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Comprehensive Evaluation of Disease and Pest Resistance, Agronomic Performance, and Economic Potential of 54 Grape Varieties in Azerbaijan

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ABSTRACT

The research investigated the agrobiological and phytosanitary characteristics of 54 local and introduced table grape varieties from the Ampelographic Collection of the Research Institute of Viticulture and Winemaking, with a focus on resistance to key pests and fungal diseases, drought tolerance, and economic potential. Using OIV descriptors, resistance was evaluated on 5- and 9-point scales for downy mildew, powdery mildew, grey rot, *Lobesia botrana*, and phylloxera. The findings revealed significant variation in disease and pest resistance across varieties. Among all varieties, only two (Emin and Elmin) showed high resistance to all three major fungal diseases, and the Bandi and Arna-Grna varieties were the most susceptible ones. Only 7 varieties showed drought resistance. For downy mildew, 31 varieties (e.g., Gyozal Uzum, Muscat of Alexandria) were tolerant to moderately resistant. Similar diversity was noted for powdery mildew and grey rot, with most varieties being moderately resistant. Only the Emin and Elmin varieties showed very high resistance to iron chlorosis. Based on 25 OIV descriptors, the innovative model was applied and the varieties evaluated. 13 varieties were found to be unpromising, 14 varieties are sufficiently promising, and the remaining 27 varieties are highly promising. The grape variety potential scores ranged from 83.6 to 149.2, with the lowest value for the Bandi variety, 121.7 for the control variety Ala shany, and the highest—149.2—for Ikijinsli ag shany. The Ganjavi, Kahraba, and Novrast varieties also showed considerable promise. Economic analysis highlighted substantial yield losses (42.5–78.8%) in varieties without chemical protection, even among resistant types. In contrast, 3–6 chemical treatments significantly reduced losses, enhancing both yield and profitability. Compared to highly susceptible varieties, tolerant and resistant varieties can eliminate two or three chemical applications. This, in turn, reduces the pesticide load on the grape yield and its cost, resulting in up to 6.16% higher net profits compared to the control. This study demonstrates that combining phenotypic analysis, based on OIV descriptors, which cover the most valuable morphological, biological, and economic characteristics of grape varieties, with economic evaluation can effectively screen for high-efficiency grape varieties suitable for local promotion and reducing pesticide dependence.

1. INTRODUCTION

Although many grape varieties grown in various viticultural regions of the world have sufficient ecological plasticity in their agrotechnical and technological indicators, practice shows that the "ideal variety" suitable for cultivation in all ecological and geographical regions of the world, and allowing for obtaining a programmed (meeting all technological requirements) high yield of grapes in various agroecological zones, does not yet exist. Therefore, in viticulture, natural conditions, variety (all biological characteristics of the variety), and cultivation methods should be considered as a single goal.

It is known that, along with biological characteristics of grape varieties, their productivity and economic significance largely depend on the soil and climatic conditions of the growing zone, agricultural practices, the degree of susceptibility to diseases and pests, and a number of other factors. Recently, against the background of global warming, changes have occurred in the biology and bioecology of diseases and pests of agricultural plants, including grapes, expressed in new variations, strains, and races; their aggressiveness increases, and new phases in the development of pest offspring and their harmfulness appear. According to literary data, about 800 parasitic pests, more than 1000 fungal, bacterial, viral, and microplasma diseases have been found on grapes to date. Currently, about 1000 species of fungi have been found on various parts of the grape bush in the viticultural regions of the world. Of these, more than 700 have been identified on wood, up to 200 on leaves, and more than 200 on fruits. About 200 species of fungi were found on the roots [1-

3].

As in countries engaged in viticulture, in the conditions of Azerbaijan, grapevines are more susceptible to fungal diseases such as downy mildew (*Plasmopara viticola* Berl. et de Toni), oidium (*Erysiphe necator* Schwein), gray rot (*Botrytis cinerea* Pers.), anthracnose (*Elsinoe ampelina* Shear), Phomopsis cane and leafspot (*Phomopsis viticola*) and very dangerous phylloxera (*Viteus vitifoliae* Schimer), European grapevine moth (*Lobesia botrana* Schiff.), grape mite (*Colomerus vitis* Pgst.), grape mealybug (*Planococcus vitis* Risso), two-spotted red spider mite (*Tetranychus urticae*), etc., and during the strong development of these harmful organisms, farms suffer great economic damage [1, 2, 4].

If fungal diseases and pests of grapes are not controlled, a large part (35-80%) or the entire crop may be lost, depending on the resistance characteristics of grape varieties and the extent of the disease. In case of epiphytotic with strong development of powdery mildew, not only quality losses are observed, but also up to 50% of the crop [3].

If *Lobesia botrana* is not properly controlled, with strong development of the pest, up to 75-80% of the crop may rot [5]. In many viticultural countries, the greatest harm to vineyards is caused by downy mildew (*Plasmopara viticola*). Under favourable conditions for the development of this disease, a loss of 50-100% of the crop is observed [6, 7].

The level of realisation of the economic potential of the productivity of vineyards existing in the world varies greatly. This indicator depends on the cultivation zone, agrotechnical and phytosanitary background, varietal characteristics of grapes, and other factors, and fluctuates within 35-90%. In general, for 25% of varieties, the level of realization of the economic potential of productivity is ineffective (up to 50%), for 35% it fluctuates within 50-60%, for 27.5% - 60-70%, and only for 12.5% of varieties this indicator is at a high level (above 70%). The level of realisation of this potential for table varieties is, on average 52%, for technical varieties, 62%. The main factors leading to a decrease in the level of realisation of the economic potential of productivity in industrial vineyards are the low adaptive potential of varieties and their resistance to diseases and pests. In world practice, bushes infected with diseases have higher losses. Protection of grapes from pests is one of the most expensive measures. Depending on the variety, its location, phytosanitary condition of the plantings, the means necessary for protecting vineyards may differ by 2-6 times. Currently, among the wide variety of varieties, a significant portion falls to the share of varieties with low adaptive potential and insufficient or weak resistance to widespread harmful organisms. Such vineyards sharply reduce the yield, quality of the harvest, economic efficiency and stability, competitiveness of grapes and wine in the market. Therefore, the analysis of the variability of the infectivity of grape plants, the determination of varieties with high resistance to harmful organisms, and their introduction into production are urgent tasks in viticulture [8-10].

