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Short communication

Reaction of *Vitis* genotypes at the National Active Germplasm Site to downy mildew infection under tropical humid conditions of India

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ABSTRACT

Two hundred and sixty six grape accessions at National Centre for Grapes, Pune were evaluated for their resistance / susceptibility to downy mildew during three consecutive natural epiphytotic conditions from 2004 to 2006, using the IPGRI/UPOV/OIV rating scale of 1-9. Twelve accessions, *viz*. Maroo Seedless, Bianca, Sirius, Madhu Angoor, Khalili, Seyve-Villard 12-375, Seyve-Villard 23-501, EC 38478, Carolina Black Rose, Seyve-Villard 18-315, Seyve-Villard 12-309 and Seyve-Villard 18-402 were rated as highly resistant. Seven accessions, *viz*. Seibel 9813, Seibel 9308, Seyve-Villard 12-364, Champanel, Amber Queen, 1613 C, Sauvis IP 365 were rated as resistant. The field reaction of these accessions was confirmed *in vitro* by leaf disc technique. Accessions H-533 and Concord (*V. labrusca*) were rated as moderately susceptible. All other accessions, including most of the commercial cultivars were found susceptible to highly susceptible to downy mildew.

Keywords: Downy mildew, grape germplasm, natural infection.

Grape is an exotic and remunerative fruit crop of India with high nutritional value. Commercial cultivars belong to *V. vinifera* L., which is highly susceptible to downy mildew disease caused by *Plasmopara viticola* (Berk. & Curt.) Berl. & de Toni. It causes severe loss under epiphytotic as well as non-epiphytotic conditions (Sawant *et al*., 12). Viticulture is thus not only a risky enterprise but also costly as a number of prophylactic and curative fungicide applications are necessary (Sawant and Sawant, 8). Further, the development of resistance in the pathogen against the commonly used fungicides is posing a serious threat to the dependence on only chemical based disease management strategy. Apart from cultivating resistant varieties, breeding for disease resistance is a viable, sustainable option to manage the problem (Blattner and Schaller, 2). Identification of the gene(s) responsible for resistance and their introgression into commercial varieties is desirable for sustained grape production. Availability of resistance sources having different mechanism opens up the possibilities to identify major QTLs and linked markers for marker-assisted selection and gene pyramiding.

The earlier observations on downy mildew resistance in grape were based on evaluation of limited germplasm at different geographical locations and probably using different rating scales (Datar, 4; Patil, 7; Patil *et al*., 6; Thind *et al*., 10; Verma *et al*., 11), and thus a comparative rating of wide number of accessions is not available. The aim of the present study was to evaluate the reaction of the consolidated grape accessions to downy mildew disease under uniform tropical humid environmental conditions following a standard evaluation scale, to i) identify the sources of resistance for breeding programm, ii) select accessions for the development of molecular markers, and iii) find promising downy mildew resistant table and wine grape varieties suitable for organic viticulture.

The 266 grape accessions maintained at the National Active Germplasm Site of the National Research Center for Grapes, Pune, were evaluated for resistance to downy mildew under natural epiphytotic conditions during three consecutive monsoon seasons from 2004-2006. This included indigenous and exotic table, raisin, wine, juice and rootstock varieties, *Vitis* species or their hybrids. The vines were grafted on Dogridge rootstock, planted at a spacing of 304 cm ×183 cm, trained on Y trellises and were 6-year-old at the beginning of the study. The genotypes with unknown reaction were interspersed with known susceptible genotypes providing ideal conditions for screening.

Ratings were done when heavy infection of downy mildew was observed on the vines of susceptible cultivars, *viz*. Thompson Seedless and Flame Seedless. The first six leaves on young growing shoots of all the twelve vines of each accession were scored on a resistance/susceptibility scale of 1-9 by observing the level of infection of *Plasmopara viticola* on the

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leaves (IPGRI/UPOV/OIV, 5). The three-year ratings were averaged, and the accessions that scored a rating between 1 to 3 were re-evaluated *in vitro* using leaf disc technique (Staudt and Kassemeyer, 9) for confirmation of its resistant reaction. The discs were observed under Leica MZ12.5 stereo zoom microscope and observations were recorded based on the UPOV rating system (IPGRI/UPOV/OIV, 5). The experiment was repeated twice.

