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Original Article

Assessment of the Susceptibility of Grapevine Genotypes in the Eastern Anatolia Region Genetic Resource Plot to Powdery Mildew (*Erysiphe necator*) Under Natural Infection Conditions

Tevhit Geçim[1]✉, Nalan Yıldırım Doğan[2], Hasan Pınar[3], Abdurrahim Bozkurt[1]

[1]Horticultural Research Institute Directorate, Erzincan
[2]Erzincan Binali Yıldırım University, Faculty of Arts and Sciences, Department of Biology, Erzincan
[3]Erciyes University, Faculty of Agriculture, Department of Horticulture, Kayseri

[1]https://orcid.org/0000-0003-2406-9929, [2]https://orcid.org/0000-0002-5344-5367, [3]https://orcid.org/0000-0002-0811-8228, [4]https://orcid.org/0000-0001-7315-202X

✉: tevhit.gecim@tarimorman.gov.tr

ABSTRACT

Powdery mildew disease caused by *Erysiphe necator* is an economically important disease of grape varieties of the *Vitis vinifera* species worldwide. The use of resistant grape varieties in the control of the disease is extremely important for human and environmental health. In this study, the tolerance levels of 203 local cultivars, two tolerant (Regent and Kishmish Vatkana) and two sensitive (Karaerik and Italia) cultivars collected within the scope of the Eastern Anatolia Region Grapevine Genetic Resources Project were determined against the pathogen *Erysiphe necator* under natural conditions. A visual scale based on sporulation density and necrosis formation on the leaves was used for evaluation and four vines were evaluated for each genotype. The colonisation rate on the surface of the leaves was determined according to the scale values between 0-7. The severity of the disease was calculated based on the lesions on the leaves and the susceptibility of the genotypes was determined. As a result of the study, 3 of the genotypes were highly resistant (HR), 44 were resistant (R), 68 were susceptible (S) and 88 were highly susceptible (HS) in terms of powdery mildew disease severity. Among these genotypes, 50 out of 197 genotypes belonging to *Vitis vinifera* species and all *Vitis labrusca* genotypes showed tolerance below 30% in terms of disease severity. *Vitis vinifera* subsp. *sylvestris* (Sarmalık Üzüm) was classified as susceptible with a disease severity of 37.99%. In the study, *V. vinifera* showed more sensitivity than other species. The most resistant genotype was Izabelle-1 (3.88%) and the most susceptible genotype was Beyaz Üzüm S1 (90.07%).

Key words: Genetic resource, Grape genotypes, Powdery mildew, Natural infection, *Vitis vinifera*

Doğu Anadolu Bölgesi Asma Genetik Kaynak Parselindeki Genotiplerin Doğal Enfeksiyon Koşullarında Külleme Hastalığına (*Erysiphe necator*) Duyarlılıklarının Değerlendirilmesi

ÖZ

Erysiphe necator'un neden olduğu külleme hastalığı, dünya çapında *Vitis Vinifera* türüne giren üzüm çeşitlerinin ekonomik açıdan önemli bir hastalığıdır. Hastalığın kontrolünde dirençli üzüm çeşitlerinin kullanımı insan ve çevre sağlığı açısından son derece önemlidir.Bu çalışmada Doğu Anadolu Bölgesi Asma Genetik Kaynakları projesi kapsamında toplanan ve koruma altına alınan 203 yerel çeşit ile 2 tolerant (Regent ve Kishmish Vatkana) ve 2 duyarlı (Karaerik ve Italia) çeşidin doğal koşullar altında *Erysiphe necator* patojenine karşı toleranslık düzeyleri belirlenmiştir. Değerlendirmede yapraklar üzerindeki sporulasyon yoğunluğu ve nekroz oluşumuna dayalı görsel skala kullanılmış ve her genotip için dörder asma değerlendirilmiştir. Yaprakların yüzeyindeki kolonizasyon oranı, 0-7 arasındaki skala değerlerine göre belirlenmiştir. Yaprakların üzerindeki lezyon değerleri üzerinden hastalık şiddeti hesaplanarak genotiplerin duyarlılık durumları belirlenmiştir. Çalışma sonucunda külleme hastalık şiddeti bakımından 3 genotip oldukça dirençli (HR), 44 genotip dirençli (R), 68 genotip hassas (S) ve 88 genotip oldukça hassas (HS) olarak belirlenmiştir. Bu genotipleri türler bazında incelendiğinde *Vitis vinifera* türüne ait 197 farklı genotipten 50'si ve *Vitis labrusca* genotiplerinin tamamı, hastalık şiddeti bakımından %30 un altında tolerans göstermiştir. Ayrıca *Vitis vinifera* subsp. *sylvestris* türüne ait Sarmalık üzümün hastalık şiddet derecesi %37.99 ile hassas sınıfında yer almıştır. Türlere dayalı değerlendirmede *V. vinifera*'nın diğer türlere kıyasla daha fazla hassasiyet gösterdiği belirlenmiştir. İncelenen genotipler arasında en dirençli genotip olarak İzabelle-1 (%3.88) belirlenirken, en hassas genotip Beyaz Üzüm S1 (%90.07) olarak tespit edilmiştir.