Sustainability in fresh grape and wine production has become a matter of growing importance worldwide, both for society and for those working in viticulture and winemaking. One of the main challenges facing the sector is the impact of harmful organisms, which can cause considerable economic losses. For this reason, the selection of tolerant grape varieties and the development and introduction of new cultivars tolerant to major fungal diseases have gained special relevance. The use of such varieties makes it possible to reduce the need for plant protection products by about 75%, use water more efficiently, prevent soil compaction, and lower production costs [11].

Ryazantsev et al. [12] investigated the resistance of 33 local and introduced grape varieties to fungal diseases, as well as the economic damage caused by these pathogens, under the conditions of the Lower Volga region of Russia. Based on the resistance levels of the studied cultivars, an appropriate plant protection strategy was developed. The researchers determined that six varieties were susceptible to downy mildew: Madeleine Angevine, Aleshyonkin, Zhemchug Saba, Chasselas White, Ukrainka, and Bulgaria. Sixteen varieties showed moderate resistance (tolerance), including Smuglyanka Moldavskaya, Vostorg Red, Pleven European, Hungarian Kishmish, Vostorg Ideal, Korinka Russkaya, Nektarny, Bianca, and others. Eight varieties were classified as resistant: Levokumsky Ustoichivy, Summer Muscat, Vostorg, Ezop, Kobzar, Vostorg Black, Lyusi White, and Augustin. Finally, three varieties demonstrated high resistance: Baco Noir, Severny Plechistik (Northern Plechistik), and Lydia. Highly resistant varieties and hybrid forms can be recommended for environmentally friendly cultivation technologies, in which the use of chemical plant protection products is minimized due to the application of a comprehensive set of agronomic practices. Varieties belonging to the group of highly resistant cultivars can be successfully grown without the use of chemical treatments against downy mildew. The most mildew-resistant varieties are also characterized by weak susceptibility to other diseases such as powdery mildew, black spot, and grey, black, and white rots, as well as anthracnose. Such complex-resistant cultivars can be recommended for industrial cultivation in this region, including for organic or biodynamic viticulture.

Most preparations are not able to completely and efficiently cover the surface of the leaves and shoots of the plant, due to weak hydrophilicity, and their effectiveness is low. These disadvantages reduce the effectiveness of spraying the preparation and increase its consumption. There are also such factors as the high cost of chemical preparations, environmental problems associated with their use, and risks to living organisms. Thus, it is very important to develop methods aimed at reducing chemical treatments and based on the phytopathological and immunological characteristics of various grape varieties to obtain a high-quality and economically profitable harvest.

The main objectives of our research are:

* To systematically evaluate the resistance of 54 grape varieties to various biotic and abiotic stress factors.

* To quantify the differences in economic benefits among grape cultivars with different resistance levels.

* To conduct phytopathological and entomological assessments of the examined grape varieties under natural infection pressure, and to classify them into the following groups: highly susceptible, susceptible, tolerant, resistant, and highly resistant.

* To determine the economic losses in grape varieties with different resistance levels when no chemical control measures are applied.

* To identify and evaluate appropriate chemical treatment schemes for grape cultivars with varying resistance levels, and to assess the economic damage caused by diseases under different spraying regimes.

* To define resistance-based cultivar recommendations aimed at reducing and optimizing the use of pesticides.

* To determine the biological relationship between berry

compactness in clusters and the development of the pest *Lobesia botrana* and the fungal pathogen *Botrytis cinerea* in the studied grape varieties.

* To assess the prospects of grape cultivars based on 25 OIV ampelographic descriptors covering the most important economic, agronomic, biological, and breeding characteristics, and to identify promising varieties with high agricultural and economic value under specific growing conditions.

* To identify the factors directly influencing the development of Botrytis cinerea bunch rot and to determine the correlation relationships among these factors.

2. MATERIALS AND METHODS

2.1 Study area and experimental conditions

The studies were conducted in 2022-2024 in the collection vineyard of the Experimental Station of the Scientific Research Institute of Viticulture and Winemaking, located in the Shamakhi region in northeastern Azerbaijan (coordinates of the location 40°37'59.3"N 48°36'23.6"E). The experimental site is located at an altitude of 660 m above sea level. The soils of the site are brown and, to a lesser extent, fulvous. The soil contains a significant amount of easily assimilated nitrogen and exchangeable potassium, as well as a small amount of phosphorus. In these soils, the humus content ranges from 3.5% to 4.0%, nitrogen from 0.24% to 0.29%, phosphorus from 0.18% to 0.21%, and potassium from 2.0% to 2.2%. During the study years, the precipitation amount was 996.2 mm (2022), 560.6 mm (2023), and 732.8 mm (2024), respectively. The experimental plot is irrigated; the plants are approximately 25 years old; the bushes have a multi-arm fan-shaped form and are grown on a three-tier trellis. The bushes are grown under general agricultural conditions. Phytopathological assessment for powdery mildew (*Plasmopara viticola* Berl. et de Toni) was carried out in May-June (twice), for downy mildew (Uncinula necator Burrill) at the end of July, and for chlorosis – once in June. The root form of phylloxera (Phylloxera vastatrix) was examined in July, and the leaf form (Viteus vitifolii Schimer) in June. The grapevine moth (*Lobesia botrana* Schiff.) produces four generations in Azerbaijan, and all generations damage various organs of the grape plant. The study determined the extent of damage caused by the third generation (during berry ripening). Evaluations were conducted in August, September, and October, depending on the ripening period of the studied varieties. Evaluations for gray mold (*Botrytis cinerea* Pers.) were also conducted during this period, i.e., when the berries reached full ripeness. Disease and pest evaluations in the natural condition were conducted on vines that were not subjected to chemical pest control, with 10 vines for each variety.

2.2 Evaluation methods and OIV classification system

According to the classification of the International Organisation of Vine and Wine (OIV), resistance is assessed by five gradations: 1 point - very unstable, 3 points - unstable, 5 points - moderately resistant (tolerant), 7 points - resistant, and 9 points - resistant. Resistance of grape varieties and forms to iron chlorosis is determined by the OIV 401 descriptor, and resistance to drought by OIV 403. Resistance to diseases and pests is considered one of the most important indicators. Resistance of varieties to downy mildew is assessed by descriptors 451, 452, 452-1, 453, to powdery mildew - by 454, 455, 455-1, 456, to grey rot - by 458, 458-1, 459, to phylloxera - by descriptors 461, 462 [13, 14].

Under natural conditions, the resistance of grape varieties to the main fungal diseases (downy mildew, powdery mildew, grey rot, etc.) and pests (grape leaf roller, mealy aphid, etc.) is determined on a five-point scale using the methods specified.

