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Evaluation of downy mildew resistance in various accessions of wild *Vitis* species

by

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S u m m a r y : 107 accessions of 21 species from America and East Asia were investigated for resistance to downy mildew, *Plasmopara viticola*, by the leaf disc test. The species, *Vitis rotundifolia*, *munsoniana* and *yenshanensis* showed resistance in all accessions investigated (rating 1.0). *Vitis cinerea*, *palmata* and *shuttleworthii* can be rated as moderate resistant (rating 1.1 - 1.9). In *V. candicans*, *doaniana*, *piasezkii*, *riparia*, *rubra* and *tiliifolia* resistant as well as susceptible accessions were observed. In *V. acerifolia*, *aestivalis*, *amurensis*, *champinii*, *lanata*, *rupestris*, *solonis*, *vinifera* and *vulpina* all accessions showed susceptibility to the fungus, the rating varied from 1.1 to 7.2.

K e y w o r d s : downy mildew, Plasmopara viticola, resistance, grape breeding, Vitis species.

Introduction

Downy mildew, *Plasmopara viticola* (De Bary) Berlesè et de Toni, is still the most important fungus disease in many wine-growing regions. Although different fungicides are known to be satisfactory tools for controlling downey mildew infections resistant varieties should be favoured to omit spraying and, subsequently, to reduce production costs.

Soon after the introduction of *P. viticola* from America to Europe in the middle of the last century great efforts were made to breed varieties resistant to the fungus. Native species from America, i.e. *V. aestivalis*, *cinerea*, *lincecumii*, *riparia*, *rupestris*, and *labrusca* were used as resistant sources by French breeders. Several resistant cultivars which are in test in Europe today can be traced back to these hybrids (Staudt *et al.* 1984).

Sources of resistance to *P. viticola* within *V. vinifera* have been searched for several times and differences in the susceptibility among the cultivars have been investigated (Vederevskij *et al.* 1965, Li and Doazan 1985). But they did not meet the demands for breeding a resistant variety. Therefore, native resistant wild species of America and Asia still seem to represent the best sources for resistance breeding (Espino and Nesbitt 1982; Zhang *et al.* 1990).

A series of wild species has been collected on occasion of an extensive programme for screening resistance to transmission of viruses by nematodes (Staudt and Kassemeyer 1990, Staudt and Weischer 1992). About 100 of these accessions were also screened for resistance to *P. viticola* and the results will be presented herewith.

Materials and methods

P l a n t s : Various 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. M. A. Walker, Department of Viticulture and Enology, Davis, CA; Dr. B. Comeaux, Galveston College, Galveston, TX; and several accessions were collected by G. Staudt mainly in Florida.

No efforts were made to straighten out the correct taxonomy of the accessions used.

L e a f d i s c t e s t : Well grown leaves from the 5th and 6th insertion per shoot were washed under running water and subsequently dried with kleenex. Discs of 16 mm in diameter were cut out with a corkborer. Seven discs each were placed upside down in petri dishes of 5 cm in diameter floating on 10 ml tap water. The upper dish was layed out with filter paper in order to increase air humidity.

I n o c u l u m : A strain of *P. viticola* was used which was isolated from the vineyards in Freiburg. This strain was maintained on plants of cv. Müller-Thurgau, which is highly susceptible to *P. viticola*, or sporangia were collected from spontaneous infections in the field. The sporangia were carefully taken off the sporangiophores with a moist brush and collected in a tube containing tap water. The number of living sporangia, which displayed a hyalin plasma and which were white coloured, was calculated with a hematocytometer. The suspension was diluted to a concentration of 20,000 to 30,000 sporangia per ml by adding tap water.

I n f e c t i o n : With a piston-pipette 50 µl droplets containing 1, 000 - 1, 500 sporangia were applicated to the lower surface of the leaves. The inoculation was carried out during the light period (14 h, HQL, 10 klx) at 21 ± 2 °C in a growth chamber.

I n c u b a t i o n : 24 h after inoculation droplets were removed from the leaves by a vacuum pump under low pressure. The time of incubation was 5 d.