Anahtar kelimeler: Genetik kaynak, Üzüm genotipleri, Külleme hastalığı, Doğal enfeksiyon*, Vitis vinifera*

INTRODUCTION

Turkey is one of the most important countries in the world for vineyard areas and grape production. Due to the ideal climatic conditions and favourable growing conditions, there are very rich *Vitis* gene resources in Turkey (Yıldırım et al., 2019). The geographical location of the country, being situated in both the Near East and the Mediterranean Basin, plays an important role as a gene centre for viticulture (Ağaoğlu, 1986). In addition, the region between the Black Sea and the Caspian Sea, which covers the northeastern part of the Anatolian peninsula, is considered to be the gene centre and cultivation area of *V. vinifera* L. species. This situation reveals that Turkey has an extremely rich genetic diversity in terms of both wild vine (*Vitis vinifera* ssp. sylvestris) and cultivated vine (*Vitis vinifera* ssp. *sativa*) (Çelik et al., 1998). It is extremely important to reveal the differences within these gene resources and to use them in breeding by evaluating them in the future (Yağcı and Daler, 2023).

Grape (*Vitis vinifera*) is one of the most important fruit species cultivated as table, juice, wine and raisins. Although *Vitis vinifera* is one of the most commercially important species, it is susceptible to many fungal diseases such as powdery mildew (*Erysiphe necator* (Schw.) Burr.) and downy mildew (*Plasmopara viticola* (Berk. Et Curt) Berl et de Toni) (Reisch et al., 2012; Eibach and Töpfer, 2015; Bozkurt and Yağcı, 2024). Powdery mildew disease caused by the pathogen *Erysiphe necator* is one of the common fungal diseases of grapes and can cause significant yield loss and decrease in fruit quality by affecting all green tissues of the vines (Feechan et al., 2013; Mwamahonje et al., 2015; Pimentel et al., 2021; Aşçı et al., 2021; Sosa-Zuniga et al., 2022; Bozkurt et al., 2023; Maddalena et al., 2023). This disease not only affects grape yield, but can also affect the quality of fruit and wine, including berry flavour and various metabolites (Yu et al., 2022). The susceptibility of grapevines to powdery mildew may differ among cultivars (Boso and Kassemeyer, 2008; Yıldırım et al., 2019; Bozkurt and Yağcı, 2024) and understanding the factors affecting this susceptibility is crucial for disease management in vineyards. Considering the devastating effects of this disease, breeding studies have been initiated worldwide to develop resistant or tolerant plant varieties against this disease (Atak and Şen, 2021; Bozkurt, 2023). Due to the economic importance of *E. necator*, breeders first screened genetic materials to breed resistant varieties (Wan et al., 2007).

It is known that grapevine gene resources play a critical role in determining the effects of powdery mildew disease and the resistance mechanisms of plant phenotypes against the disease. In particular, the resistance levels of different grapevine genotypes against powdery mildew disease have been examined and it has been observed that there are significant differences between species (Atak and Göksel, 2019; Bozkurt and Yağcı, 2024). It has been reported that the majority of cultivated grape cultivars from the species *Vitis vinifera* lack genetic resistance to *E. necator*, making them highly susceptible to powdery mildew (Kunova et al., 2021). The research and utilisation of grapevine genetic resources offers an important avenue for the development of grape varieties with enhanced resistance to diseases and environmental stresses. These genetic resources harbour important traits for combating both biotic and abiotic stresses such as cold, drought, pests and diseases. By utilising genetic diversity in grapevine populations, researchers can identify individuals with superior traits or those that are naturally resistant to specific stress factors.

In this study, it was aimed to determine the susceptibility of 203 different grapevine genotypes protected in the Eastern Anatolia Region Grapevine Genetic Resource Plot against powdery mildew disease by natural infection method.

MATERIALS AND METHODS

Material

The material of the study consisted of 203 local grape varieties/genotypes collected within the scope of 'Eastern Anatolia Region Grapevine Genetic Resources' project from the provinces (Erzincan, Erzurum, Iğdır, Artvin, Sivas, Ardahan, Bingöl, Van, Mardin, Tunceli and Gümüşhane) within the responsibility area of Erzincan Horticultural Research Institute Directorate. Of these genotypes, 197 were *Vitis vinifera*, 5 were *Vitis labrusca* and 1 was *Vitis vinifera* subsp. sylvestris. In addition, two tolerant varieties (Regent and Kishmish Vatkana) and two susceptible varieties (Karaerik and Italia) were selected as controls for the study. These varieties/genotypes were collected and maintained in the genetic resource plot (Table 3). The study was conducted in the genetic resource plot, employing a coincidence block design with four replications and a single vine in each replication.