OIV 401: Iron chlorosis has to be assessed on soils with high lime content and/or during spring on heavy wet soils. It is critical to indicate whether the variety under description was grafted, growing on its own roots, or as a rootstock. 1 = yellow leaves, more than 10 % of leaf surface with necroses, stunted shoots; 3 = mature leaves with pure yellow color, beginning necroses between main veins; 5 = pure yellow leaves with green main veins; 7 = pale green leaves with appearance of a net of fine green veins; 9 = dark green leaves [14].

OIV 403: The testing of rootstocks must be assessed after grafting with a *V. vinifera* variety. 1 = necrotic or totally dry leaf with leaf drop; 5 = yellowish leaf;. 9 = leaf totally green [14].

OIV 452: Extension of infected mildew patches on all the leaves from 4 - 6 vines has to be assessed, if possible, about 3 weeks after the onset of flowering. 1 = not limited, vast attacked patches or totally attacked leaf blades - strong fungus fructifications - pronounced and dense necrotic speckles - very early leaf drop; 3 = vast, not limited attacked patches - very strong fungus fructification - numerous necrotic speckles - leaf drop not as early as with note 1; 5 = limited attacked patches 1-2 cm in diameter - more or less severe fungus fructification - irregular formation of necrotic speckles; 7 = less attacked patches - less fructification - few necrotic speckles; 9 = punctuated or no symptoms, neither fructification nor necrotic speckles [14].

OIV 455: Climatic influences affecting the infection have to be considered at the time of assessment. 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 mycellial 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; 9 = greatly suppressed symptoms or none at all – no mycelium or visible fructification [14].

Phytopathological evaluation of grape bunches infected with downy mildew in a natural background [4, 15].

1 point. Fruit damage in bunches is more than 50% to 100%.

3 points. Fruit damage in bunches ranges from 25% to 50%.

5 points. Fruit damage in bunches ranges from 10% to 25%.

7 points. Fruit damage in bunches ranges from 5% to 10%

9 point. Damage to individual fruits is observed in bunches (1 to 5%).

Determination of resistance to Grey mould (*Botrytis cinerea* Pers.) [4, 15].

1 point. Very sensitive – fruit rot in individual bunches of diseased bushes is more than 50%. The number of fungal spores is extremely high.

3 points. Sensitive – The infected cherries are covered with a dense gray coating. In individual bunches, the rotting of cherries reaches 50%.

5 points. Relatively resistant – fruit rot in individual bunches is from 5% to 10%.

7 points. Resistant - damage to cherries in bunches does not exceed 5%.

9 points. Highly resistant - Individual berries rot in highly resistant bunches. When the humidity is relatively high, fungal spores may be poorly formed.

The damage caused by *Lobesia botrana* at the stage of berry ripening is measured on a five-point scale. Depending on the variety, the pest affects the berries to varying degrees. Thus, an infestation of up to 5% is considered very weak and is assessed as 1 point, at 5-25% - weak, 2 points, at 25-50% - average, 3 points, at 50-75% - strong, 4 points, and at 75-100% - very strong, 5 points [4, 15].

The correlation coefficient (r) between various indicators was calculated using the Pearson formula [16]:

$$r = \frac{\sum(x-\bar{x})\sum(y-\bar{y})}{\sqrt{[\sum(x-\bar{x})^2]\sum[(y-\bar{y})^2]}}$$

where, $\bar{x}$ and $\bar{y}$ are the mean values of the variables of x and y.

For digital assessment of grape varieties' prospects in a specific agroclimatic zone, 25 OIV descriptors were selected for the most important features and indicators and included in the "New Model for Assessing Prospects". The 25 descriptors used in assessing prospects are: OIV301- Time of bud burst; OIV629- The period from bud opening to full ripening of the berries; OIV305- Time of beginning of wood maturity; OIV 604- Mature leaf: length of vein N4; OIV 630- Level of development of the node (quantity); OIV153- Inflorescence: number of inflorescences per shoot; OIV502- Bunch: weight of a single bunch; OIV504- Yield per m²; OIV505- Sugar content of must; OIV204- Bunch: density; OIV206- Bunch: length of peduncle of primary bunch; OIV220- Berry: length; OIV222- Berry: uniformity of size; OIV223- Berry: shape; OIV225- Berry: color of skin; OIV228- Berry: thickness of skin; OIV236- Berry: particularity of flavor; OIV237- Classification of berry taste and aroma; OIV238- Berry: length of pedicel; OIV240- Berry: ease of detachment from pedicel; OIV242- Berry: length of seeds; OIV351- Vigor of shoot growth; OIV 452- Leaf: degree of resistance to Plasmopara (leaf disc test); OIV 455- Leaf: degree of resistance to Oidium (leaf disc test); OIV 459- Cluster: degree of resistance to Botrytis [13, 14].

On the other hand, the numerical values and the corresponding codes of the ampelodescriptors bunch density (OIV 204), berry skin colour (OIV 225), and specific berry aroma (OIV 236) were changed in such a way that their role increased in assessing their suitability for breeding and prospects. Since the studied and improved traits are not equally important, it is important to establish a "weight" (correction coefficient) for each trait in the comprehensive assessment of varieties.

To evaluate the adaptive potential and breeding suitability of grape varieties in a specific agroclimatic zone, a total of 25 key OIV ampelographic descriptors were selected and incorporated into a comprehensive assessment model. Each trait was assigned a correction coefficient (weight) based on its relative importance in viticultural and enological performance. The final score, referred to as the prospectiveness index (P), is calculated as the weighted sum of the selected descriptors:

$$P = \sum_{i=1}^{25}(w_i \times \mathrm{OIV}_i)$$

where, w_i is the weight (correction coefficient) and OIV_i is the score of the i^{th} descriptor. This model allows for a nuanced and quantitative comparison of grapevine genotypes under local conditions.

The assessment of grape variety resistance to pests and diseases, such as *Lobesia botrana*, iron chlorosis, drought, and fungal infections, is based on standardized classification systems and OIV descriptors, which provide a quantitative framework for evaluating susceptibility and informing viticultural management decisions. The density of berries in a bunch is one of the factors influencing the development of the *Lobesia botrana*. Bunch density varies depending on the biological characteristics of varieties and forms, growing technology and conditions, and other factors. If the density coefficient of a bunch does not exceed 0.200 g/cm^3, the bunch is considered very sparse, at 0.201-0.300 g/cm^3 - sparse, at 0.301-0.400 g/cm^3 - dense, and above 0.401 g/cm^3 - very dense [17].