Twelve accessions were rated as highly resistant as they scored a rating of 1 in field screening (Table 1). Eight of these accessions scored a rating of 1 in *in vitro* screening, too, while four scored a rating of more than 1 but less than 3. Seven accessions scored average rating of more than 1 but less than 3, in both field and *in vitro* evaluation, hence were rated as resistant. The comparative reaction of the Seyve-Villard hybrids to *Plasmopara viticola* is presented in Fig. 1a and 1b. Accession H-533 and Concord (*V. labrusca*) (Fig. 1c) were rated as moderately susceptible as they scored a rating of more than 3 but less than 5. All other accessions, including most of the commercial cultivars were found susceptible (47 accessions) to highly susceptible (198 accessions) to downy mildew. Thompson Seedless from all sources was highly susceptible. Rangspey Black, an indigenous collection from Kinnaur was also susceptible. Based on this study 44 accessions with varying level of resistance/ susceptibility were selected for marker analysis with large number of microsatellite primers to identify the closely associated markers.

The nineteen downy mildew resistant to highly resistant accessions including the French inter-specific hybrids, *viz*. the six different Seyve-Villard accessions and the two Seibel accessions can be used in hybridization for evolving downy mildew resistant cultivars. Some of them can be used for fruits, e.g. Maroo Seedless, a cross of Carolina Black Rose and Ruby Seedless made at CSIRO, Australia, with medium to large seedless fruit with bluish-black skin and firm flesh; Carolina Black Rose, itself, is an interspecies cross (a hybrid between *vinifera* and some of the French hybrids) developed in USA; Madhu Angoor, a clonal selection from Carolina Black Rose, made by the Grape Research Centre, Hyderabad; Amber Queen, the interspecific cross (*vinifera*; *labrusca*; *riparia*) from USA can be suitable for the Indian table grape industry. Khalili and Seibel 9308 are early ripening varieties (Anon, 1; Chadha and Shikhamany, 3) and hence will be more suitable for north India.

Among the wine varieties through found to be resistant to downy mildew, Champanel, can be used for both wine and table purpose and is also resistant to heat and drought and adapts well in any soil, including alkaline and black soils; Bianca (Seyve-Villard 12-375 × Bouvier), a white wine variety of Hungarian origin, which is reported to be resistant to powdery mildew also as well as giving good quality wine; Sirius, a disease resistant late budding variety, bred at French Guiana from Villard Blanc × Bacchus, and producing Riesling type wine; Seyve-Villard 12-375, a white wine grape, hold promise. These varieties can be grown under organic culture regime or used as a parent for breeding for downy mildew resistance.

Datar (4) found Khalili, Goethe, Malagha, Westfield, and Buckland Sweet Water as moderately susceptible; on the contrary our study rated Khalili as resistant under field as well as *in vitro* conditions, Goethe, Malagha and Westfield as susceptible and Buckland Sweet Water as highly susceptible. However, in both the studies Amber Queen was found as resistant to downy mildew. Similarly Patil (7) reported varieties Concord, Bangalore Blue and Catawba as resistant, while in this study they were found moderately susceptible to susceptible. These differences in observations could be due to geographical conditions or different rating scales used for the assessment.