Method

Determination of Susceptibility of Genotypes to Powdery Mildew by Natural Infection Method

In order to determine the susceptibility levels to powdery mildew disease, powdery mildew infected panicles, shoots and leaves were collected from vineyards in Erzincan and Üzümlü between 19-23 June. These infected plant materials were brought to the vineyard where the genotypes were located and placed at appropriate intervals without any artificial inoculation and naturally infected with powdery mildew pathogens. This process was repeated five times at one week intervals to ensure the robustness of the results. No fungicide application was made in the study vineyard and powdery mildew infections on the leaves were monitored. Genotypes were evaluated at the first appearance of powdery mildew infections on the leaves in early August.

Counting and Evaluation

Natural infection assessment was carried out on the leaves between 1-4 August. For counting and evaluation of sporulation, a visual scale based on sporulation intensity and necrosis formation established by Wang et al. (1995) was used. For disease assessment, 4 vines were used for each local cultivar/genotype and all leaves on 2 shoots from the right and left side of each vine were examined. The colonisation rate on the surface of the leaves was determined according to the scale values between 0-7. According to the scale values, disease severity on the leaves were calculated using the Towsend Heuberger formula (Townsend and Heuberger, 1943) and sporulation severity was calculated and given as percentage (%) (Table 1). Then, disease susceptibility levels of local cultivars according to disease severity were evaluated according to Wang et al. (1995) (Table 2).

Towsend Heuberger Formula: $P = \sum(n \times v \div Z \times N) \times 100$

P - Percentage of disease severity,
n - Number of diseased leaves,
v - Numerical value of the degree of disease,
Z - Highest scale value,
N - Number of leaves examined.

Table 1. Infection rating levels of genotype leaves for their degree of resistance to powdery mildew under natural infection conditions

Scale Value	Disease Severity (%)
0	< 0.1
1	0.1 – 5.0
2	5.1 – 15.0
3	15.1 – 30.0
4	30.1 - 45.0
5	45.1 – 65.0
6	65.1 – 85.0
7	> 85

Table 2. Susceptibility levels according to powdery mildew disease severity

Disease Severity (%)			Disease Severity Index	
0.00	<	0.10	I -	Immune
0.11	-	5.00	HR -	Highly resistant
5.01	-	25.00	R -	Resistant
25.01	-	50.00	S -	Sensitive
50,01	-	100.00	HS -	Highly sensitive

RESULTS AND DISCUSSION

As part of the "Eastern Anatolia Region Grapevine Genetic Resources" project, the susceptibility of 203 local grape varieties/genotypes, along with 2 susceptible and 2 tolerant grape varieties, to powdery mildew was evaluated under natural inoculum conditions in 2023. The severity of the disease observed on the leaves was relatively assessed. According to the findings, 4 genotypes scored 1 point, 28 genotypes scored 2 points, 24 genotypes scored 3 points, 44 genotypes scored 4 points, 67 genotypes scored 5 points, 33 genotypes scored 6 points and 4 genotypes scored 7 points. Disease severity was then calculated for each genotype using the Towsend Heuberger formula (Townsend and Heuberger, 1943). When the disease severity of 203 different genotypes and 4 control varieties in the genetic resource plot were analysed, powdery mildew disease severity was between 3.88 (Izabelle-1) and 90.07 (White Grape S1) (average 44.08%). In addition, disease susceptibility levels of genotypes according to disease severity were evaluated according to Wang et al. (1995) for powdery mildew disease. When the susceptibility level of genotypes to powdery mildew was analysed according to powdery mildew disease severity, 3 genotypes were highly resistant (HR), 44 genotypes were resistant (R), 68 genotypes were susceptible (S) and 88 genotypes were highly susceptible (HS). When the powdery mildew natural infection results of Kishmish Vatkana and Regent, which are known to be tolerant control varieties, were evaluated, the disease severity was 4.46 and 5.08, the scale values were 1 and 2 points, and the disease susceptibility levels were measured as highly resistant (HR) and resistant (R), respectively. Similarly, as a result of the evaluations made in Italia and Karaerik, which are known to be susceptible, the scale values were 6 points and their disease susceptibility levels were determined as highly susceptible (HS) (Table 3). The results of the study and the differences in the susceptibility of the cultivars to powdery mildew disease are consistent with previous studies. As a matter of fact, many grape varieties belonging to *Vitis vinifera* and *Vitis labrusca* species were examined for their susceptibility to powdery mildew disease. In the findings obtained, it has been reported both in our study and in different studies that most varieties of *V. vinifera* are susceptible to *E. necator*, while *V. labrusca* is tolerant, and that this susceptibility varies on variety basis (Atak et al., 2017; Bozkurt et al., 2023; Şen, 2024; Bozkurt and Yağcı, 2024). Wan et al. (2007), in order to determine the resistance to powdery mildew disease in Vitis spp. gene pool, 66 genotypes from 13 Vitis species were studied under natural conditions. They used the 0-7 scale and determined that 46 of 66 genotypes were resistant to powdery mildew in their scoring according to this scale. Similarly, Atak et al. (2017) tested 26 genotypes of *V. labrusca*, 6 interspecific cultivars and 3 cultivars of *V. vinifera* for susceptibility to powdery mildew by natural and artificial inoculation methods. In the artificial powdery mildew scoring of the study, Isabella (Yalova and Tekirdağ) and Kyoho varieties were found to be highly resistant (HR) and Italia variety was found to be highly susceptible (HS). On the other hand, in a remarkable study conducted over a period of two years, Bozkurt et al. (2023) artificially inoculated 15 different grape cultivars with the pathogen *E. necator* under greenhouse conditions to evaluate their susceptibility to powdery mildew over a period of seven weeks. When the results of the seventh week were analysed, infection rates for resistant cultivars were relatively low and ranged between 5.9% and 10.3%. On the other hand, increases ranging between 67.3-96.7% were observed in the more susceptible varieties Horoz Karası, Künefi, Erciş, Dökülgen, Fenerit, Italia, Muhammedi, Karaerik, Vakkas, Narince and Hatun Parmağı. Şen, (2023) conducted a study to determine the resistance to powdery mildew and powdery mildew diseases in 307 hybrid genotypes obtained as a result of cross breeding studies carried out by Atatürk Garden Cultures Central Research Institute. As a result of natural and artificial inoculation tests, 9 genotypes resistant to powdery mildew disease were identified. These findings emphasise the critical role of genetic factors in determining the susceptibility of grape varieties to powdery mildew (Parage et al., 2012).

