From the ASEV Climate Change Symposium Part 1 – Viticulture

Adoption of New Winegrape Cultivars to Reduce Pesticide Use in Europe

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Abstract

Background and goals
Climate change has led to increasingly difficult weather conditions and therefore, new challenges for grapegrowers. In Europe, increasing climatic variability is leading to a variety of problems, causing extremely dry summers in one year and extremely wet conditions accompanied by high pathogen pressure in the next. Especially in very wet years, viticulture requires the extensive use of pesticide products to prevent yield and quality loss. The European Union’s ambitious goal to reduce pesticide usage in agriculture by 50% by 2030 (EC 2020) is putting further pressure on grapegrowers. However, after more than one-hundred years of grapevine breeding, there are many disease-resistant cultivars available for today’s grapegrowers.

Methods and key findings
This Insight provides an overview on the development of these new disease-resistant cultivars in Europe, their advantages, and the problems that grapegrowers face when using them to adapt to the conditions affected by climate change. Prejudice and uncertainty about these new cultivars has led to a low adoption rate within the grapegrowing sector. Ongoing research that aims to mitigate these doubts will be presented herein.

Conclusions and significance
Disease-resistant grapevine cultivars allow grapegrowers to reduce fungicide usage by up to 80%, depending on cultivar and environmental conditions. These cultivars are an important part of the effort to reduce pesticide usage in viticulture and therefore, to fulfill the demands for pesticide reduction set by the European Union.

Key words: climate change, disease-resistant cultivars, grapevine breeding, pesticide reduction, PIWI, sustainability

Introduction

In 2020, the European Union (EU) passed the Farm to Fork strategy, which set an ambitious goal to reduce the amount of chemical pesticides used in agriculture by 50% by 2030 (EC 2020). This goal is particularly pertinent to viticulture, as grapes receive about two-thirds of the fungicides used in the EU, despite covering only ~3.5% of the agricultural area (EC 2007). In addition to political pressure on European grapegrowers to use less pesticides and be more sustainable, the public is also demanding more sustainability in the production of agricultural products and therefore, from wines. This pressure drives research and extension institutions and companies to further innovation and development of new management techniques, application machines, prediction tools, and fungicide formulations. However, grapevine breeders offer high quality fungus-resistant grapevine cultivars as alternatives to the highly susceptible Vitis vinifera cultivars primarily grown in Europe. These pesticide reduction goals, together with climate change, are the biggest challenges European grapegrowers face today.

History of Grapevine Breeding in the EU and Germany

One of the most promising options for European grapegrowers in their efforts to reach the pesticide reduction goals set by the EU are the many fungus-resistant cultivars, as most allow for an immediate reduction in fungicides of at least 50%. The current wealth of resistant cultivars would not be available if not for the many resistance breeding programs initiated throughout Europe, as a direct answer to the introduction of downy mildew (Plasmopara viticola), powdery mildew (Erysiphe necator), and Phylloxera from North America in the 19th century. The V. vinifera cultivars grown in Europe in the 19th century were all susceptible to these pathogens, and due to high yield losses, the existence of viticulture was in danger. However, with the development of the first fungicides and
breeding of rootstocks, grapegrowers were able to manage the threats. The first breeding programs for fungus-resistant scions in Europe were initiated in France. Based on North American Vitis species and hybrids of V. vinifera bred with North American Vitis species, many private French breeders started to develop new cultivars by crossing them with V. vinifera. This was done in the interest of improving the wine quality of the resistant hybrids, as wines of these North American hybrids were usually not to the liking of European consumers. The resulting cultivars, the so-called French hybrids, allowed for a significant reduction of fungicides and therefore were quickly adopted by those in the French viticulture industry. However, many newly-bred cultivars were barely tested for their wine quality before their dissemination to grapegrowers. Apart from cultivars with high potential, there were also cultivars with rather low quality due to off-flavors stemming from their wild Vitis ancestors. These French hybrids spread to over 400,000 ha in France, accounting for around one-third of the French viticultural area (Galet 1988) until their cultivation was prohibited in the mid-20th century due to quality concerns. This decision still reverberates in the minds of European grapegrowers today. French hybrids were the sources of plant material for many other European breeding programs, which continued backcrossing them with V. vinifera cultivars. One of the longest lasting, continuous, resistance breeding programs started in 1925 in Germany at the Institute for Grapevine Breeding Geilweilerhof and led to the first resistant cultivars in the 1990s. These cultivars were accepted for quality wine production in Germany. In particular, the cultivar Regent was in high demand, also adopted across several European countries, and ultimately reached ~2200 ha in Germany, accounting for ~2% of the German viticultural area. Inspired by the success of these German cultivars, several European countries or Institutions re-initiated their own resistance breeding programs, most notably the INRAE in France with their ResDur breeding programs (Schneider et al. 2019) and the University of Udine in Italy, whose cultivars were marketed worldwide by Vivai Cooperativi Rauscedo (Testolin et al. 2023).

