2024	2025
'Golden Delicious'	**1.3** sd=0.6 n=53	**7.3** sd=1.5 n=52	(4.0) (sd=0.9) (n=53)	**7.8** sd=1.1 n=58	**4.4** sd=1.2 n=59	**4.5** sd=1.3 n=58
Mean incidence	**1.1** n=1407	**1.8** n=1399	(3.3) (n=245)	**2.2** n=1431	**1.6** n=1441	**1.3** n=1438

Over 60% of the genotypes with sufficient data were never scored above 3 for leaf scab infestation. Less than 10% got a score of 7 (50% infestation) or more (59 genotypes) (Fig. 1). Among them were Golden-related newer varieties such as 'Maigold' or 'Elstar', but also genetic resources such as 'Kasseler Reinette' or 'Boskoop'.
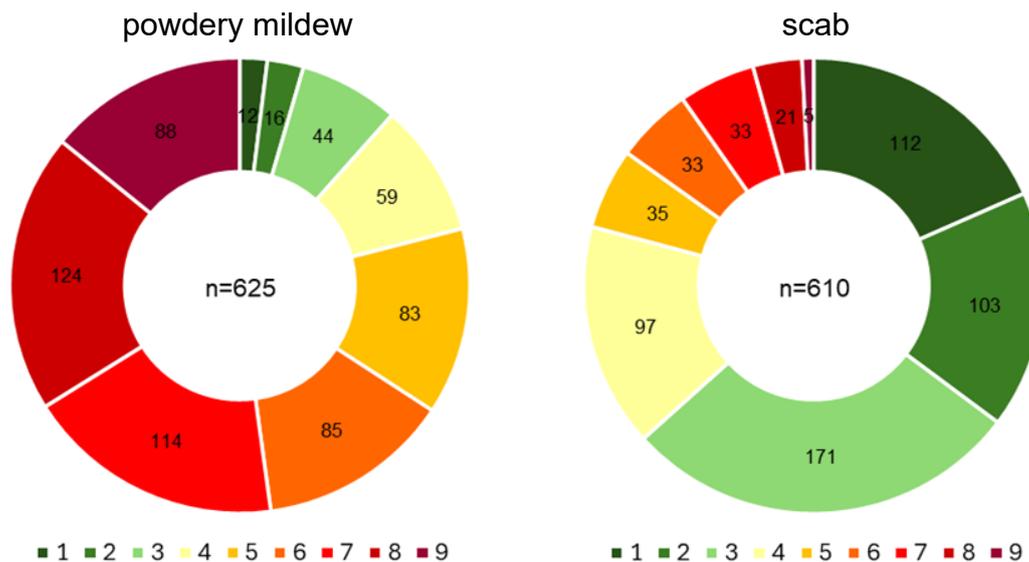
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Figure 1: Distribution of highest score per genotype. On the left: powdery mildew data 2018-2022, on the right: leaf scab data 2019 and 2022-2025.

Marssonina leaf blotch

Marssonina leaf blotch infestation was high after artificial inoculation in 2020/21. Mean infestation of 'Golden Delicious' was every year above 7 at the second scoring. All genotypes showed some infestation. 95% were scored 7 or higher (regarding symptom spreading) in some year, especially in 2025. However, some genotypes regularly displayed below-average infestation. Among them 'Baarapfel', 'Süsser Pfaffenapfel Solothurn', 'Leuenapfel', 'Noldiapfel', 'Candil Sinap' and 'Grauer Hordapfel'. Additionally, differences in leaf drop were observed. Beginning of October 2025, mean values of leaf drop per genotype varied widely despite generally high symptom spreading.

Discussion

Sufficient infestation allowed a differentiation of the varietal susceptibility to powdery mildew. A classification was published on the national database (PGREL-NIS 2023). The classification of the former trial is also available there (PGREL-NIS 2019). Seven genotypes showed a low susceptibility to powdery mildew in both trials, e.g. 'Birnförmiger Apfel', 'Jakob Lebel', 'Küssnachter' and 'Mühlloch'. It would be useful to validate potentially robust genotypes with data from other locations. For some, robustness was confirmed by literature or other studies. The proportion of genotypes with no or low infestation was considerably higher for scab than for powdery mildew, as in similar studies, e.g. Höfer *et al.*, 2021. Mean scab incidence was surprisingly low, even in years with favourable conditions. The potential positive effect of a very diversified mixed planting could be a partial explanation (Stewart *et al.,* 2023). However, the high infestation of 'Golden Delicious' indicates that sufficient disease pressure was present and well distributed in some years. It seems that the local scab population might be particularly well adapted and more virulent towards the widespread Golden genetics. It would thus be useful to confirm the robustness of so far low infested genotypes in trials with other scab strains (Laurens et al., 2004).

The artificial inoculation of the orchard with Marssonina leaf blotch worked well but led to a disease pressure presumably far above the norm (Szalatnay & Bettschart, 2025). Therefore, the absolute infestation data should be interpreted with caution. In addition, the assessment for Marssonina proved to be more challenging than for the other diseases. The scoring system was accordingly expanded. Our trial confirmed previous findings that all known

varieties develop infestation under sufficient pressure (e.g. Szalatnay & Bettschart, 2025). Nevertheless, differences between varieties could be observed and some varieties appeared potentially robust, even under high disease pressure. Their robustness should be further assessed, possibly also on standard trees. For both Marssonina and scab, fruit scoring would also be useful.

In addition to direct cultivation or use for breeding, further molecular characterisation of the identified robust genetic resources would be valuable, to understand underlying mechanisms and to identify potential new resistances (as in Höfer *et al.,* 2021; Richter *et al.,* 2025). In conclusion, the trial highlighted some potentially robust or resistant cultivars, especially for powdery mildew and Marssonina leaf blotch. After final scoring in 2026 a robustness classification of the over 600 genotypes will be established for Marssonina and scab, as already done for powdery mildew.

Acknowledgements

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