Table 3. Names and origin of local cultivars/genotypes and disease severity, scale value and susceptibility levels after natural infection

Genotypes	Species Name	Powdery Mildew Disease Severity (%)	Disease Scale Value	Disease Susceptibility Level
Abdehir	*Vitis vinifera*	81.03 ± 0.82	6	HS
Adesa	*Vitis labrusca*	3.90 ± 0.76	1	HR
Ağın Beyazı	*Vitis vinifera*	48.28 ± 1.40	5	S
Ağır Ağız	*Vitis vinifera*	15.39 ± 1.77	3	R
Ahmetoğlu	*Vitis vinifera*	52.31 ± 0.59	5	HS
Al Üzüm (Olur)	*Vitis vinifera*	8.35 ± 0.77	2	R

HR-Highly resistant, R-Resistant, S-Sensitive, HS-Highly sensitive

Table 3. (Continued) Names and origin of local cultivars/genotypes and disease severity, scale value and susceptibility levels after natural infection

Genotypes	Species Name	Powdery Mildew Disease Severity (%)	Disease Scale Value	Disease Susceptibility Level
Al Üzüm (Torul)	*Vitis vinifera*	9.03 ± 1.53	2	R
Altuntaş	*Vitis vinifera*	66.80 ± 1.63	6	HS
Arapgir	*Vitis vinifera*	82.22 ± 0.71	6	HS
Askeri	*Vitis vinifera*	53.88 ± 0.98	5	HS
Aş Üzümü	*Vitis vinifera*	83.79 ± 0.88	6	HS
At Memesi	*Vitis vinifera*	24.12 ± 0.40	3	R
Azerbaycan Çavuşu	*Vitis vinifera*	30.86 ± 1.29	4	S
Azezi	*Vitis vinifera*	31.19 ± 1.48	4	S
Bağlarbaşı	*Vitis vinifera*	51.07 ± 2.79	5	HS
Balcani	*Vitis vinifera*	42.91 ± 0.89	4	S
Besni	*Vitis vinifera*	16.99 ± 1.64	3	R
Beyaz Amasya	*Vitis vinifera*	56.52 ± 2.54	5	HS
Beyaz Bambo	*Vitis vinifera*	7.59 ± 0.87	2	R
Beyaz Hatun Parmağı	*Vitis vinifera*	47.87 ± 1.26	5	S
Beyaz Kış Üzümü	*Vitis vinifera*	28.13 ± 2.43	3	S
Beyaz Kişmiş	*Vitis vinifera*	62.65 ± 1.66	5	HS
Beyaz Tatlı Çekirdekli	*Vitis vinifera*	6.35 ± 1.68	2	R
Beyaz Turfanda	*Vitis vinifera*	30.73 ± 1.94	4	S
Beyaz Üzüm S1	*Vitis vinifera*	90.07 ± 0.73	7	HS
Beyaz Üzüm S2	*Vitis vinifera*	87.65 ± 0.61	7	HS
Beyaz Üzüm S3	*Vitis vinifera*	44.02 ± 1.13	4	S
Beyaz Üzüm S4	*Vitis vinifera*	7.32 ± 1.19	2	R
Beyaz Üzüm S5	*Vitis vinifera*	6.76 ± 1.31	2	R
Beyaz Üzüm S6	*Vitis vinifera*	12.91 ± 0.87	2	R
Beyaz Üzüm S7	*Vitis vinifera*	56.17 ± 2.48	5	HS
Beyaz Üzüm T1	*Vitis vinifera*	41.25 ± 1.76	4	S
Beyaz Üzüm T2	*Vitis vinifera*	38.40 ± 4.37	4	S
Beyaz Üzüm T3	*Vitis vinifera*	51.18 ± 0.68	5	HS
Beyaz Üzüm V2	*Vitis vinifera*	31.46 ± 0.93	4	S
Beyaz Üzüm(Çukurbağ)	*Vitis vinifera*	70.08 ± 1.52	6	HS
Boğazkere	*Vitis vinifera*	62.28 ± 1.27	5	HS
Bulut	*Vitis vinifera*	7.83 ± 0.81	2	R
Çavuş (Geçit)	*Vitis vinifera*	80.50 ± 0.72	6	HS
Çavuş (Koçkar)	*Vitis vinifera*	10.81 ± 0.95	2	R
Çavuş (Yukarıdere)	*Vitis vinifera*	56.49 ± 1.71	5	HS
Çavuş(Bayırbağ)	*Vitis vinifera*	11.79 ± 1.13	2	R
Çayra Üzümü	*Vitis vinifera*	20.84 ± 1.50	3	R
Çekirdeksiz Beyaz	*Vitis vinifera*	9.37 ± 3.56	2	R
Çekirdeksiz Kara Üzüm	*Vitis vinifera*	58.88 ± 1.09	5	HS
Çekirdeksiz Kırmızı Üzüm	*Vitis vinifera*	58.50 ± 0.87	5	HS
Çekirdeksiz Kişmiş	*Vitis vinifera*	60.14 ± 0.78	5	HS
Çekirdeksiz Sarı Üzüm	*Vitis vinifera*	72.49 ± 0.67	6	HS
Çemiç 1	*Vitis vinifera*	52.25 ± 3.75	5	HS
Çemiç-2	*Vitis vinifera*	10.29 ± 1.09	2	R