3. RESULTS AND DISCUSSIONS

3.1 Resistance of grape varieties to stress factors

During the years of research, the studied grape varieties were tested for their resistance to iron chlorosis, downy mildew, powdery mildew, grey mould, as well as to the phylloxera pest and drought, both on bunches and on leaves, in field and laboratory conditions. It was found that the varieties exhibit varying degrees of resistance to the indicated diseases and drought (Table 1 and Figure 1).

The resistance of grape varieties to chlorosis is of great importance. As it became clear, three varieties (Agadai, Ag shany, Ikijinsli ag shany) are very unstable to iron chlorosis, 17 varieties (Tabrizi, Ala shany, Alphonse Lavalle, etc.) are tolerant, 12 varieties (Ag Derbendi, Kahraba, Chahrayi taify, etc.) are unstable, 20 varieties (Gara khatyny, Nagshabi, Muscat of Hamburg, etc.) are resistant, and only two varieties (Emin and Elmin) are very resistant (Table 2).

The studies also showed differences in the resistance of varieties to drought resistance indicators. Drought-resistant varieties prevailed here. Of the 54 varieties studied, 25 varieties (Huseyni, Shabrany, Surmei, etc.) were unstable to drought, 17 varieties (Ag Khalili, Ganjavi, Black Magic, etc.) were tolerant, 5 varieties (Ikijinsli ag shany, Gyrmyzy saabi, Novrast, etc.) were very resistant, and 7 varieties (Shamakhy marandisi, Kahraba, etc.) were resistant.

One of the most dangerous diseases of grapes is downy mildew. Mildew, or downy mildew (*Plamopara viticola* Berl. et Toni), harms wide varieties and hybrid forms of grapes from year to year. Favourable conditions for the spread of the disease are temperatures above +10°C and high humidity; at the infection stage, the presence of droplet-liquid moisture is necessary. Also, the spread of mildew is facilitated by such visible factors as the thickening of shoots on the bush and the strong development of weeds due to the low level of agricultural measures carried out [6, 18-20].

When determining the degree of resistance of the studied varieties, different results were also obtained. No varieties resistant or very resistant to the leaf form of downy mildew were found. Varieties resistant to the disease were in the minority. Thus, only one variety, Moldova, was noted as resistant to this disease. The absolute majority of varieties - 31 (Gyozal uzum, Sarygilya, Muscat of Alexandria, etc.) were grouped as tolerant-moderately resistant. As we can see, here again there are no very resistant varieties; only eight varieties (Novrast, Ag Huseyni, Chahrai taifi, etc.) turned out to be very unstable, and this is a good indicator; 14 varieties (Ag Khalili, Arna-grna, Gyrmyzy saabi, etc.) were noted as unstable.

Table 1. Resistance of local and introduced table grape varieties to diseases and pests

Varieties	OIV 401	OIV 403	OIV 451	OIV 452	OIV 453	OIV 454	OIV 455	OIV 456	OIV 458	OIV 459	OIV 461	OIV 462	Degree of Susceptibility to Grape Leaf Roller, %	Degree of Susceptibility to Grape Leaf Roller, in points	Cluster Density Coefficient
Local varieties															
Absheron khatynysy	7	5	5	5	5	5	7	5	7	7	7	1	24.6	7	0.12
Absheron gelinbarmagy	7	5	5	5	5	5	3	5	7	5	7	1	21.6	7	0.14
Agadai	1	5	5	5	5	5	5	5	7	3	7	3	36.8	5	0.26
Ag Derbendi	3	5	3	3	3	1	3	5	7	1	7	3	55.2	3	0.34
Ag Khalili	7	5	3	3	5	1	1	3	5	1	7	1	58.6	3	0.28
Ag shany	1	5	5	5	7	7	5	5	7	5	7	3	32.4	5	0.21
Gara şany	7	5	5	5	7	7	5	5	7	7	7	3	16.3	7	0.20
Tabrizi	5	5	3	3	3	5	5	5	5	1	7	3	63.8	3	0.28
Ala shanı	5	5	5	5	5	7	7	5	7	5	7	3	23.4	7	0.26
Arna-grna	5	5	3	3	5	1	3	5	5	3	7	3	52.6	3	0.27
Ganjavi	7	5	5	5	7	7	7	5	7	5	7	3	26.7	5	0.32
Gyozal uzum	7	5	5	5	7	7	7	7	7	7	7	3	17.6	7	0.24
Huseyni	3	3	5	5	5	3	1	5	5	1	7	1	75.0	3	0.18
Ikijinsli ag shany	1	1	5	5	7	5	5	5	7	5	7	3	28.2	5	0.16
Kahraba	3	7	5	5	7	7	7	7	7	7	7	3	5.8	7	0.32
Gyrmyzy saabi	3	1	3	3	7	1	1	3	5	1	7	3	72.5	3	0.26
Mahmudu	7	5	5	5	7	7	7	7	7	7	7	3	8.3	7	0.25
Novrast	3	1	1	1	7	1	1	3	5	1	7	1	68.4	3	0.29
Oguz uzumu	7	7	5	5	7	7	5	7	7	5	7	3	19.4	7	0.27
Sarygila	3	5	5	5	7	5	5	7	7	5	7	3	24.4	7	0.30
Surmei	7	3	5	5	7	5	5	3	7	3	7	3	57.7	3	0.25
Shabrany	7	3	5	5	7	5	5	7	5	7	7	3	20.3	7	0.28
Shamakhy marandisi	7	7	5	5	7	7	5	7	7	3	7	3	76.8	1	0.36
Ag Huseyni	5	1	1	1	7	5	3	3	5	3	7	3	69.2	3	0.16
Gara khatyny	7	3	5	5	5	5	5	5	7	3	7	3	56.2	3	0.30
Nagshbi	7	3	5	5	5	5	5	5	7	3	7	3	71.4	3	0.28
Gara kechimemesi	7	3	5	5	7	3	1	3	7	1	7	1	72.4	3	0.34
Bandi	7	3	5	5	7	3	3	1	7	1	7	1	74.0	3	0.40
Elmin	9	7	5	5	7	7	7	7	7	7	7	5	16.2	7	0.22
Emin	9	7	5	5	7	7	7	7	7	7	7	5	18.4	7	0.26
İntroduced varieties															
Alphonse Lavalle	5	3	5	5	7	7	5	5	7	5	7	3	12.4	7	0.30
Black Magic	5	5	5	5	7	7	5	7	7	7	7	3	18.4	7	0.24
Chahrai taifi	3	1	1	1	7	5	5	3	5	3	7	1	52.6	3	0.23
Danlas	5	3	3	3	7	7	5	5	7	3	7	3	64.4	3	0.30
Muscat of Hamburg	7	7	5	5	7	7	7	7	7	7	7	3	7.8	7	0.23
Muscat of Alexandria	7	3	3	3	5	5	5	3	7	5	7	1	36.5	5	0.28
Muscat of Italy	7	3	3	3	3	3	3	3	7	1	7	1	73.3	3	0.18
Cardinal	5	3	3	3	3	3	3	3	5	1	7	1	63.8	3	0.20
Katta-kurgan	3	3	3	3	3	3	3	3	5	1	7	1	51.8	3	0.24
Janjal gara	7	3	5	5	7	7	5	7	7	3	7	3	25.5	5	0.30
Michel Paleri	7	3	5	5	7	7	5	5	7	3	7	3	30.0	5	0.32
Moldova	5	7	7	7	9	7	7	7	7	7	7	5	23.8	7	0.28
Parkent	3	3	1	1	5	3	3	5	7	5	7	3	43.4	5	0.21
Prima sortu	5	3	3	3	5	5	3	5	7	7	7	3	9.3	7	0.24
Preobrajenye	5	3	3	3	5	5	5	5	7	3	7	3	15.5	7	0.32
Red globe	5	3	5	5	7	5	5	5	7	5	7	3	27.0	5	0.23
Viktoria	5	3	3	3	7	7	5	5	7	5	7	3	32.0	5	0.20
Ora	5	3	3	3	7	7	7	5	5	5	7	3	34.0	5	0.28
Pobeda	3	3	1	1	7	5	3	5	7	5	7	1	21.6	7	0.20
Tuya tish	3	5	1	1	5	5	3	3	7	3	7	1	54.3	3	0.30
Prenentable	5	5	1	1	5	7	5	3	5	5	7	3	25.0	7	0.25
İchkimar	3	3	1	1	5	3	5	1	5	3	7	1	71.0	3	0.21
Dnestrovskiy rozovy	5	3	5	5	7	7	5	5	5	3	7	3	73.0	3	0.31
Dekabrsky	5	3	5	5	7	7	5	5	5	3	7	3	67.0	3	0.31