Climate Change Adaptation as a Breeding Goal

While pathogen resistance has been one of the most important aspects of new grapevine cultivars, today’s breeders also try to address climate change in their breeding programs. In recent years, the impact of climate change on viticulture has become more noticeable and is already leading to yield loss or quality reduction in European vineyards due to drought stress, sunburn, or frost, among other issues. While increased temperatures and a lack of precipitation are the main consequences of climate change, they are not the only problems encountered in viticulture, as climatic variability increases in general. For example, in the Palatinate grapegrowing area of Germany, grapegrowers suffered from high precipitation and, subsequently, high downy mildew pressure in 2016, leading to substantial yield losses. In 2017, a warm spring followed by a few nights of frost in May led to severe frost damage in the fields. In contrast, 2018 to 2020 were very hot years, and the vines suffered from lack of precipitation and sunburn. These years experienced some of the earliest budbreak, flowering, veraison, and harvest ever recorded in Europe, which proved difficult for the winemaking industry, resulting in many wines with very high alcohol levels. Another wet year occurred in 2021, leading to unprecedented disease pressure by downy mildew. Consequently, grapevine breeders aim to develop new cultivars with a high degree of resistance against pathogens and a higher resilience to abiotic stresses such as drought, heat, and later budbreak and ripening periods. Additionally, climate change may lead to pests and pathogens in areas in which they were previously absent, requiring viticulturists to manage subsequent new diseases and damage in susceptible vineyards.

The process of breeding new grapevine cultivars is very time consuming. Depending on the specificities of the breeding programs, the time may vary; on average it takes between 20 and 25 years from the cross until a new grapevine cultivar receives variety protection. A publication by Reynolds (2015) includes additional information on different global breeding programs and their peculiarities. The breeding program at the Institute for Grapevine Breeding Geilweilerhof in Germany was recently described in detail (Töpfer and Trapp 2022). Today, breeders rely heavily on an early selection of grapevine seedlings with molecular markers (marker-assisted selection [MAS]) before the seedlings are planted into the fields and undergo the required steps of each breeding program. Throughout these steps, breeders select the best breeding lines for their resistance in the field (also against diseases not covered by molecular markers or resilience to abiotic stresses), the viticultural characteristics (e.g., growth, yield, or phenology), and of course, wine quality. Breeders are looking for the best possible combinations of these traits before they take these breeding lines to external trials in cooperation with winemakers. Finally, variety protection and national registration are pursued and the new cultivar is made available for interested grapegrowers.

Adoption of New Cultivars

Germany is one of the leading countries in the adoption of the new generations of disease-resistant grapevine cultivars. Thanks to several long-lasting breeding programs, German viticulture has many new cultivars available for cultivation. Since the early 1990s, German breeders developed 36 resistant cultivars, which are protected and registered (or in the process of registration) today. After the introduction of resistant cultivars into the German market in the 1990s, the area in which they were planted rose to ~3% and remained at that level, although new cultivars with higher resistance and new wine styles were introduced. In addition to the cultivars developed by German breeders, there are ~40 more cultivars approved for planting and winemaking in Germany. Many of these additional cultivars are from other
European breeders like the aforementioned French INRAE or the Italian Vivai Cooperativi Rauscedo. Today's acreage of the most important resistant cultivars in Germany is shown in Table 1. Grapegrowers, especially in the traditional European grapegrowing countries, tend to be more reluctant to grow new resistant cultivars, leading to lower adoption rates in these countries. However, this is slowly changing. In France, there was a demand for new cultivars in recent years due to rising pressure from the public to reduce pesticide applications. In 2022, the Champagne region even approved a new cultivar from the INRAE, Voltis, for the production of Champagne (with protected designation of origin). Additionally, resistant cultivars are also gaining ground in other European countries. For example, in Hungary, grapegrowers mostly plant resistant cultivars due to economic reasons; many of these cultivars were locally bred in Hungary. In several smaller grapegrowing countries in the EU (e.g., the Netherlands and Denmark), the use of copper as a plant protection agent is prohibited, therefore they rely almost exclusively on resistant cultivars.

