Breeding resistante cultivars to downy and powdery mildew

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Abstract:

The creating of the ‘ideal cultivar’ appeared in the second part of the 19th century, which has resistance to downy mildew and powdery mildew combined with the quality of European varieties. The resistance breeding to fungal pathogens grapevine was based on Vitis species that are autochthonous in North-America, and underwent a coevolution with the pathogen. Despite of the remarkable success achieved, the final goal combining the complex resistance and the vine qualities into one genotype was not reached. This is mainly due to the polygenic character of inheritance at both of the attributes. The Muscadinia rotundifolia has immunity to most pathogens infecting grapevine. French breeders determined that extreme resistance to powdery mildew is dominantly inherited due to RUN 1 gene. Our results suggested that the V. amurensis’s resistance to downy mildew is inherited by oligogenic way. Using dominant resistance of V. vinifera cv. Kishmish vatkana (REN 1) has an important additional possibility. The progeny was scored for resistance after artificial inoculation in laboratory and natural infection in field and we use marker assisted selection (MAS) for powdery mildew selection in grapevine.

Our breeding project aims at extending the cultivar sortiment with wine and table grape varieties of high quality and at the same time immune to powdery mildew and highly resistance to downy mildew. Starting in 1999 our breeding program, we combine resistant genes of different origin against powdery mildew and also against downy mildew. We crossed M. rotundifolia x V. vivifera BC₃ and BC₄ hybrids with V. amurensis x V. vinifera and other complex hybrids. Our results showed that it is possible to achieve the more than 100 year-old-aim, but not in that way it was first dreamt, but by using the resistant genes of Muscadinia rotundifolia and V. amurensis species.

Introduction

The powdery mildew Erysiphe necator (Uncinula necator (Schw.) Burr.), and the downy mildew Plasmopara viticola (Berk. Et Curtis ex de Bary), is one of the most severe pathogens of grapevine; both of them are native to North America. They arrived in Europe in the 19th century and have been causing epidemics since that time. The powdery mildew is able to infect all green parts of the plant, downy mildew distroys leaves and berries. The resistance breeding to fungal pathogens of grapevine was based on Vitis species that are autochthonous in North America and underwent coevolution with the pathogen. Over the last hundred years resistance has been researched intensively in many many countries, for creating new to fungus diseases resistant cultivars.
Resistance breeding based on French-American hybrids

In Hungary grape resistance breeding emerged after the Second World War at university départements and also at research institutes for viticulture and enology. Back-crossing of Seyve-villard hybrids and others French-American hybrids started widely after 1957. The first result of this work was Zalagyöngye and further achievements like Bianca, Medina, Nero and others, bred by József Csizmazia and László Bereznai (1968). Many table and wine cultivars followed them: Pölöskéi muskotály and Teréz with the highest resistance, Palatina, Csillám, Viktória gyöngye, Duna gyöngye (Kozma et al., 1986). Despite of the remarkable success achieved, the final goal combining the complex resistance and the vine quality into one genotype was not reached using alone French-American resistance sources. This is mainly due to the polygenic character of inheritance at both of the attributes (Bouquet 1986).

Combining resistance genes of V. amurensis and French-American hybrids

Vitis amurensis, a wild grape from East-Asia was used as a resistance source against frost, but it came out, that some biotypes of the species are resistant to downy mildew. One part of V. amurensis x V. vinifera hybrids have good resistance to downy mildew (Koleda, 1974). This resistance is inherited by few genes on a dominant way (Stin,Filippenko 1974). Further new possibilities arose in cross breeding combination of Vitis amurensis hybrids and French-American hybrids. Kriszten (1990) made the first combination of the two resistance source: SV12375 x Alföld 100 (V. vinifera x V. amurensis BC1). From this family 2 individuals were selected for candidate variety and they were used succesfully for further backcrossing as well. In these candidate varieties fungus disease resistance, frost and winter hardiness and early ripening were combined into one genotype.

In 1984 a new resistance breeding program started within Hungarian- Yugoslavian cooperation in which progenies of French-American hybrids (Bianca, Zalagyöngye) and V. amurensis, BC2 hybrids were crossed (Cindric 1980, 1986).

Genetic analysis of hybrid families showed, that resistance to downy and powdery mildew is inherited dominantly, but degrees of resistance are defined by poligenic effects. Resistance and quality are inherited independently from each other. Analysis of these hybrids showed, that concerning resistance to downy mildew, the resistance of a part of the progeny can be better than their parents (Kozma 2000).

Progenies of Vitis amurensis and French-American hybrids are valuable donors for resistance breeding, mainly for creating high resistance to downy mildew (Kozma, 1997, 2000).