Table 2. Prospects of local and introduced varieties of table grapes according to an innovative model

Varieties	OIV Ampelodescriptors for Assessing Prospects and "Weight" for the Corresponding Features (Correction Coefficient)																									Overall Prospect Score	Difference Relative to Control
	OIV301	OIV629	OIV305	OIV604-1	OIV630	OIV153	OIV502	OIV504	OIV505	OIV204	OIV206	OIV220	OIV222	OIV223	OIV225	OIV228	OIV236	OIV237	OIV238	OIV240	OIV242	OIV351	OIV 452	OIV 455	OIV 459		
	0.5	2.5	0.4	0.2	1.5	0.7	1.0	2.5	2.2	0.7	0.2	1.0	2.0	1.0	1.8	0.4	1.5	1.3	0.2	0.5	0.2	0.5	1.0	1.0	0.8	-	
Ala shany (control)	3	3	5	7	7	3	5	5	7	9	7	7	2	3	5	5	3	2	5	5	5	7	5	7	5	121.7	-
Absheron khatynysy	5	5	9	9	7	3	3	3	9	7	5	5	2	3	7	5	1	1	5	5	5	5	5	7	7	123.2	+1.5
Absheron gelinbarmagy	5	5	7	9	7	3	3	3	7	7	7	9	2	9	7	5	1	1	7	7	3	5	5	3	5	118.8	-2.9
Agadai	3	3	5	7	7	3	3	5	7	7	5	7	1	3	7	3	1	1	5	5	3	9	5	5	3	111.4	-10.3
Ag Derbendi	5	1	5	7	7	3	5	7	5	7	5	9	1	9	7	5	3	1	5	7	3	9	3	3	1	117.2	-4.5

