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Evaluation of resistance to grapevine powdery mildew (*Uncinula necator* [Schw.] Burr., anamorph *Oidium tuckeri* Berk.) in accessions of *Vitis* species

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Summary: 119 accessions, including species from America and Asia, various hybrids and breeding stocks, were tested for resistance to powdery mildew (*Uncinula necator*) by a leaf disc test. *Vitis candicans*, *V. munsoniana*, *V. piasezkii* and *V. rotundifolia* were found to be resistant with a rating of up to 1.4 in all accessions (1- no infection, 9- very strong infection). *V. munsoniana* and *V. rotundifolia* showed extremely high resistance and may be excellent material for breeding programs. However, the accessions of *V. candicans* and *V. piasezkii* should be preferred for breeding of powdery mildew resistant grapevine varieties because of the corresponding chromosome number. The surprisingly high number of 10 species included resistant as well as susceptible accessions. *V. doaniana* and *V. tiliaefolia*, probably *V. palmata* and most of the accessions of *V. shuttleworthii* may be characterized as moderately resistant. *V. cordifolia*, *V. lanata*, *V. rupestris* and some accessions of *V. vulpina* and cultivars of *V. vinifera* proved to be highly susceptible.

Prüfung verschiedener *Vitis*-Herkünfte auf Resistenz gegen den Echten Mehltau (*Uncinula necator* [Schw.] Burr., anamorph *Oidium tuckeri* Berk.)

Zusammenfassung: Mit dem Blattscheibentest wurden 119 Herkünfte verschiedener Arten aus Amerika und Asien, von Bastarden und Zuchtstämmen auf Resistenz gegen den Echten Mehltau (*Uncinula necator*) geprüft. Mit einer Bonitierung bis zu 1.4 (1 = keine Infektion, 9 = sehr starke Infektion) erwiesen sich alle untersuchten Herkünfte von *Vitis candicans*, *V. munsoniana*, *V. piasezkii* und *V. rotundifolia* als resistent. *V. munsoniana* und *V. rotundifolia* zeigten eine extrem hohe Resistenz und stellen damit ein ausgezeichnetes Material für die Züchtung dar. Wegen der mit *V. vinifera* übereinstimmenden Chromosomenzahlen sollten aber die Herkünfte von *V. candicans* and *V. piasezkii* für die Züchtung mehltauresistenter Rebsorten bevorzugt werden. Die überraschend hohe Zahl von 10 Arten schloß resistente und anfällige Herkünfte ein. *V. doaniana* und *V. tiliifolia*, wahrscheinlich auch *V. palmata* und die meisten Herkünfte von *V. shuttleworthii* können als teilresistent bezeichnet werden. *V. cordifolia*, *V. lanata*, *V. rupestris* und einige Herkünfte von *V. vulpina* sowie einige Sorten von *V. vinifera* haben sich als hochempfindlich erwiesen.

Key words: powdery mildew, Uncinula necator, Oidium tuckeri, resistance, Vitis species, breeding.

Introduction

Epidemics caused by powdery mildew (*Uncinula necator* (Schw.) Burr., anamorph *Oidium tuckeri* Berk.) have seriously increased in European vineyards in the last years. This may partly be due to the favourable climatic conditions for the development of the pathogen and likewise to a reduced efficacy of chemical control.

Resistance to powdery mildew has been investigated in different species and cultivars of *Vitis vinifera* by Boubals (1961) and Pospisilova (1978). In recent years intensive screening of germplasm has been carried out by Doster and Schnathorst (1985), Patil *et al.* (1990), Roy and Ramming (1990), Eibach (1994), and Wang *et al.* (1995).

Since Stein, Heintz and Blaich (1985) have elaborated a leaf disk test for powdery mildew resistance, large scale testing can be carried out by a relative simple laboratory method. In this paper the powdery mildew resistance of about 120 accessions of various *Vitis* species is presented. The same collection has already been tested for downy mildew resistance (Staudt and Kassemeyer 1995).

Materials and methods

Plant material: Accessions were received by courtesy of P. L. Forsline, National Germplasm Repository for Apple and Grapes, USDA/ARS/NAA, New York State Agricultural Experiment Station, Geneva, NY; Dr. J. A. Mortensen, IFAS, Agricultural Research Center, University of Florida, Leesburg, FL; Dr. A. Bouquet, Montpellier, Dr. M. A. Walker, Dept. of Viticulture and Enology, University of California, Davis, CA and Dr. B. Comeaux, Galveston College, Galveston, TX.