Piramidisation of resistance genes of Muscadinia rotundifolia, V.amurensis, French-American hybrids and V.vinifera

The Muscadinia rotundifolia resistance source is a new step in combining high level (symptomless) resistances and fruit quality. This species has monogenic powery mildew resistance and oligogenic downy mildew resistance among others. Bouquet (1983) described the symptomless downy mildew resistance of Muscadinia rotundifolia in a 3 genic model. Muscadinia hybrids originating from V. vinifera backcrosses which have inherited the powdery mildew resistance gene (RUN 1) show also downy mildew resistance. One of the downy mildew resistance genes is linked to the RUN 1 locus. The other one or two genes have probably drifted from the genom (Bouquet et al.2000). The VRH 3082-1-42 hybrid from the BC4 generation possess only one downy mildew resistance gene.
In 1999 we started a new crossing program in which we combine dominant powdery mildew and downy mildew resistance of (Muscadinia rotundifolia x V. vinifera) BC₄ hybrid with powdery mildew and downy mildew resistance of V. amurensis x V. vinifera x French-American complex hybrid (table1.) (Cindric et al. 2003, Kozma, Dula 2003). From this family the 99-1-48 individual was backcrossed by V. vinifera cv. Pinot noir, half of the progeny inherited the powdery mildew resistance and 40% of these individuals possessed the highest level of downy mildew resistance.

In a following cross the dominant powdery mildew and downy mildew resistance of (Muscadinia rotundifolia x V. vinifera) BC₄ hybrid was combined with the downy mildew resistance of V. amurensis x V. vinifera BC₂. We gained hybrids of symptomless powdery and downy mildew resistance within one genotype, because downy mildew resistance of V. amurensis, and M. rotundifolia completed each other (Kozma,Dula 2003). Moreover we were able to combine complex symptomless resistance with excellent wine quality, and found promising individuals after the first wine evaluations.

By using table grape cultivars for backcrossing we also have different hybrid families as basic materials for resistant table grape breeding, that will be combined among each other in the next generation.

Most of grapevine (Vitis vinifera) cultivars are susceptible to Erysiphe necator, but significant differences can be found in the grade of this attribute. There are some middle-asian cultivars with remarkable powdery mildew resistance in the subconvar. antasiatica group, cv. Kishmih vatkana the best among them (Filippenko, Stin 1977, Pospisilova 1978, Vojtovic 1987). The powdery mildew resistance of Vitis vinifera origin is a curiosity not only from breeding, but also from evolutionary and pathological point of view. This resistance is not the result of the coevolution of the host and pathogen, but rather due to abiotic stress adaptation.

In the progeny of a cross of the susceptible V. vinifera cv. Nimrang and the resistant V. vinifera cv. Kishmish vatkana a dominant monogenic form of inheritance was found. We named this powdery mildew resistance gene REN 1. This means, that cv. Kishmish vatkana is an effective source of powdery mildew resistance for breeding.

We have combined the two independently evolved resistance genes RUN 1 (from Muscadinia rotundifolia) and REN 1 from (V. vinifera), and expect the result of a secure and durable resistance against new races of Erysiphe necator.

To be able to distinguish individuals of RUN1, REN1 and RUN1+ REN1 resistance we use Marker Assisted Selection, since both genes are already mapped.

**Conclusion**

By combining the mono or oligogenic resistance of (Muscadinia rotundifolia x V. vinifera) hybrids, (Vitis amurensis x V. vinifera) hybrids and Vitis vinifera cv, Kishmish vatkana, it proved to be possible to breed new cultivars with high level complex resistance and excellent fruit quality in a traditional way.
Malaga seedling × *M. rotundifolia* G 52 (2n=40) × *V. amurensis* × *V. vinifera* F$_2$ population (2n=38)

F$_1$ NC 6-15 × Cabernet sauvignon

F$_1$ NC 6-15 × Cabernet sauvignon

BC$_1$ VRH 8628 × Grenache noir

BC$_1$ VRH 8628 × Grenache noir

Merlot noir × BC$_2$ VRH 5-18-79

Merlot noir × BC$_2$ VRH 5-18-79

BC$_3$ VRH 1-28-82 × Aubin

BC$_3$ VRH 1-28-82 × Aubin

BC$_4$ 3082-1-42 × SK 86-2-293 x Riesling

BC$_4$ 3082-1-42 × SK 86-2-293 x Riesling

BC$_5$ 99-1 (Bouquet, A. 1996)

BC$_5$ 99-1 (Bouquet, A. 1996)

Pedigree of 99-1 hybrid family

Figure 1. Pedigree of 99-1 hybrid family containing three resistance sources
Literature