Ag Khalili	5	7	9	7	7	3	3	3	3	9	7	7	2	9	1	7	3	1	5	7	7	7	3	1	1	107.0	-14.7
Ag shany	5	5	5	7	7	3	5	5	9	9	7	7	2	4	7	5	3	2	5	5	5	7	5	5	5	134.7	+13
Gara şany	5	5	5	7	5	1	3	5	7	9	7	7	2	3	5	5	3	2	5	5	5	7	5	5	7	120.9	-0.8
Tabrizi	5	5	5	9	7	5	5	9	7	7	5	7	2	9	7	3	3	2	5	5	5	9	3	5	1	140.3	+18.6
Arna-grna	7	1	3	7	5	3	5	7	5	7	5	7	1	3	1	3	1	1	3	3	3	7	3	3	3	90.0	-31.7
Ganjavi	5	5	5	9	9	5	7	9	7	7	5	7	2	3	7	7	3	2	3	3	5	9	5	7	5	146.7	+25
Gyozal uzum	5	5	3	7	5	3	3	5	5	9	7	9	2	9	3	5	3	1	5	5	5	7	5	7	7	122.2	+0.5
Huseyni	5	7	3	7	7	1	7	5	5	9	7	9	2	8	7	7	3	2	7	7	3	7	5	1	1	131.1	+9.4
Ikijinsli ag shany	7	5	7	5	5	3	7	9	7	9	7	7	2	9	7	7	3	3	5	7	7	7	5	5	5	149.2	+27.5
Kahraba	7	5	7	7	5	3	5	7	9	9	9	7	2	3	7	7	3	3	7	7	5	9	5	7	7	146.0	+24.3
Gyrmyzy saabi	7	5	3	5	5	1	5	5	5	9	5	9	2	9	3	7	3	3	7	7	7	5	3	1	1	114.4	-7.3
Mahmudu	3	3	3	7	7	1	5	7	5	9	7	7	2	3	5	5	3	2	7	7	5	7	5	7	7	123.1	+1.4
Novrast	5	9	7	7	7	3	5	7	7	9	5	9	1	9	7	7	3	3	7	7	7	9	1	1	1	144.4	+22.7
Oguz uzumu	5	5	5	9	7	5	5	7	7	7	5	7	2	3	7	5	3	2	5	5	5	7	5	5	5	134.3	+12.6
Sarygila	5	3	5	7	7	3	5	7	7	7	5	7	2	3	7	5	3	2	5	5	5	7	5	5	5	141.4	+19.7
Surmei	5	5	5	5	5	1	9	7	5	7	5	7	2	9	3	5	1	1	5	5	5	7	5	5	3	127.5	+5.8
Shabrany	3	3	5	5	7	1	5	5	5	9	7	7	2	3	3	5	3	1	7	7	3	7	5	5	7	111.2	-9.5
Shamakhy marandisi	7	1	5	7	7	3	9	9	7	1	5	7	2	9	3	5	3	1	5	3		9	5	5	3	124.2	+2.5
Ag Huseyni	5	7	3	5	5	1	5	5	5	9	7	9	2	9	1	7	3	2	7	7	3	9	1	3	3	116.7	-5
Gara khatyny	5	5	7	7	7	3	3	5	7	3	5	7	2	9	3	7	3	2	3	3	5	7	5	5	3	120.1	-1.6
Nagshabi	5	5	7	7	7	3	5	5	7	3	5	7	2	3	1	3	1	1	3	3	3	7	5	5	3	106.2	-15.5
Gara kechimemesi	5	5	5	7	5	1	7	5	7	5	7	7	2	9	3	5	1	1	5	5	3	7	5	1	1	111	-10.7
Bandi	5	3	3	3	5	1	5	5	5	1	3	7	1	4	1	3	1	1	3	3	3	7	5	3	1	83.6	-38.1
Elmin	5	3	7	9	9	5	5	7	7	7	7	7	2	4	3	5	3	3	7	5	7	7	5	7	7	133	+11.3
Emin	3	3	7	9	9	5	5	7	7	7	7	7	2	4	7	5	3	3	5	5	7	7	5	7	7	138.8	+17.1
Alphonse Lavalle	5	5	5	5	7	3	7	7	5	7	7	9	2	3	5	5	3	3	5	7	5	7	5	5	5	130.8	+9.1
Black Magc	5	5	3	5	5	5	5	9	5	7	5	7	1	9	5	5	3	3	5	7	7	7	5	5	7	135	+13.3
Chahrai tayfi	7	1	5	7	7	1	9	9	5	7	7	9	1	9	9	7	3	3	7	7	7	7	1	5	3	135.4	+13.7
Danlas	7	7	5	5	7	5	5	7	5	7	5	7	2	4	1	7	3	3	5	5	5	7	3	5	3	123.8	+2.1
Muscat of Hamburg	5	1	7	7	7	5	5	7	5	9	9	7	2	3	3	3	4	6	7	3	3	7	5	7	7	123.8	+2.1
Muscat of Alexandria	5	1	3	5	5	1	7	7	5	7	5	7	1	4	1	3	4	6	5	3	3	7	3	5	5	105.2	-16.5
Muscat of Italy	7	5	5	7	7	3	7	9	7	7	7	9	1	9	7	7	4	6	5	3	5	9	3	3	1	124.6	+2.9
Cardinal	7	7	3	5	5	3	7	5	5	9	7	9	1	3	3	5	4	5	5	3	7	7	3	3	1	119.1	-2.6
Katta-kurgan	7	1	3	5	5	3	9	5	5	3	5	7	1	3	1	3	1	2	5	3	3	7	3	3	1	85.9	-35.8
Janjal gara	5	5	7	7	7	3	5	5	7	5	5	7	2	4	5	5	1	2	5	3	5	7	5	5	3	118.7	-3
Michel Paleri	5	5	5	5	5	3	5	7	5	7	7	7	2	5	5	5	3	2	5	5	5	7	5	5	3	121.9	+0.2
Moldova	7	5	3	5	7	5	5	9	5	7	5	7	2	5	5	5	1	1	5	5	5	5	7	7	7	133	+11.3
Parkent	7	3	3	5	5	1	9	7	5	9	7	9	2	5	9	7	3	1	7	7	7	9	1	3	5	128.2	+6.5
Prima	7	7	3	5	5	3	5	7	3	7	5	7	2	3	5	5	4	2	5	7	5	7	3	3	7	125.4	-1.3
Preobrajenye	5	5	3	7	5	3	5	5	5	5	5	7	2	9	9	5	3	2	5	5	5	7	3	5	3	123.9	+2.2
Red globe	7	1	5	7	7	5	9	9	5	9	7	9	2	3	3	5	3	3	7	5	5	7	5	5	5	127.8	+6.1
Viktoria	7	5	5	7	7	5	7	7	5	7	5	9	2	4	7	5	3	2	7	5	5	7	3	5	5	123.3	+1.6
Ora	7	7	5	5	5	5	7	5	5	7	5	5	2	3	1	5	3	2	5	5	5	7	3	7	5	118.3	-3.4
Pobeda	7	1	5	7	5	3	9	7	5	9	5	9	2	9	5	5	3	1	7	7	5	7	1	3	5	124	+2.3
Tuya tish	7	3	5	7	5	1	7	7	5	7	5	7	1	4	1	3	1	1	5	5	5	7	1	3	3	97.2	-24.5
Prezentable	7	3	5	5	5	3	7	5	5	7	5	7	1	4	7	3	1	1	5	5	5	5	1	5	5	132.4	+10.7
Ichkimar	7	5	3	5	5	3	5	5	5	9	5	9	2	9	3	5	3	1	7	7	3	5	1	5	3	115.2	-6.5
Dnestrovsky rozovy	5	3	3	5	5	5	5	7	5	7	5	7	1	3	9	5	1	1	5	5	5	5	5	5	3	116	-5.7
Dekabrsky	5	3	3	5	5	5	5	7	5	7	5	7	1	8	5	5	1	1	5	5	5	5	5	5	3	107.8	-13.9

