PRELIMINARY FIELD STUDIES OF RESISTANCE OF GEORGIAN GRAPEVINE GERMPLASM TO POWDERY MILDEW (*ERYSIPHE NECATOR*)

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Abstract:

Context and purpose of the study
Erysiphe necator Schwein is a fungus that causes grapevine powdery mildew. It is one of the most problematic pathogens attacking *Vitis vinifera* L. The pathogen infects all green parts of the plant and reduces grape yield and quality. The suppression on mildew-susceptible cultivars requires intensive use of fungicides against pathogen, which has negative impact on the environment and human health. The identification, quantification, and use of host resistance is therefore a research priority favored by grape growers, genetics, breeders and winemakers, governments, regulatory and grant agencies.

At the end of 19th century, the breeding programs were carried out by crossing *V. vinifera* with resistant species, and in particular with North American Vitis that co-evolved with the pathogen. However, obtained hybrids were mostly unsuitable for the production of high-quality wines, due to their unpleasant foxy aromas. Nearly all major cultivars of *V. vinifera* exhibit little evidence of strong genetic resistance against *E. necator*, with the exception of ontogenic resistance that appears to be a universal trait. However, recent studies have indicated that certain *V. vinifera* cultivars of Caucasus and Central Asian origin exhibit an unusual degree of field resistance to powdery mildew. Some Georgian *V. vinifera* accessions from the South Caucasus have been reported to be resistant to *E. necator* and to have no known genetic relationship to non-vinifera species. The aim of our preliminary research was to quantitatively measure the field resistance of local Georgian varieties to powdery mildew, as a necessary first step to more in-depth phenotyping and genetic studies.

Material and methods
Three Georgian grapevine collections (Shumi, Mukhrani, and Jighaura) were monitored three times per year in order to reveal resistance to powdery mildew of Georgian *V. vinifera* germplasm (both cultivated and wildly-growing grapevines) in the field condition. Resistance to powdery mildew was recorded as field ratings of disease incidence and severity following natural infection at different phenological stages in June, August, and September based on the OIV 455 descriptor for the leaf and OIV 456 for cluster resistance.
The evaluation was conducted on the cultivated vines treated with commonly-used fungicides for disease management in the collections.

Results
We assessed the resistance of 346 Georgian grapevine varieties under field conditions in 2022. Twenty seven of the foregoing varieties revealed very high resistance to powdery mildew, 62 had high resistance and 221 medium resistance, and 36 low or very low resistance. Our results suggest that there is substantial diversity in resistance to powdery mildew among the foregoing local varieties of *V. vinifera*.

Keywords: Grapevine, Erysiphe, Susceptibility, South Caucasus, OIV

1. Introduction

Georgia in the South Caucasian region is considered one of the most important primary centers of grapevine domestication, in the larger area comprising Oriental Anatolia, Syria, and Northern Mesopotamia, where the first viticulture emerged, towards the middle of the 6th Millennium BC (Forni 2012). The region is rich in grapevine diversity and wild grapevines are widely present in the area (Maghradze et al. 2012). Georgian grapevine germplasm consists of about 525 cultivars (Ketskhoveli et al. 1960) and distinguished with high genetic variability (De Lorenzis et al. 2015) and various ampelographic characters, agronomical traits, and phenological diversity (Maghradze et al. 2012).

Erysiphe necator Schw. is a fungus that causes powdery mildew of grapevine. It is a common pathogen of Vitis species, including the wine grape of *Vitis vinifera* which is the most cultivated grapevine species worldwide. In certain weather conditions the pathogenic fungus infects all green parts of the plant causing losses in grape yield and quality.

The control of downy mildew on grapevine requires regular application of fungicides. But it has to be mentioned that the intensive use of chemicals has a negative impact on the environment and human health (Blasi et al. 2011). Cultivation of the resistant grapevine varieties is a good method for reducing damage due to powdery mildew. In the 19th century, breeding programs were carried out by crossing *V. vinifera* with resistant species and in particular with American Vitaceae that co-evolved with the pathogen. However, obtained hybrids were unsuitable for the production of high-quality wines, due to their unpleasant foxy aromas coming from the American species of the Vitis genus (Eibach and Töpfer, 2015)

It is believed that *V. vinifera* has little or no genetic resistance against *E. necator* but the observation of Georgian scientists (Gotsiridze 1980) and recent studies of European researchers reviled some varieties resistant to the powdery mildew-causing fungus (Possamai et al. 2021). Some Caucasian *V. vinifera* accessions have been reported to be resistant to *E. necator* and to have no genetic relationship to known sources of resistance to powdery mildew. The Georgian varieties 'Shavtsitska' and 'Tskhvedianis Tetra' showed strong partial resistance to *E. necator* which segregated into two cross populations: the resistant genotypes delayed and limited the pathogen mycelium growth, sporulation intensity, and a number of conidia generated (Possamai et al. 2021). These studies are based on the investigation of part of the Georgian grapevine germplasm, a larger part of which was not studied yet.