HR-Highly resistant, R-Resistant, S-Sensitive, HS-Highly sensitive

Table 3. (Continued) Names and origin of local cultivars/genotypes and disease severity, scale value and susceptibility levels after natural infection

Genotypes	Species Name	Powdery Mildew Disease Severity (%)	Disease Scale Value	Disease Susceptibility Level
Çiğitsiz Üzüm	*Vitis vinifera*	73.92 ± 2.24	6	HS
Çiklep	*Vitis vinifera*	59.05 ± 1.92	5	HS
Direjik	*Vitis vinifera*	61.74 ± 1.67	5	HS
Ekber Üzümü	*Vitis vinifera*	53.70 ± 2.23	5	HS
Elhakkı	*Vitis vinifera*	64.31 ± 0.42	5	HS
Emceoğlu	*Vitis vinifera*	64.59 ± 0.74	5	HS
Ergan Üzümü	*Vitis vinifera*	43.04 ± 1.47	4	S
Erkenci Çavuş	*Vitis vinifera*	61.69 ± 0.91	5	HS
Eskibeyli Siyah Üzüm	*Vitis vinifera*	52.82 ± 3.57	5	HS
Gedikli Ağın Beyazı	*Vitis vinifera*	29.98 ± 1.33	3	S
Gedikli Beyaz Üzüm	*Vitis vinifera*	16.22 ± 1.39	3	R
Gedikli Siyah Üzüm	*Vitis vinifera*	30.80 ± 0.98	4	S
Gelin Parmağı	*Vitis vinifera*	75.65 ± 0.85	6	HS
Gineş	*Vitis vinifera*	5.54 ± 1.58	2	R
Gökgolot	*Vitis vinifera*	66.84 ± 1.28	6	HS
Gül Üzümü	*Vitis vinifera*	41.18 ± 2.39	4	S
Gümüş Beyazı	*Vitis vinifera*	38.54 ± 6.65	4	S
Güz İstanbul	*Vitis vinifera*	8.29 ± 0.85	2	R
Hacı Tesbihi	*Vitis vinifera*	65.48 ± 2.46	6	HS
Hanım Göbeği	*Vitis vinifera*	57.59 ± 0.93	5	HS
Harthul	*Vitis vinifera*	31.20 ± 0.99	4	S
Hasani-1	*Vitis vinifera*	71.52 ± 0.96	6	HS
Hasani-2	*Vitis vinifera*	22.61 ± 0.74	3	R
Hathul	*Vitis vinifera*	8.72 ± 2.01	2	R
Hatun Parmağı	*Vitis vinifera*	70.70 ± 4.97	6	HS
Hatun Parmağı(Olur)	*Vitis vinifera*	39.83 ± 0.39	4	S
Hedfi	*Vitis vinifera*	48.32 ± 1.65	5	S
Hemrani	*Vitis vinifera*	69.55 ± 1.07	6	HS
Herci	*Vitis vinifera*	60.64 ± 0.52	5	HS
Heseni	*Vitis vinifera*	19.09 ± 1.93	3	R
Hocabaş	*Vitis vinifera*	41.95 ± 2.32	4	S
İnce Beyaz	*Vitis vinifera*	73.30 ± 2.13	6	HS
İnek Memesi	*Vitis vinifera*	57.03 ± 0.79	5	HS
İri At Memesi	*Vitis vinifera*	14.26 ± 2.19	2	R
İri Keçi Memesi	*Vitis vinifera*	33.47 ± 1.79	4	S
İsabella 1	*Vitis labrusca*	3.88 ± 1.25	1	HR
İzabella-2	*Vitis labrusca*	4.03 ± 1.27	1	HR
İzmir Siyahı	*Vitis vinifera*	63.42 ± 1.80	5	HS
Kabarcık	*Vitis vinifera*	63.00 ± 1.94	5	HS
Kabuğu Yuka	*Vitis vinifera*	28.16 ± 0.77	3	S
Kalduk	*Vitis vinifera*	58.57 ± 0.96	5	HS
Kamik	*Vitis vinifera*	71.76 ± 0.49	6	HS
Kara Gahet	*Vitis vinifera*	45.05 ± 2.20	5	S
Kara Menüşke	*Vitis vinifera*	43.57 ± 9.56	4	S
Kara Üzüm	*Vitis vinifera*	43.20 ± 1.35	4	S