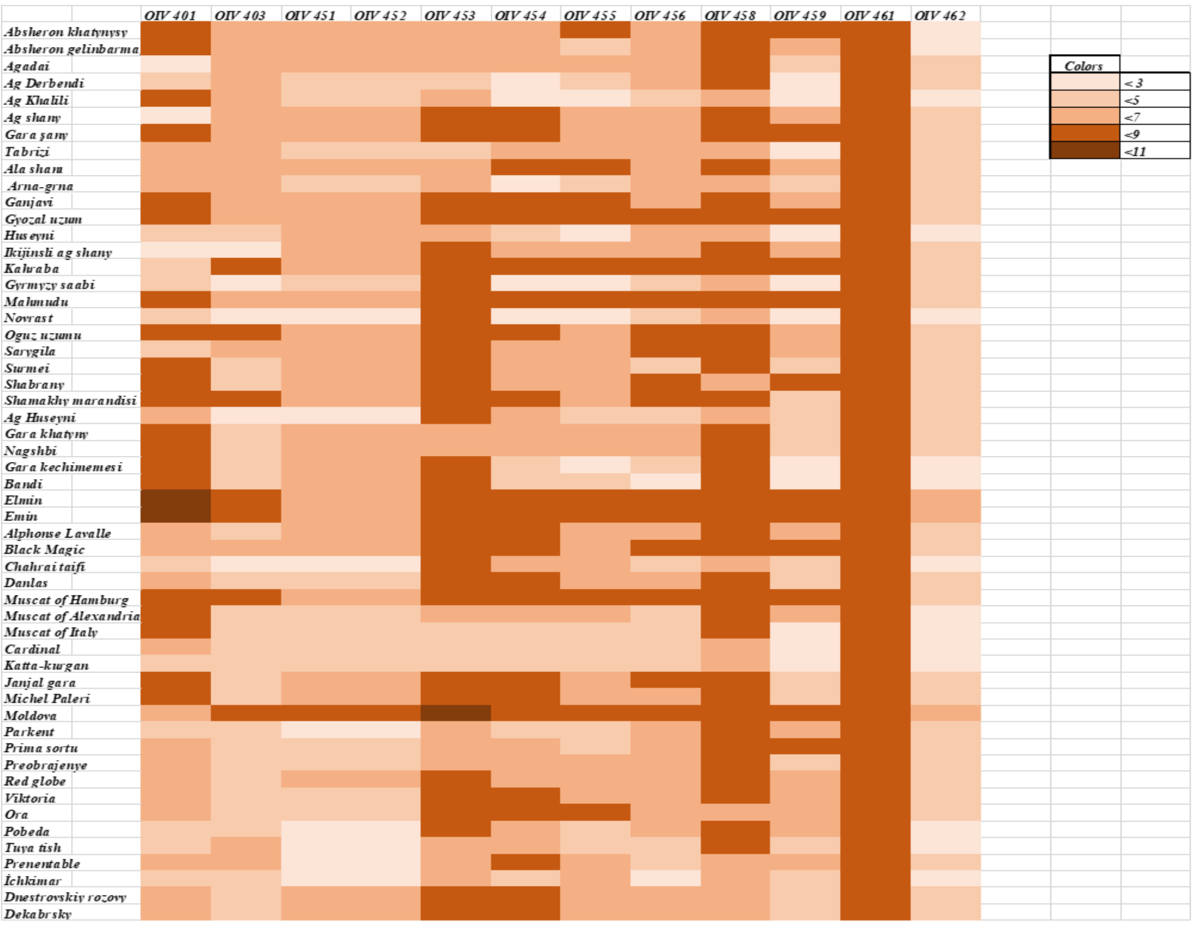

Figure 1. Heat map of resistance indicators of 54 local and foreign grape varieties to some biotic and abiotic factors (based on 12 OIV ampelodescriptors)

The map reflects the different resistance indicators of the grape varieties in Table 1.

As noted, different degrees of resistance to downy mildew were also determined on bunches. At the same time, very unstable varieties were not encountered, and this is very good. At the same time, unstable varieties were in the minority - only five varieties (Tabrizi, Muscat of Italia, Cardinal, etc.). Only one variety (Moldova) was noted as very resistant. Resistant varieties were in the majority: 32 varieties (Mahmudu, Novrast, Muscat of Hamburg, etc.) were grouped as resistant, 16 varieties (Absheron khatynysy, Nagshabi, Parkent, etc.) as tolerant.

Another disease studied in the research was powdery mildew, and here, too, a wide range of resistance was noted in different species. Among the varieties studied, there were no varieties that were very resistant to powdery mildew. At the same time, very few varieties - only five (Ag Khalili, Ag Derbendi, Arna-grna, etc.) showed themselves to be very unstable. The number of unstable varieties was also small - only eight (Huseyni, Gara kechimemesi, Bandi, etc.). Many varieties (23 varieties) were resistant to this disease (Gara shany, Emin, Alphonse Lavalle, etc.). 18 varieties (Absheron gelinbarmagy, Agadai, Muscat of Alexandria) were moderately resistant or tolerant.

Resistance to powdery mildew was noted in the leaves and bunches of plants. Thus, both in bunches and in leaves, there was no very strong resistance to this disease, and the same number of very unstable varieties. According to the results of the research, 11 varieties (Ala shany, Emin, Elmin, etc.) were resistant, 12 varieties (Absheron gelinbarmagy, Ag Derbendi, Bandi, etc.) were unstable, and 26 varieties (Agadai, Ikijinsli ag shany, Danlas, etc.) were tolerant.

The level of resistance to powdery mildew in bunches also varied. It turned out that there were no very resistant varieties; only two varieties (Bandi, Ichkimar) were very unstable, the majority were varieties with an average degree of resistance (Absheron Khatynysy, Agadai, Ag Shany, Gara Shany, Tabrizi, Red Globe, Victoria, Pobeda, etc.). The number of resistant (Kahraba, Mahmudu, Oguz Uzumu, Sarygilya, Shamakhy Marandisi, Muscat of Hamburg, Black Magic, Moldova, etc.) and unstable (Gyrmyzy Saabi, Novrast, Surmei, Ag Huseyni, Chahrai Taifi, Muscat of Alexandria, Muscat of Italia, Cardinal, etc.) varieties was 13 each.

Another widespread disease of grapes is grey mould. Grey mould (*Botrytis cinerea* Pers.) can increase in inflorescences, berries, leaves, and shoots. For the development of fruiting vineyards, grey mould on inflorescences and berries of small size, its development is provided by high humidity and air temperature in the range of 5-30°C. Infected inflorescences are covered with grey hairs conidial spores, acquire a brown colour, and die. Sometimes a separate part of the bunch burns, and then the infected part breaks off and falls off. In wet weather, the berries rot and acquire a brown colour, become watery, and the skin cracks. Berries infected with grey mould are covered with a grey layer of fungal spores, and the bunches can completely rot within 5-7 days. In the second morning of summer, prolonged dry weather followed by prolonged rains is especially favourable for developing grey mould. Grey mould is a parasite of the damaged part, so bunches damaged by grape leaf rollers, cutworms, wind, and physiological cracks, due to the accumulation of excess water in the berries, are infected faster. The active development of grey mould is also facilitated by excessive thickening of shoots on the bush, shading of bunches by leaves and weeds, damage by hail, sunburn, excessive load of the bushes with crops, excessive application of nitrogen fertilisers, and late watering [21-23].