Source of inoculum: A population of *Uncinula necator*, maintained on *Vitis vinifera*, cv. Kerner, grown in a greenhouse was used as source of conidia.

Leaf disk test: Well grown leaves of the 5th or 6th insertion of shoots from plants grown in pots in a greenhouse under favourable conditions were washed with 70 % ethanol and subsequently with tap water to remove possibly existing hyperparasites, e.g. *Ampelomyces* spp., and dried with blotting paper. Ten disks of 16 mm in diameter were cut out with a corkborer. Five disks were displayed in petri

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dishes (9 cm in diameter) upside up. Two layers of moistened filter paper soaked with 5 ml H_2O ensured optimal humidity for the leaf disks. For inoculation, conidia of *U. necator* were brushed from the mycelium on the leaf disks immediately after the onset of sporulation. For each petri dish a cover glass was inoculated as control. After 4 d the density of the conidia and their germination were investigated. The density of conidia was about 1,000 per leaf disk. The petri dishes with the inoculated leaf disks were maintained in a growth chamber at 18 h fluorescent light and 25 ± 2 °C.

Test for resistance and rating: After 4, 8, 12, and 16 d the mycelium and the development of sporangiophores were rated by a stereo-microscop (60 x) according to the scheme published by STEIN *et al.* (1985) and the OIV (ANONYMOUS 1983):

1	no infection
2	very weak infection (< 2.5 % of the leaf area attacked)
3	weak infection (2.5 - 10 % of the leaf area attacked)
4 - 5	intermediate infection (11 - 25 % of the leaf area attacked)
6 - 7	strong infection (26 - 60 % of the leaf area attacked)
8 - 9	very strong infection (> 60 % of the leaf area attacked)

The ratings given in the text and tables are the result of at least two tests with two replications with 5 disks each. Accessions rated as resistant showed no infection after 2-4 tests or a mean maximum rating of 1.4 per test. In the latter case the individual rating of a disk never exceeded 2 (very weak infection). The highly susceptible *V. vinifera* cv. Kerner was used as control. The average rating was 5.0-8.5 per test.

Results and Discussion

As can be seen from Tab. 1, 119 accessions of 24 species, 7 unidentified species and 22 hybrids were investigated. More than half of the accessions were shown to be susceptible. *Vitis cordifolia*, *V. lanata*, *V. rupestris* and *V. vulpina* displayed a high susceptibility with ratings of about 8.5, similar to *V. vinifera* cv. Kerner.

V. candicans, *V. munsoniana*, *V. piasezkii* and *V. rotundifolia* displayed resistance in all accessions tested. These observations correspond to the results of BOUQUET (1986), who reported resistance of *V. rotundifolia* and of some *V. vinifera* x *V. rotundifolia* hybrids. The results obtained with *V. piasezkii* are in agreement with those of WANG *et al.* (1995), with the exception of *V. yenshanensis*.

In 10 species and in the hybrids of *V. vinifera* x *V. rotundifolia* and *V. rufotomentosa* x *V. vinifera* resistant and susceptible accesssions were found. In most cases the ratings for the susceptible accessions were up to 5.2 (*V. cinerea*). However, relatively low ratings were observed for the susceptible accessions of *V. doaniana* (1.9-2.9), *V. tiliaefolia* (1.2-2.2) and in most accessions of *V. shuttleworthii* (1.0-3.0, except one accession with 4.9). These species may, therefore, be designated as moderately resistant. This may be true also for *V. palmata* in the group of susceptible species, the accession of which showed a rather low rating of 2.7.

Compared to EIBACH (1994 a and b), who considered genotypes with a rating of up to 3 to be tolerable, classifi-

Table 1

Species tested for resistance to powdery mildew (*Uncinula necator*). (Rating see Materials and methods)

Species/Hybrids	Number of resistant accessions Rating 1.0–1.4	Number of susceptible accessions Rating 1.5–9.0
Species with all accessions being resistant		
V. candicans	2	-
V. munsoniana	5	-
V. piasezkii	1	-
V. rotundifolia	3	-
Species with resistant and susceptible accessions		
V. acerifolia	2	2
V. aestivalis	3	6
V. argentifolia	1	1
V. cinerea	4	4
V. doaniana	2	3
V. rubra	1	3
V. rufotomentosa	1	2
V. shuttleworthii	1	7
V. tiliaefolia	2	1
V. vulpina	1	2
Hybrids *V. vinifera* x *V. rotundifolia*	7	4
Hybrids *V. rufotomentosa* x *V. vinifera*	1	2
Unidentified species	4	3
Species with all accessions being susceptible		
V. amurensis	-	2
V. champinii	-	6
V. cordifolia	-	7
V. lanata	-	1
V. longii	-	2
V. palmata	-	1
V. rupestris	-	4
V. solonis	-	3
V. vinifera	-	3
V. yenshanensis	-	1
V. solonis x *V. amurensis*	-	1
V. solonis x *V. rupestris*	-	1
V. amurensis x *V. riparia*	-	1
Hybrids UC Davis	-	5