HR-Highly resistant, R-Resistant, S-Sensitive, HS-Highly sensitive

Table 3. (Continued) Names and origin of local cultivars/genotypes and disease severity, scale value and susceptibility levels after natural infection

Genotypes	Species Name	Powdery Mildew Disease Severity (%)	Disease Scale Value	Disease Susceptibility Level
Karaeznek	*Vitis vinifera*	7.18 ± 1.06	2	R
Karaeznek 2	*Vitis vinifera*	51.31 ± 1.30	5	HS
Karakabarcık	*Vitis vinifera*	47.51 ± 1.64	5	S
Karul	*Vitis vinifera*	19.35 ± 3.96	3	R
Keçi Memesi	*Vitis vinifera*	6.40 ± 0.96	2	R
Keleş	*Vitis vinifera*	30.84 ± 0.46	4	S
Kerfoki	*Vitis vinifera*	49.83 ± 0.35	5	S
Kerimgandi	*Vitis vinifera*	6.20 ± 1.39	2	R
Kerkuş	*Vitis vinifera*	53.22 ± 1.00	5	HS
Keten Gömlek	*Vitis vinifera*	42.51 ± 1.05	4	S
Kırmızı İstanbul	*Vitis vinifera*	29.73 ± 2.22	3	S
Kırmızı Keçi Memesi	*Vitis vinifera*	37.63 ± 1.08	4	S
Kırmızı Üzüm T1	*Vitis vinifera*	64.12 ± 1.14	5	HS
Kırmızı Üzüm T2	*Vitis vinifera*	42.75 ± 1.14	4	S
Kırmızı Üzüm T3	*Vitis vinifera*	58.49 ± 1.43	5	HS
Kırmızı Üzüm (Eskibeyli)	*Vitis vinifera*	71.37 ± 2.04	6	HS
Kışlık Beyaz	*Vitis vinifera*	68.71 ± 0.94	6	HS
Kızıl Türlü	*Vitis vinifera*	53.27 ± 2.08	5	HS
Kızıl Üzüm (Erzincan)	*Vitis vinifera*	69.37 ± 0.81	6	HS
Kızıl Üzüm (Erciş)	*Vitis vinifera*	71.19 ± 0.86	6	HS
Kirfok	*Vitis vinifera*	46.97 ± 1.19	5	S
Kirli Şerife	*Vitis vinifera*	21.77 ± 0.72	3	R
Kişmiş Üzümü	*Vitis vinifera*	30.32 ± 1.03	4	S
Kokulu Üzüm	*Vitis labrusca*	7.45 ± 0.91	2	R
Korostol	*Vitis vinifera*	16.94 ± 2.42	3	R
Koyun Gözü	*Vitis vinifera*	46.95 ± 0.66	5	S
Kuduruş	*Vitis vinifera*	7.81 ± 1.29	2	R
Kuş Üzümü	*Vitis vinifera*	23.49 ± 2.73	3	R
Kuzu Kuyruğu	*Vitis vinifera*	24.64 ± 0.25	3	R
Laz Üzümü	*Vitis labrusca*	8.04 ± 1.54	2	R
Mazlumani	*Vitis vinifera*	53.38 ± 1.12	5	HS
Mazruma	*Vitis vinifera*	43.51 ± 1.40	4	S
Mehmetoğlu	*Vitis vinifera*	44.02 ± 0.61	4	S
Meneşker	*Vitis vinifera*	64.35 ± 4.37	5	HS
Merzune M1	*Vitis vinifera*	5.15 ± 0.57	2	R
Merzune M2	*Vitis vinifera*	36.96 ± 0.81	4	S
Mesebbe	*Vitis vinifera*	63.40 ± 0.58	5	HS
Mesma	*Vitis vinifera*	31.50 ± 0.45	4	S
Mezarlık	*Vitis vinifera*	19.62 ± 0.59	3	R
Mıh Üzümü	*Vitis vinifera*	51.98 ± 0.50	5	HS
Miskali	*Vitis vinifera*	51.59 ± 0.76	5	HS
Mor Amasya	*Vitis vinifera*	53.23 ± 0.73	5	HS
Müskü	*Vitis vinifera*	51.58 ± 1.18	5	HS
Nanebur	*Vitis vinifera*	22.67 ± 1.02	3	R
Nar Tanesi	*Vitis vinifera*	53.44 ± 5.08	5	HS