Despite the advantages of disease tolerant cultivars, many grapegrowers in the more traditional European grapegrowing areas are still reluctant to grow these new cultivars and express their doubts about them. The following three sections detail points of particular concern often raised by grapegrowers.

### Doubts about the durability of the new cultivar resistance properties

The advances in grapevine genetics over the last 20 years led to the detection of many resistance loci, which breeders can follow with molecular markers in today's breeding programs (for an overview see: [www.vivc.de/loci](http://www.vivc.de/loci)). These molecular markers also provide insight into resistance in cultivars bred in a strictly empirical way by selecting the most resistant breeding lines, as was the standard procedure before MAS. Many of the new resistant cultivars in Europe rely on the same source of resistance, and often the resistance against a pathogen is conferred by a single resistance locus (Töpfer and Trapp 2022). History has shown that single-locus resistance is prone to being overcome by newly emerging pathogen strains adapted to these resistance mechanisms (Browning and Frey 1969), and grapevines are no exception. Peressotti et al. (2010) first reported on downy mildew resistance-breaking strains of *P. viticola*. This strain was able to overcome Rpv3.1-confessed resistance, and although the cultivar Bianca was carrying Rpv3.1 as a resistance locus, its susceptibility to *P. viticola* was similar to that of traditional *V. vinifera* cultivars. To prevent the development of these strains, it is of utmost importance to apply a minimal amount of pesticide to kill possible resistance-breaking strains before they can develop into larger populations. Rpv3.1 is also the sole major resistance locus in

**Table 1** The acreage of 23 disease-resistant cultivars grown in Germany in 2022. "Others" mostly constitutes newer disease-resistant cultivars, but also includes a portion of not further specified traditional cultivars. Data from the German Federal Office of Statistics ([https://www.destatis.de/DE/Themen/Branchen- Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Wein/Publikationen/Downloads- Wein/rebblaechen-2030315227004.pdf?__blob=publicationFile](https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Wein/Publikationen/Downloads-Wein/rebblaechen-2030315227004.pdf?__blob=publicationFile)).