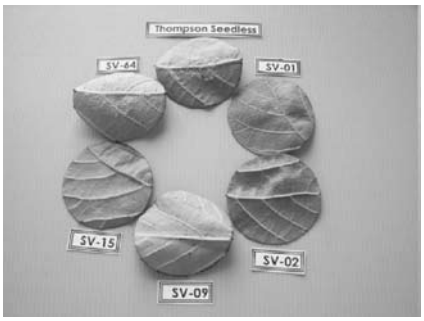

Fig. 1a. *In vitro* reaction of Seyve-Villard hybrids to *Plasmopara viticola.*

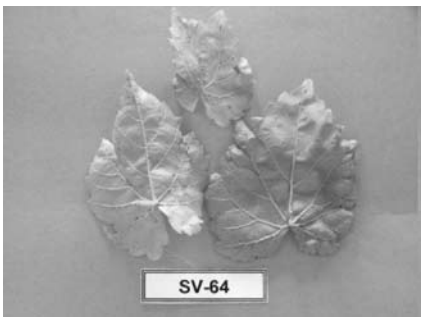

Fig. 1b. Field reaction of Seyve-Villard hybrid 12-364 to downy mildew.

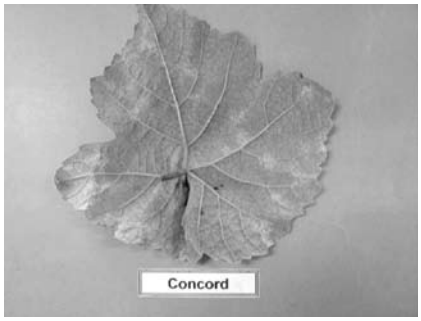

Fig. 1c. Field reaction of Concord to downy mildew.

Table 1. Reaction of grape accessions to downy mildew disease.