HR-Highly resistant, R-Resistant, S-Sensitive, HS-Highly sensitive

Table 3. (Continued) Names and origin of local cultivars/genotypes and disease severity, scale value and susceptibility levels after natural infection

Genotypes	Species Name	Powdery Mildew Disease Severity (%)	Disease Scale Value	Disease Susceptibility Level
Nörgah	*Vitis vinifera*	31.36 ± 0.94	4	S
Papaz Üzümü	*Vitis vinifera*	34.64 ± 2.97	4	S
Pembe Üzüm T1	*Vitis vinifera*	54.65 ± 1.95	5	HS
Pembe Üzüm T2	*Vitis vinifera*	44.71 ± 0.33	4	S
Pembenaz	*Vitis vinifera*	29.29 ± 1.72	3	S
Pırtik	*Vitis vinifera*	11.18 ± 2.25	2	R
Sarı Golot	*Vitis vinifera*	46.98 ± 1.29	5	S
Sarı Yezendayı	*Vitis vinifera*	54.47 ± 1.81	5	HS
Sarmalık Üzüm	*Vitis vinifera* subsp. *sylvestris*	37.99 ± 0.49	4	S
Selüke Pembe Üzüm	*Vitis vinifera*	36.28 ± 0.34	4	S
Selüke Yeşil Üzüm	*Vitis vinifera*	36.30 ± 0.16	4	S
Servi Beyaz Gevrek	*Vitis vinifera*	86.81 ± 1.51	7	HS
Servi Beyaz Üzüm	*Vitis vinifera*	48.75 ± 3.05	5	S
Servi Kara Üzüm	*Vitis vinifera*	30.69 ± 0.58	4	S
Servi Lice Üzümü	*Vitis vinifera*	46.45 ± 1.00	5	S
Servi Mor Erkenci	*Vitis vinifera*	66.43 ± 1.40	6	HS
Servi Pembe Üzüm	*Vitis vinifera*	75.30 ± 1.33	6	HS
Siyah Hatun Parmağı	*Vitis vinifera*	75.21 ± 0.84	6	HS
Siyah Mayhoş Üzüm	*Vitis vinifera*	7.62 ± 0.51	2	R
Siyah Şarap Mayası	*Vitis vinifera*	40.77 ± 2.74	4	S
Siyah Şire	*Vitis vinifera*	11.82 ± 0.41	2	R
Siyah Tatlı Çekirdekli	*Vitis vinifera*	66.99 ± 4.12	6	HS
Siyah Turfanda	*Vitis vinifera*	29.24 ± 0.10	3	S
Siyah Üzüm G1	*Vitis vinifera*	48.74 ± 2.44	5	S
Siyah Üzüm G2	*Vitis vinifera*	56.35 ± 1.00	5	HS
Siyah Üzüm S1	*Vitis vinifera*	60.18 ± 6.16	5	HS
Siyah Üzüm S2	*Vitis vinifera*	44.45 ± 1.24	4	S
Siyah Üzüm T1	*Vitis vinifera*	68.91 ± 0.72	6	HS
Siyah Üzüm T2	*Vitis vinifera*	59.94 ± 0.74	5	HS
Siyah Üzüm T3	*Vitis vinifera*	66.13 ± 0.78	6	HS
Siyah Üzüm T4	*Vitis vinifera*	27.71 ± 0.90	3	S
Siyah Üzüm V1	*Vitis vinifera*	59.24 ± 1.17	5	HS
Siyah Üzüm V2	*Vitis vinifera*	42.39 ± 0.86	4	S
Siyah Üzüm V3	*Vitis vinifera*	22.76 ± 1.01	3	R
Siyah Üzüm V6	*Vitis vinifera*	44.22 ± 1.25	4	S
Siyah Üzüm V7	*Vitis vinifera*	44.50 ± 1.45	4	S
Siyah Üzüm(Dutluca)	*Vitis vinifera*	63.26 ± 2.99	5	HS
Suşehri Beyaz Üzüm	*Vitis vinifera*	74.57 ± 1.66	6	HS
Şafra	*Vitis vinifera*	87.54 ± 0.37	7	HS
Şebik Karası	*Vitis vinifera*	67.73 ± 1.33	6	HS
Şilfoni	*Vitis vinifera*	43.83 ± 1.82	4	S
Şire	*Vitis vinifera*	47.12 ± 5.51	5	S
Şirelik Üzüm	*Vitis vinifera*	66.39 ± 0.58	6	HS