T e s t f o r r e s i s t a n c e a n d r a t i n g : Five days after inoculation symptoms were noted with a stereomicroscope for the first time. The rating was repeated af-

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ter two days. According to the UPOV-rating-system the following scheme was used:

1: No symptoms at all; in case of necroses this is specially noted. 3: One to a few sporangiophores, which are barely seen by the naked eye; they can only be observed by a stereo-microscope. 5: Dissolute sporangia patches which can easily be detected. 9: Many sporangiophores produce a dense sporangia patch as on cv. Müller-Thurgau.

Accessions which did not produce any sporangiophore were rated as resistant. All accessions rated resistant in 1990 were tested again in 1991. Of the resistant accessions several showed strong hairiness on the lower side of the leaves. In order to know whether the resistance was caused by the hairiness the hairs were removed by a rasor blade or forceps and subsequently the spots were inoculated according to the normal testing procedure.

Results and discussion

As can be seen from Tab. 1, 107 accessions of 21 species were investigated. Of three species all accessions showed resistance to *P. viticola*. This statement may be valid only for *V. munsoniana* and *V. rotundifolia*. In these two species, resistance may probably be traced back to the same strong system of host hypersensitive response which is also operating for the resistance to virus transmission by nematodes (STAUDT and WEISCHER 1992). According to the investigations of EIBACH *et al.* 1989, and ZHANG *et. al.* 1990, a similar strong resistance may be valid in *V. yenshanensis*. But further investigations are necessary to verify the results concerning *V. yenshanensis*. If one accepts ratings of up to 1.9 still as resistant, or at least as moderate resistant, *V. cinerea, V. palmata* and *V. shuttleworthii* may also be put in order here. One accession of the hitherto unidentified species showed also resistance. According to recent observations (P.L. FORSLINE by personal communication, 1994) it probably belongs to *V. rubra*.

The rating of 6 other species clearly showed resistant as well as susceptible accessions within the same species. This was observed in *V. candicans, V. doaniana, V. piasezkii, V. riparia, V. rubra*, and *V. tiliifolia* (Tab. 1 and 2). Similar results were reported by DIEHL (1988). .

The remaining 9 species and in addition 8 accessions of the unidentified species showed susceptibility in all accessions. Among the 9 hybrids investigated, three accessions showing resistance or moderate resistance originated from crosses with *V. rotundifolia*. The parents of the susceptible hybrids belonged to *V. amurensis, V. riparia, V. rubra, V. rufotomentosa, V. rupestris* and *V. solonis*.

Except the accessions of *V. munsoniana* and *V. rotundifolia* most of those which had been shown to be resistant had leaves with dense prostrate hairs on the lower surface. To test whether this morphological character implied the resistance to *P. viticola* or whether the resistance was due to a plant-cell reaction, the hairs of the lower surface of the leaves were removed and the leaves subsequently inoculated and rated as usual. Several accessions formerly rated as resistant now showed susceptibility. Two accessions of *V. candicans* and *V. shuttleworthii* showed a resistance rating of 1.3 and 1.0, respectively. This indicates that the resistance was caused by a cell reaction. But there was also an accession of *V. shuttleworthii* which displayed now susceptibility after removal of hairs.

All resistant accessions showed necroses after the infection with sporangia of *P. viticola*. This may be explained by a host hypersensitive response reaction.

Table 1

Species tested, susceptible and resistant (rating 1.0) accessions

Vitis species	Susceptible accessions	Rating	Resistant accessions
acerifolia	7	2.0 - 4.7	-
aestivalis	13	1.1 - 6.0	-
amurensis	2	1.1 - 2.2	-
candicans	1	1.0 - 2.3	1
champini	5	3.9 - 7.2	-
cinerea	4	1.0 - 1.8	3
doaniana	4	1.0 - 3.4	1
lanata	1	4.3	-
munsoniana	-	1.0	5
palmata	1	1.4	-
piasezkii	1	1.0 - 3.8	2
riparia	1	1.0 - 2.4	1
rotundifolia	-	1.0	7
rubra	3	1.0 - 6.4	1
rupestris	3	3.5 - 6.6	-
shuttleworthii	3	1.0 - 1.9	2
solonis	3	1.5 - 3.2	-
tiliifolia	2	1.0 - 5.0	1
vinifera cv. Mü-Th.	1	6.3	-
vulpina	9	1.6 - 5.9	-
yenshanensis	-	1.0	1
species unidentified	9	1.1 - 5.8	1
hybrids	8	1.3 - 7.4	-

Conclusion

Genes for resistance to *P. viticola* introduced by French breeders originated from restricted resources, i.e. only from certain North American species. To meet the present day demands, a broading of the spectrum of genes for resistance is urgently needed. Because of the different chromosome numbers the genes for strong resistance of *V. munsoniana* and *V. rotundifolia* will probably not be available in the next decades for our breeding programmes. Therefore, all efforts should be made to introduce as many resources of the genus as possible from other regions for subsequent screening.