The aim of the research was a screening of the Georgian grapevine germplasm to susceptibility Powdery mildew under field conditions in different grapevine collections in Georgia.

2. Material and methods

Plant material and growing conditions

Resistance to powdery mildew was recorded following natural infection at different collections of grapevines in Georgia: Shumi (GEO036 according to FAO codding), Mukhrani (GEO031), and Jighaura (GEO038) in order to reveal resistance to powdery mildew of Georgian *V. vinifera* germplasm (both cultivated and wildly growing consisting with escaped, or feral and *Vitis sylvestris* grapevines). The evaluation was done on the grapevine accessions were treated with commonly-used fungicides for disease management in the collections.

2.1 For the evaluation of the attacked patches of all the leaves from 4 - 6 vines at two periods, after the onset of flowering (young leaves) and before or after vintage (mature leaves). For the evaluation of the disease, there were used scores according of OIV 455 descriptors as following: 1 = unlimited infection; complete or nearly complete attack of the leaves - ample mycelium and fungus fructification; 3 = vast attacked patches, some of them limited - leaf blade, partly attacked – obvious mycelial growth and fungus fructification; 5 = attacked patches usually limited with a diameter of 2-5 cm; 7 = limited attacked patches with a diameter of less than 2 cm - little mycelium and limited fungus fructification (the presence of *Oidium* is only indicated by a slight curling of leaf blade); 9 = greatly suppressed symptoms or none at all – no mycelium or visible fructification (merely a slight curling of leaf blade).

2.2 Evaluation of Oidium attack on all the clusters from 4 – 6 vines was done in periods, before veraison and before vintage. For disease evaluation has been used scores according of OIV 456 descriptors as following: 1 to 3 = very many berries of all clusters attacked with Oidium (all clusters are attacked, some, however, can be attacked moderately) – many cracked berries; 5 = many attacked berries (up to 30 %), most clusters are moderately attacked, some, however, can be attacked severely –cracked berries are rare; 7 to 9 = only a few

berries out of all clusters are attacked (a few clusters only are slightly attacked) no cracked berries.

2.3 *Statistical analysis* - Data were analyzed by using GraphPad Prism 5 software (GraphPad Software, Inc., La Jolla, CA, USA).

3. Results and discussion

The first evaluation of the patches of the growing leaves (on May 15-25. 2022) after the onset of flowering didn`t reveal any symptoms of *E. necator* in any of Georgian grapevine collections. It has to be mentioned that cultivated vines were treated with commonly-used fungicides for disease management. Another reason can be non-suitable climatic conditions for the development of the powdery mildew.
The second evaluation was done from on 13.10.2022 in Mukhrani collection, in 28.10.2022 in Shumi collection and in 01.11.2.22 in Jighaura collection. The results of the evaluation of Oidium attack on all the clusters before veraison and before vintage revealed different resistance among Georgian grapevine varieties. In Table 1 it is shown grapevine accessions that revealed equal resistance of both leaves and clusters.
Totally it has been accessed the resistance of 346 Georgian grapevine varieties under field conditions in 2022. Twenty-seven of the foregoing varieties revealed very high resistance to powdery mildew, 62 had high resistance and 221 medium resistance, and 36 low or very low resistance.

Table 1: Classification of varieties according to their resistance of downy mildew on leaves and clusters (2022)