<table>
<thead>
<tr>
<th>Rank</th>
<th>Disease-resistant cultivar</th>
<th>Parentage</th>
<th>Acreage 2022 (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regent</td>
<td>Diana x Chambourcin</td>
<td>1.618</td>
</tr>
<tr>
<td>2</td>
<td>Cabernet blanc</td>
<td>Cabernet Sauvignon x Regent</td>
<td>260</td>
</tr>
<tr>
<td>3</td>
<td>Solaris</td>
<td>Merzling x (Severnyi x Muscat Ottoloi)</td>
<td>207</td>
</tr>
<tr>
<td>4</td>
<td>Souvignier gris</td>
<td>Seyval blanc x Zaehringer</td>
<td>204</td>
</tr>
<tr>
<td>5</td>
<td>Johanniter</td>
<td>Riesling x Freiburg 589-54</td>
<td>141</td>
</tr>
<tr>
<td>6</td>
<td>Muscaris</td>
<td>Solaris x Muscat a Petits Grains blanc</td>
<td>117</td>
</tr>
<tr>
<td>7</td>
<td>Cabernet Cortis</td>
<td>Cabernet Sauvignon x Solaris</td>
<td>60</td>
</tr>
<tr>
<td>8</td>
<td>Phoenix</td>
<td>Bacchus Weiss x Villard blanc</td>
<td>46</td>
</tr>
<tr>
<td>9</td>
<td>Pinotin</td>
<td>Cabernet Sauvignon x Regent</td>
<td>36</td>
</tr>
<tr>
<td>10</td>
<td>Helios</td>
<td>Merzling x Freiburg 986-60</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>Prior</td>
<td>Freiburg 4-61 x Freiburg 236-75</td>
<td>21</td>
</tr>
<tr>
<td>12</td>
<td>Cabertin</td>
<td>Cabernet Sauvignon x Regent</td>
<td>19</td>
</tr>
<tr>
<td>13</td>
<td>Monarch</td>
<td>Solaris x Dornfelder</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>Saphira</td>
<td>Arnsburger x Seyve Villard 1-72</td>
<td>11</td>
</tr>
<tr>
<td>15</td>
<td>Rondo</td>
<td>Severnyi x Saint Laurent</td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>Cabernet Carbon</td>
<td>Cabernet Sauvignon x Bronner</td>
<td>7</td>
</tr>
<tr>
<td>17</td>
<td>Hibernal</td>
<td>(Seibel 7053 x Riesling) F2 O.P.</td>
<td>8</td>
</tr>
<tr>
<td>18</td>
<td>Cabernet Carol</td>
<td>Cabernet Sauvignon x Solaris</td>
<td>5</td>
</tr>
<tr>
<td>19</td>
<td>Piroso</td>
<td>Geisenheim 6423-14 x Freiburg 54-64</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>Bronner</td>
<td>Merzling x (Severnyi x Saint Laurent)</td>
<td>6</td>
</tr>
<tr>
<td>21</td>
<td>Merzling</td>
<td>Seyval blanc x (Riesling x Pinot gris)</td>
<td>3</td>
</tr>
<tr>
<td>22</td>
<td>Staufer</td>
<td>Bacchus Weiss x Villard blanc</td>
<td>0</td>
</tr>
<tr>
<td>23</td>
<td>Villaris</td>
<td>Sirius x Vidal blanc</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td></td>
<td>699</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>3.518</td>
</tr>
</tbody>
</table>
many of the German resistant cultivars, and grapegrowers observed a perceived loss of resistance of the cultivar, citing this loss as a reason not to grow resistant cultivars. This perceived decrease of resistance is due to the manifestation of Rpv3.1-breaking P. viticola strains in the fields. Often these fields were left untreated, and minimal pesticide applications (adapted to the cultivar and disease pressure) could have prevented or minimized losses due to downy mildew. The probability of the development and manifestation of resistance-breaking pathogen strains is decreased by minimal pesticide applications, which is extraordinarily important considering that grapevine cultivars can be grown for centuries. Breeders are presently focused on increasing the durability of the resistance properties in their cultivars by pyramiding resistance loci (Töpfer et al. 2011). The current goal for breeders is to further minimize the amount of plant protection needed by combining several resistance loci against the most important pathogens. However, recent studies have shown that even combining two resistance loci against downy mildew does not prevent the need for minimal protection, as P. viticola strains breaking through both Rpv3.1 and Rpv12 were found (Wingerter et al. 2021). The conclusion is that even cultivars with pyramided resistance will need some pesticide applications, as viticulture without pesticide applications is not only infeasible, but also rather irresponsible in the long term. However, even cultivars carrying only the Rpv3.1 resistance locus, like Regent, were able to yield healthy grapes in the high disease pressure years of 2016 and 2021 in Germany with only 50% of the pesticide applications. Taken together, the current options for grapegrowers allow for a reduction of fungicide use of at least 50%, which is consistent with the goals set by the EU. If treated responsibly, this reduction potential can be preserved for future generations.

Doubts about successful commercialization of wines from new cultivars

A study from 2020 reported concerns from grapegrowers that several factors unique to new cultivars have made the marketing and selling of wines from these cultivars more difficult in today’s wine market than that of traditional cultivars (Kiefer and Szolnoki 2020). For German consumers, the grapevine cultivar is—apart from the price—the most important factor in their purchasing decision, with sustainable production only secondary (Nesselhauf et al. 2020). As new cultivars require a new name, consumers need to familiarize themselves with these cultivars and their advantages. This involves frequent communication between producer and consumer, which is unfortunately difficult to facilitate in supermarkets (the main location for a German consumer to buy wine), and substantial communicative effort and resources are required for face-to-face sales in a producer’s shop.