1.	Highly resistant
i.	(A rating of 1 in field and *in vitro*)
	Maroo Seedless, Bianca, Sirius, Madhu Angoor, Khalili, Seyve-Villard 12-375, Seyve-Villard 23-501, EC 38478
ii.	(A rating of 1 in field but > 1 to < 3 *in vitro*)
	Carolina Black Rose, Seyve-Villard 12-309, Seyve-Villard 18-315, Seyve-Villard 18-402
2.	Resistant (a rating of ≥ 1 to < 3 in field also *in vitro*)
	Seibel 9813, Seibel 9308, Seyve-Villard 12-364, Champanel, Amber Queen, 1613 C, Sauvis clone IP 365
3.	Moderately Susceptible (a rating of ≥ 3 to < 5)
	H-533, Concord
4.	Susceptible (a rating of ≥ 5 to 6.9)
	A3-1 (*V. labrusca*), A4-2 (*V. labrusca*), A7-2 (*V. labrusca*), A8-3, Angoor Kalan, Arka Shyam, BA × BS-71-50, Bangalore Blue, Barbarossa, Beauty Seedless, Benzuhio, Black Muscat, Black Round, Catawba, Charas, Convent Large Black, Crimson Seedless, Diamond Jubilee, E12/3, E5/12 (AES × BC), E6/2, Fruhroter Veltliner, Grasa de Contenoir, Gulabi (Muscat Hamburg), Isabella (B10-2), Kinnauri-1, Kinnauri-2, Lake Emerald, Malvasia Bianca de Vaparis, Motia, Muscat White, Olympia, Pearl of Csaba, PSIII-8-6, Rangspey Black, Rizamat, Sekerie, Sonaka, Spin Sahebi × Pandhari Sahebi, Tannet, A18-1 (*V. solonis* × *V. riparia*) and other seven accessions, *viz*. E2/7, Goethe, Jaffayam, malagha, Pierce, Rose Ciolet and Rose of Peru (*V. labrusca*), which were found to be identical genotypes by microsatellite analysis.
5.	Highly susceptible (a rating of 7.0 - 9.0)
	A3-3, A39-2, AES × BM, Alamwick, Alden, Amber Sweet, Anab-e-Shahi, Angoor Kalan, Arka Chitra, Arka Hans, Arka Kanchan, Arka Krishna, Arka Majestic, Arka Neelamani, Arka Shweta, Arka Soma, Arka Trishna, Arkavati, Armas, Athens, BA × Per-75-32, Babeasca Neagra, Bangalore Purple, Banqui Abyad, Black Champa, Black Damas Rose, Black Monukka, Black Prince, Black Seedless, Buckland Sweet Water, Cabernet Sauvignon, Cardinal, Carignane, Castiza, Centennial Seedless and its clone (Manjari Naveen), Champach, Charark-2, Charark-4, Chardonnay, Cheema Sahebi, Chenin Blanc, Christmas Rose, Clairette, Coarna Niagra, Coarna Regia, Country Bangalore, Delight, Dilkush, Doradillo, E8/5, E30/14 (BC×TS), E21/28, E34/29 (CS×CLB), Early Perlette, Fantasy Seedless, Fateasca Alba, Fateasca Niagara, Flame Seedless, Foster Seedling, Garganega, Golden Queen, Grenache Blanc, Grenache Noir, Gulabi-1 (B 28-3), Gulabi-2, Gulabi × Bangalore Purple, Gulabi × Fakri, H-144, H-27, H-5, Haitha, Husain Black Kabuli, Husain Kadu, Hy23-14-23, Italia, Italia (Korean), Jaos Beli, Julesky Muscat, Kali Sahebi, Katta, Katta Kurghan, Keonigin Der, Kismish Chernyi and its clone (Sharad Seedless), Large White, Madeleine Angevine, Merbien Seedless, Merlot, Muscat, Muscat Hamburg, Muscat Petit Grains, Niagra Vertis, Omania Black, Palomino, Pandhari Sahebi, Perlette and its clones (Loose Perlette and New Perlette), Peru White, Pinot Noir, Pusa Navrang × Chardonnay T-(A 48-1), Pusa Navrang, Pusa Navrang × Red Globe, Pusa Navrang × Flame Seedless, Pusa Urvashi, Queen of Vineyards, Red Globe, Red Muscat, Red Muscat Selection (A 16-2), Red Prince, Ribier (Alphonse Lavalle), Rubi Red, Ruby Seedless, Sahebi Ali, Sangiovese, Saperavi, Semillon, Shiraz, Spin Sahebi, Sultanine-II, Sundekhani Seeded, Superior Seedless, Tempranillo, Thompson Seedless and synonym (Sultana) and its clones (2A clone, Sonaka mutant, Sonaka, Pusa Seedless, Tas-A-Ganesh, Vijay Chaman, Kishmish Rozavis, Kishmish Rozavis White, Kishmish Beli, Manik Chaman, Maruti Seedless), Tigvosa, Trebbiano, Tsimlanski Cherryi, Ugni Blanc, Venus, Vermentino, Victoria, Viognier, *Vitis parviflora* (Kinnaur), *Vitis parviflora* (open pollinated seedlings), Waltham Cross, Westfield, White Sweet, E31/4 (BC × TS), E32/8 (BC × TS), Hy17-54-4-17, MA × RR-76-3, A23-1, A25-1(Black Wine), E2/1, A2/3 (*Vitis* spp.), E-2/7, 2PSIII-13-2, A3-1 (*V. labrusca*), A 18-3, A25-3 (Kishmish Red), E26/3, E29/3 (BC × TS), A4-2 (*V. labrusca*), E4/15 (AES × BB), E-19-4 (BB × CS), E 4/30 (AES× BC), E5/4, E5/12 (AES × BC), E5/20 (AES × BC), E31/5 (BC × TS), A6-1, E6/2, A15/2 (19/20), E 29/6 (BC × TS), A7-2 (*V. labrusca*), A7-3, E7/24 (AES × CLB), E29/7 (BC × TS), A8-3, E-8/5, PSIII-8-6, E8/24 (AES × CLB), F26/8, B9-3, E-9/3, A11-1, PSII-11-1, PSIII-11-4, E12/2 (BB × CLB), E12/3, PSIII-12-3, PSIII-12-14, two accessions, *viz*. Gold and Fakri with identical microsatellite profiles and other two accessions Arki and Ceffer which are identical genotypes.

Abbreviations : AES = Anab-e-Shahi, BA = Banqui Abhyab, BB = Bangalore Blue, BC = Black Champa, CLB = Convent Large Black, CS = Cheema Sahebi, MA = Madeleine Angevine, PN = Pusa Navrang, RR = Ruby Red, TS = Thompson Seedless

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