A few accessions can be offered from our investigations of which the Asiatic *V. yenshanensis* and others from North America should be worthwhile to be included in breeding programms for resistant grapevine varieties. Es-

Table 2

Origin of resistant and moderate resistant (rating < 2.0) accessions

Species	Acc. No.	Origin	Rating
V. aestivalis	ST 86	GVIT (Geneva) 896	1.6
	ST 161	Everglades Park, FL	1.3
	ST 166	St. Marks, FL	1.7
	ST 167	Bristol, FL	1.1
V. amurensis	ST 115	GVIT (Geneva) 689	1.1
V. candicans	ST 178	♂ Leesburg, FL	1.2
V. cinerea	ST 70	WBI Freiburg	1.8
	ST 117	GVIT (Geneva) 269	1.1
	ST 122	GVIT (Geneva) 601	1.0
	ST 125	GVIT (Geneva) 170	1.6
	ST 136	GVIT (Geneva) 143	1.2
	ST 90,2-7	Comeaux No. 4877, LA	1.4
	ST 90,5-5	Comeaux No. 4880, LA	1.0
V. doaniana	ST 109	GVIT (Geneva) 165	1.3
	ST 151	Comeaux No. 3390, TX	1.8
V. munsoniana	ST 15	Z 6 (Select. 2) UC Davis	1.0
	ST 82	cv. H 17-66, Leesburg, FL	1.0
	ST 75	cv. Marsh, Leesburg, FL	1.0
	ST 21	Z 6 (Select.1) UC Davis	1.0
	ST 22	Z 5 UC Davis	1.0
V. palmata	ST 90,3	Comeaux No. 3389, LA	1.4
V. piasezkii	ST 111	GVIT (Geneva) 857	1.0
	ST 133	GVIT (Geneva) 855	1.0
V. riparia	ST 182	No. 1 Geisenheim	1.0
V. rotundifolia	ST 2	Select. 2 UC Davis	1.0
	ST 3	Select. 3 UC Davis	1.0
	ST 4	Select. 4 UC Davis	1.0
	ST 29	Clone 55 UC Davis	1.0
	ST 30	Select. 25/26 UC Davis	1.0
	ST 168	Torreya State Park, FL	1.0
	ST 27	Clone 52 UC Davis	1.0
V. rubra	ST 124	GVIT (Geneva) 174	1.0
V. shuttleworthii	ST 80	cv. Kissimee, Leesburg, FL	1.0
	ST 79	cv. Haines City, Leesburg, FL	1.0
	ST 80	cv. Kissimee, Leesburg, FL	1.0
	ST 163	Manatee Lake, FL	1.1
	ST 164	Webster, Hwy 75, FL	1.3
	ST 172	Rodgers No. 638, FL	1.9
V. solonis	ST 135	GVIT (Geneva) 158	1.5
V. tiliifolia	ST 90,8-4	Comeaux 4851, Mexico	1.0
V. vulpina	ST 100	GVIT (Geneva) 920	1.8
	ST 138	GVIT (Geneva) 1009	1.6
	ST 165	Crystal River, Hwy 19, FL	1.8
	ST 175	Torreya Park, FL	1.6
V. yenshanensis	ST 120	GVIT (Geneva) 743.a	1.0
Species unidentified	ST 87	GVIT (Geneva) 239	1.0
Hybrids	ST 71	NC 75c 035-14, Leesburg, FL	1.3
	ST 143	cv. Demchel, Davis, CA	1.5

pecially *V. yenshanensis* from East Asia seem to be a valuable source as has been already pointed out by EIBACH *et al.* (1989) and ZHANG *et al.* (1990).

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