HR-Highly resistant, R-Resistant, S-Sensitive, HS-Highly sensitive

Table 3. (Continued) Names and origin of local cultivars/genotypes and disease severity, scale value and susceptibility levels after natural infection

Genotypes	Species Name	Powdery Mildew Disease Severity (%)	Disease Scale Value	Disease Susceptibility Level
Şitvi	*Vitis vinifera*	55.72 ± 0.90	5	HS
Ternebi	*Vitis vinifera*	52.85 ± 0.90	5	HS
Tıhmin Kabarcığı	*Vitis vinifera*	77.55 ± 0.91	6	HS
Tilki Kuyruğu	*Vitis vinifera*	7.34 ± 2.01	2	R
Tombul Üzüm	*Vitis vinifera*	22.59 ± 2.23	3	R
Turfanda	*Vitis vinifera*	7.61 ± 1.19	2	R
Tutikoğlu	*Vitis vinifera*	45.74 ± 0.97	5	S
Türkgözü	*Vitis vinifera*	43.80 ± 1.00	4	S
Tüylü Turfanda	*Vitis vinifera*	29.63 ± 2.00	3	S
Vaslı	*Vitis vinifera*	50.99 ± 0.32	5	HS
Verdani	*Vitis vinifera*	53.67 ± 2.35	5	HS
Yağ Üzümü	*Vitis vinifera*	49.74 ± 1.85	5	S
Yaz İstanbul	*Vitis vinifera*	46.23 ± 0.89	5	S
Yer Çemiçi	*Vitis vinifera*	44.40 ± 1.31	4	S
Yer Meneşgiri	*Vitis vinifera*	55.35 ± 1.06	5	HS
Yeşil Üzüm	*Vitis vinifera*	73.22 ± 2.02	6	HS
Yeşilyurt Üzümü	*Vitis vinifera*	70.27 ± 4.12	6	HS
Yezendayı	*Vitis vinifera*	72.00 ± 1.66	6	HS
Zehni	*Vitis vinifera*	42.50 ± 0.92	4	S
Zeyti	*Vitis vinifera*	41.72 ± 1.10	4	S
Karaerik	*Vitis vinifera*	84.31 ± 3.83	6	HS
Italia	*Vitis vinifera*	72.17 ± 1.78	6	HS
Kismish Vatkana	*Vitis vinifera*	4.46 ± 0.88	1	HR
Regent	*Vitis vinifera*	5.08 ± 0.42	2	R

HR-Highly resistant, R-Resistant, S-Sensitive, HS-Highly sensitive

CONCLUSIONS

This study is the first research aimed at determining the tolerance and susceptibility levels of 203 local grape varieties/genotypes collected from the Eastern Anatolia Region against powdery mildew disease. The findings obtained have revealed the interactions of different genotypes with the *Erysiphe necator* pathogen under natural inoculation conditions. Three different *Vitis* species were examined in the study, and it was determined that *Vitis labrusca* varieties were more resistant than *Vitis vinifera* varieties. In particular, *Vitis vinifera* subsp. *sylvestris* (Sarmalık Üzüm) was calculated to be susceptible at 37.99%. The powdery mildew severity of the genotypes examined varied between 3.88 (Izabelle-1) and 90.07 (Beyaz Üzüm S1), indicating that different grapevine species exhibit varying degrees of susceptibility to powdery mildew. Among 197 different genotypes of *V. vinifera*, 50 of them, and all of the *V. labrusca* genotypes exhibited a disease severity of less than 30%. The grape genotypes identified as resistant to the disease could support the development of new varieties with improved resistance to *Erysiphe necator*, contributing to greater diversity in grape cultivation.

Our recommendations for future studies are to evaluate more genotypes and repeat similar experiments under different climatic conditions. Furthermore, the use of resistant genotypes should be encouraged when developing disease management strategies. Our recommendations for future studies in the same field and on the same subject include the performance of comprehensive studies including physiological, biochemical and transcriptomic analyses. Such studies are crucial for a better understanding and deciphering of the complex interactions of resistance genes. Furthermore, future evaluations of these genotypes need to be conducted either under field conditions or in controlled environments. Appropriate experimental setups are required to validate resistance traits and ensure the practical applicability of these genotypes in global viticulture practices.

In conclusion, this study provides significant insights into the resistance of local grape varieties/genotypes cultivated in the Eastern Anatolia Region to *E. necator* and presents the first evidence of resistance to *E. necator*.

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Declaration of interests

The authors of this article declare that there are no conflicts of interest.

Author Contributions

The authors declare that they have contributed equally to this article.

ORCID

1st Author **http://orcid.org/0000-0003-2406-9929**
2st Author **http://orcid.org/0000-0002-5344-5367**
3st Author **http://orcid.org/0000-0002-0811-8228**
4st Author **http://orcid.org/0000-0001-7315-202X**

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