What is certain is that wines of disease-resistant cultivars must primarily stand out on the basis of their quality, as praising new disease-resistant for their pesticide reduction potential can imply to consumers that the wines made from traditional cultivars are less sustainable. Due to the economic importance of wines made from traditional cultivars, producers usually avoid discussing the possibility of using new cultivars to reduce fungicide applications (Dreßler and Freund 2022). One way to overcome this dilemma is to use new cultivars in cuvées with generic names, as consumers are used to enjoying cuvées without information about the included grapevine cultivars. Additionally, consumers are gradually becoming more aware of sustainable wine production, and the term “PIWI” (the German abbreviation for Pilz widerstandsfähige Reben, meaning fungus-resistant grapevines) is starting to become a brand for new disease-resistant cultivars. Currently, there are several research projects in Europe focusing on how best to introduce new cultivars to the market; it will be interesting to see the outcomes.

Doubts about the quality of the wines from disease-resistant cultivars

In the middle of the 20th century, disease-resistant French hybrid cultivars were banned on the basis of quality concerns, effectively creating a stigma against disease-resistant cultivars that still lingers in the present day. Even today, many grapegrowers have the prejudice that all new disease-resistant cultivars are interspecific hybrids, which always carry off-flavors and show deficits in wine quality. With subsequent backcrosses of the French hybrids and thorough selection for wine quality, breeders were able to eliminate putative off-flavors, such as the foxy methyl-anthranilate, from the newer generations of disease-resistant grapevine cultivars. Due to this comprehensive effort, contemporary grapevine breeders are convinced that the quality of wines of their cultivars is equal to traditional V. vinifera cultivars, although many winemakers still assume the wines will be of lower quality. In Germany, breeders were recently supported by the enologists of the DLR Rheinpfalz in Neustadt (Weber et al. 2021): in blind tastings with wine experts and German, French, and Danish consumers, wines from disease-resistant cultivars showed equal or even better quality assessments than their counterparts made from traditional V. vinifera cultivars such as Riesling, Sauvignon blanc, or Muskateller. Grapes of fungus-resistant and V. vinifera cultivars were obtained from the same field trials and micro-vinified using the same protocol over three vintages (2019 to 2021). Red and rosé wines from disease-resistant cultivars were on par with, or rated more highly than, the traditional V. vinifera cultivars such as Merlot and Cabernet Sauvignon. These results support the statement that new disease-resistant cultivars no longer exhibit quality flaws and have equal quality potential to V. vinifera cultivars; thus, grapegrowers should be receptive to growing these cultivars.

Conclusion

Viticulture is in a state of transition. Climate change and the demand for more sustainable wine production will lead to profound changes in viticulture. There will be changes in
the cultivars grown in viticultural areas around the globe, as a response to the challenges imposed by pathogens and the changing climate. It can already be observed that Southern European cultivars are grown further north by grapegrowers adapting to the changing climate. However, these cultivars do not help with the other challenge European grapegrowers are facing: reduction of pesticide use. Thankfully, due to a long history of grapevine breeding, grapegrowers can choose from many disease-resistant cultivars today, some of which already have traits that are important for dealing with climate change, e.g., later ripening. The resistance properties of these new cultivars allow for a reduction of pesticides between 50 and 80%, which is in line with the reduction goals of the EU, and—if treated correctly—the resistances can be preserved for a long time. The wine quality of these new cultivars is, on average, equal to the highly valued traditional V. vinifera cultivars. However, marketing wines of these new cultivars is more challenging as they are still unknown to consumers. Yet with the ongoing transition in public demand toward sustainable production, the advantages of resistant cultivars will be a selling point in the future. Grapegrowers in Europe are gradually accepting new disease-resistant cultivars and are starting to embrace the advantages, however, it will be a long time until these new cultivars are accepted in the mainstream and are as popular among grapegrowers and consumers as the currently grown traditional cultivars.

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Citation


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