OIV Resistance score	**Grapevine varieties**
9	Aladasturi, Aleksandrouli, Goruli Mtsvane, Vardisphera, Tavkveri, Tamaris Kurdzeni, Institutis Grdzelmtevana, Kundza, Kuprashviliseuli, Labiladzis Tetri, Mauri Tetri, Mujuretuli, Rkatsiteli clone 4, Seura, Usakhelouri, Kartnula, Tsivchkhavera, Tskvedianis Tetri, Dziganidzis Shavi, Dzelshavi clone, Tsvrimala, Kharistvala Shavi, Tkvara, Danakharuli, Bandzura, Shavtita, Kvetari 04*
7	Aspindzuri Shavi, Atsimlizh, Akhmetis Shavi, Danakharuli clone, Tkvara, Imeruli Mtsvane, Mgaloblishvili, Mtsvivani Rachuli, Mtsvane Kviteli, Jghia, Kisi, Ananura, Atskikizh, Didshavi, Vertkvichalis Shavi, Kurkena, Maghali Mskhvilmartsvala, Nakutvneuli, Patla, Rkatsiteli Vardispheri, Saperavisebri, Uchakhardani, Kisi Mrgvali, Tsivsari, Tsitskina, Tsulukidzis Tetra, Jani Bakhvis, Apshiluri, Akhmetis Shavi, Gabekhauri Shavi, Didmtevana Shavi, Dondghlabi Shavi, Tetri Budeshuri, Ikaltos Tsiteli, Kamuri Shavi, Kapistoni, Kakhuri Tetri, Koloshi, Maghlari Mskhviltvala, Megruli Saferi, Mtsvane Kakhuri, Mkhargrdzeli, Onoura, Rko Tetri, Rtskhila, Samarkhi, Saperavi Budeshurisebuli, Supris Gorula clone, Skhilatubani, Kakutura, Korkaula, Kvira, Dzelshavi Sachkheris, Chvartla, Chroga, Chuberi, Chumuta, Khushia, Jineshi, Mekrenchkhi, Ojaleshi, Shemodgomis Shavi
5	Agashkuri, Agibji, Adreuli Vardispheri, Adreuli Tsiteli, Amlakhu, Apapinzh, Azhashki, Arabeuli Tsiteli, Arabeuli Shavi, Argvetuli Sapere, Aspindzura, Asuretuli Tetri, Ashuzhghazhi, Aghbizh, Akhardani 10, Akhmetis Tsiteli, Badagi, Batumura, Batumura Lomjaria, Bakhva, Bestavashvili, Betsoura, Borkara, Borchalo, Budeshuri Tsiteli, Gabasha, Gldanula, Gomis Tetri, Goruli Mtsvane, Daisi, Dighmura, Kartlis Dondghlabi, Dondghlabi Mtsvane, Dondghlabi Mchknara, Dudghushi, Evnadzis Tetri, Vardisphera, Zakatalis Tetri, Tavkveri, Didmartsvala, Tavkara, Tamaris Vazi, Tbiluri Pataradzis, Tvaldamtsvriseuli, Tita Rbili, Ingilouri, Kamuri, Kapistoni, Tsitsiliani Kapistoni, Kakhis Tetri, Kirtsmagara, Klarjuli, Krakhuna, Kumsi Kviteli, Kundza, Kundza Imeruli, Kuprashviliseuli, Lekuri Kurdzeni, Mamukas Sapere, Marguli Saperi, Mauri Tetri, Maghlaris Shavi, Maghlari, Machvaturi, Melikuda, Meskhuri Mtevandidi, Meskhuri Kurdzeni, Meskhuri Chitistvala, Meskhuri Kharistvala, Mtis Vazi, Mirzaanuli, Mrgvali Sapere, Mskhvilmartsvala, Mtevandidi Bakhvis, Muradouli, Mtsvivani Bakhvis,Mtsvivani Mskhviltvala, Mtsvivani Tsiteli, Mtsvivani Tsiteli, Mtsvane Rkatsiteli, Mtsvane Saperavi, Mtsvane Sachkheris, Mtsklarta, Kharistvala, Nakashidzis Jani, Natsara, Noshrio, Obchis Tsiteli, Obchuri, Dzveli, Orona, Shemokmedis Okroula, Otskhanuri Sapere, Okhtoura 12, Partala Shavi, Pakhlana, Pirghebuli, Pumpula, Zhghia Sagviano, Rokintuli Shavi, Rkatsiteli, Rkatsiteli clone 3/7, Rkatsitseli clone 48, Saamo, Samachria, Samchacha,Sapena, Saperavi, Tsru Saperavi, Didmartsvala, Saperavi clone, Saperavi clone 359, Saperavi Pachkha, Saperavi Kartlis, Sakartvelo,