Table 2

Accessions tested as resistant to powdery mildew (*Uncinula necator*), their origin and resistance rating (see Materials and methods)

Species	Acc. No.	Origin	Test No. 1	2	3	4
V. acerifolia	ST 148	Comeaux No. 4830, TX	1	1		
	ST 150	Comeaux No. 3308, TX	1	1	1	
V. aestivalis	ST 160-1	Everglades Natl. Park, FL	1	1	1	
	ST 166	St. Marks, FL	1	1.1		
	ST 161	Everglades Natl. Park, FL	1.2			
V. argentifolia	ST 86	GVIT 896.01	1.3	1.4		
V. candicans	ST 177	♀ Leesburg, FL	1.3	1	1	
	ST 178	♂ Leesburg, FL	1	1	1	
V. cinerea	ST 117	GVIT 269.01	1	1	1	
	ST 136	GVIT 143.01	1.2	1	1	
	ST 174	Torreya State Park, FL	1.2	1.2	1	1.4
	ST 90,2-4	Comeaux No. 4877, TX	1	1	1	
V. doaniana	ST 109	GVIT 165.01	1.2	1.2	1	1
	ST 154	Comeaux No. 3296, TX	1	1	1.2	
V. munsoniana	ST 21	Z 6 UC Davis, CA	1	1	1	
	ST 75	cv. Marsh, Leesburg, FL	1	1		
	ST 82	cv. H 17-66 Leesburg, FL	1	1		
	ST 157A	Everglades Natl. Park, FL	1	1	1	1
	ST 162	Everglades Natl. Park, FL	1	1.2	1.4	
V. piasezkii	ST 127	GVIT 851.01	1	1	1.3	
V. rotundifolia	ST 30	Select. Cl. 55, UC, Davis	1	1	1	
	ST 168	Torreya State Park, FL	1	1	1	
	ST 139	H 17-66, Leesburg, FL	1	1	1	
V. rubra	ST 87	GVIT 239.01	1	1	1	
V. rufotomentosa	ST 78	AC 5-3 Leesburg, FL	1	1	1	
V. shuttleworthii	ST 172	Rogers No. 638, Leesburg	1	1	1	
	ST 88	GVIT 780.01	1	1	1	1.4
	ST 95	GVIT 775.01	1	1	1	
	ST 110	GVIT 825.01	1	1	1.1	
V. tiliaefolia	ST 90,8-1	Comeaux No. 4851, Mexico	1	1.3		
	ST 171	No. 32, Leesburg, FL	1	1	1.2	
V. vulpina	ST 165	Crystal River, FL	1.1	1.2		
Hybrids *V. vinifera* x *rotundifolia*	ST 16	Bouquet 8796	1	1	1	
	ST 17	Bouquet 8771	1	1		
	ST 18	Bouquet 8772	1	1	1	
	ST 19	Bouquet 8775	1	1	1.1	
	ST 20	Bouquet 12-3-76	1	1	1	
	ST 24	Bouquet 25-4-76	1	1	1	
	ST 26	Bouquet 25-9-76	1	1	1	
Hybrid *V. rufotomentosa* x *vinifera*	ST 42	171-13 UC Davis, CA	1	1	1	
Unidentified species	ST 84	GVIT 774.01	1	1	1	

cation of resistance in this study is rather severe. However, considering that wild species were tested and that an extensive breeding program will probably follow the first crossing with the resistant stock, the pretension for the level of resistance should be rather great. Some of the accessions seem to be valuable sources for resistance breeding to powdery mildew (Tab. 2). However, further investigations are needed to inquire the resistance of berries. The latter seems to be more important than that of leaves due to the high incidence of berry infections. As has been pointed out by EIBACH *et al.* (1989) and EIBACH (1994 b), the degree of leaf infection must not necessarily correspond with that of the berries. Although in single cases significant correlations were found between foliar and berry resistance, in many cases considerable differences occurred.

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