	Sachemo, Satsuri, Sakhalkho Tetri, Simonaseuli, Sirgula, Sirgula Grdzelmtevana, Skhilatubani, Tagidzura, Tkbili Kurdzeni, Chroga Kakhuri, Uriatubnis Tsiteli, Usakhelouri Tsiteli, Kartnula, Kartula, Kvishkhuri, Kistauruli Sagvine, Kishuri, Kishuri clone 1, Ghvanuri, Gvinis Tetra, Kviteli Mkhargrdzeli, Kornistvala, Shavtita, Shavtkhila, Shavi Kurdzeni, Shavi Chinuri, Shavtsitska, Shemodgomis Tetri, Shios Vazi, Cheshi, Chechipeshi, Chinuri, Chinuri Variatsia, Chitistvala Acharuli, Chitistvala Bodburi, Chitistvala Kakhuri, Chitiskvertskha, Ckhaveri, Chkhikoura, Tsivvazi, Tsivchkhavera, Tsitska, Tsitska clone 14/25, Tsolikouri, Tsolikouri Mtsvivani, Tsolikouri Tsvrilmartsvala, Tsru–tsolikouri, Tskhenis Dzudzu, Dzelshavi, Dzelshavi Obchuri, Dzveli Aleksandrouli, Dziragouli shavi, Tsvrili kapistoni, Tsitelauri, Tsitlani, Tsitluri, Tsirkvalis Tetri clone 1, Tsirkvalis Tetri, Tsminda Tetri, Tsnoris Tetri, Chvitiluri, Chichibera, Chodi, Salkhino, Chrogha Kartlis, Chumuta clone 1, Chkapa, Kharistvala, Kharistvala Kartlis 10, Khemkhu Shavi, Khikhvis Variatsia, Khikhvi clone 430, Khikhvi Rachuli, Khoteura, Jani, Jvari, Ninotsminda 11*, Ninotsminda 09*, Ninotsminda 02*
3	Adreuli Vardispheri, Adreuli Tsiteli, Saperavi Pachkha, Arabeuli, Argvetuli Sapere, Ashughaj, Akhardani 10, Ahudji, Mskhvili Kurdzeni, Beglaris Kurdzeni, Beroula, Borchalo, Buza, Gabasha, Gabekhauri Tsiteli, Dighmura, Evnadzis Tetri, Samebis Seri 08*, Nakhiduri 15*, Tedotsminda 16*
1	Bua Kurdzeni, Budeshuri Tetri, Buera, Saphena, Saperavi Atenis, Tkupkvirta, Kartuli Saadreo, Kistauris Shavi, Rkatsiteli Shavi, Sartichala (ferma) 07, Barisakhos Gadasakhvevi*, Tedotsminda 03*, Shirikhevi 04*, Delisi 01*, Chkumi 02*, Naghomari 01*

* - Wildly growing grapevines

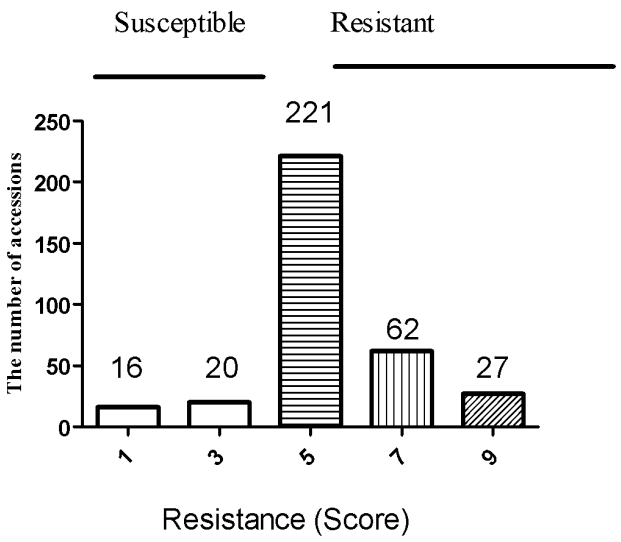

Figure 2: Frequency distribution of resistance traits of native Georgian grapevine varieties to *E. necator*: 1- very low, 3-low, 5- medium, 7- high, 9-very high

4. Conclusions

In this study, the susceptibility of Georgian cultivars and wildly growing grapevine accessions to powdery mildew have been investigated in 3 different field collection during one vegetative season (2022). The degree of resistance of the tested accessions to the American fungal disease powdery mildew was ranging from low to very high. Our results suggest that there is substantial diversity in resistance to powdery mildew among the foregoing local Georgian varieties and wildly growing grapevines of *V. vinifera.*

The results obtained in the present study is the first step for contribution to identify new resistance sources to *E. necator* among Georgian cultivars and wildly growing grapevine accessions. The first-year study enabled us to revile interesting forms that showed promising results. Observations will be continued for the next years in the field conditions and these accessions will be used for further evaluation.

5. Acknowledgments

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