Among the studied varieties, there were no very stable, unstable, or very unstable varieties. 38 varieties were marked as resistant (Absheron khatynysy, Mahmudu, Victoria, etc.), 16 varieties as moderately resistant (Gyrmyzy saabi, Ag Huseyni, Ichkimar, etc.). Resistance to grey rot in bunches did not differ very sharply; also, there were no very resistant varieties. 11 varieties (Tabrizi, Novrast, Katta-kurgan, etc.) were defined as very unstable, 16 varieties (Arna-grna, Surmei, Dneprovsky rozov, etc.) as unstable, 15 varieties (Ganjavi, Oguz uzumu, Pobeda, etc.) as tolerant, 12 varieties (Gara shany, Mahmudu, Prima, etc.) as resistant.

According to the literature, there are two forms of phylloxera: leaf and root. The scope of their damage is different. The root form damages the root system of all varieties of European and Asian origin, while the leaf form damages the leaves of varieties and rootstocks of American origin. The leaf form of *phylloxera* cannot damage the leaves of varieties belonging to the *V. vinifera* species [24].

Along with diseases, the degree of resistance to the leaf form of phylloxera was also studied in the studied varieties. Observations showed that all 54 varieties were concentrated in the group of resistant varieties. Certain differences were noted in resistance to the root form of phylloxera. Thus, 15 varieties (Huseyni, Novrast, Bandi, etc.) turned out to be very unstable, 36 varieties (Tabrizi, Nagshabi, Red Globe, etc.) were unstable, and only three varieties (Elmin, Emin, Moldova) showed average stability; very stable and stable varieties were not noted.

Several reasons cause rot diseases of grapes. Our studies, as well as those around the world, have shown that most grape bunch rot is caused by powdery mildew. When a berry is affected by this disease, the skin development stops; that is, the berries do not grow. Inside the berry, the tissues continue to develop normally. This leads to the rupture of the berry due to internal pressure. As a result, water enters the ruptured, cracked part, which contributes to the development of diseases such as white, grey, or black rot. Another cause of berry rot in the formation and development stage is the second and third generation of *Lobesia botrana* [25, 26].

Moosavi et al. [23] note that *Lobesia botrana*, being a polyvoltine (giving two or more generations per year) species, gives two to four generations per year depending on the geographical latitude, microclimate conditions, and year. From the second generation onwards, the larvae are coprophagous (fruit-feeding) and cause crop losses and bunch rot, mainly due to the spread of *Botrytis cinerea* Pers. Fr. To reduce berry rot and improve the quality of grapes during the flight of the second generation, thinning of the leaves in the area around the bunch is carried out, which can reduce the incidence of the third generation of *Lobesia botrana* by up to 70%.

The European grapevine moth (*Lobesia botrana* Den. & Schiff.) is a Mediterranean species and is widespread in industrial viticulture areas. Currently, the pest's distribution area covers all countries of the Mediterranean basin, the Middle East, and Central Asia. Significant areas are also affected in China. The pest has spread across the east coast of Africa as far as Kenya and has taken root in the viticulture areas of South America (Chile, Argentina). From 2009 to 2014, this pest was also observed in North America, in California, but was destroyed due to local quarantine measures. Currently, this pest is included in the quarantine list in many countries. In grapes, it mainly affects the generative organs, flowers, berries, and bunches. The harmful stage is caterpillars of all generations. The greatest harm is caused to grapes during the ripening process, leading to their rotting. The pest has four generations that damage grapes. The period of the first flight of the pest is the flight of those individuals that survived their development period last year and are fertilised after the flight this year. They give rise to the first generation of the grape berry moth in the new year. Therefore, for a long time, the period of the first flight has been mistakenly called the first generation; in fact, the first generation of the pest is currently being formed, and protective measures should be directed against it [5, 25, 26].

In the course of our research, the degree of infestation of varieties by points was also studied, and various results were obtained. It is gratifying to note that only one variety was considered very unstable. Also, no very resistant varieties were noted. The relative majority (22) were unstable varieties. The degree of infestation by *Lobesia botrana*, by points, allowed us to classify 22 varieties as resistant, and 11 varieties showed average resistance.

The development of pests in plants and the degree of harmfulness significantly depend on the aggressiveness of the pest, the biological and genetic characteristics of the plant, and the influence of environmental factors [1, 4]. The resistance of the studied grape varieties to various diseases and pests was assessed by visually assessing the amount of infection or damage against a natural background. It was found that the susceptibility of the varieties to various pests varies. The research work and observations were carried out in the same area and on the same background. The area where these varieties were planted and cultivated at the experimental station covers an area of 5 ha. We believe that since the phytopathological background (environment) for these varieties was the same during the research years, the differences that arose mainly depend on the origin, biological and genetic, etc., characteristics of the varieties.

3.2 Influence of bunch density on disease and pest development

Research has shown that the density of bunches contributes to the spread of diseases and pests. In our research, the coefficient of bunch density of the studied varieties was determined, and the effect of this indicator on the degree of spread of *Lobesia botrana* and the development of grey mould disease was examined. For this purpose, mathematical and statistical studies were carried out, and the degree of correlation between these indicators was revealed (Figures 2-4). As we can see, although there is a positive relationship between the coefficient of bunch density and the susceptibility to grape leaf roller, it is relatively weak (r = 0.182). There is a negative relationship between the coefficient of bunch density and the susceptibility to grey mould, which is mathematically insignificant (r = -0.270). At the same time, the relationship between the degree of spread of *Lobesia botrana* and grey mould, being negative, is mathematically high and reliable (r = -0.847). This shows that the higher the degree of susceptibility to the grape leaf roller, the more severe the grey mould disease develops on the grapes (Figures 2-4).

In our research, we examined the damage caused by the third generation of the grapevine moth (*Lobesia botrana* Schiff.) and the rot diseases it causes during the period of full maturity. According to published data, the third generation of this pest is the most dangerous and causes the greatest economic losses. The damage they cause creates conditions for the development of harmful microorganisms in the bunch, and rot-causing fungi such as *Botrytis cinerea* and Aspergillus niger develop in the berries. The extent of grapevine moth damage largely depends on several factors, such as the grape variety, the thickness and density of the berry skin, the density of the bunches, the timing of berry ripening, etc [27, 28].

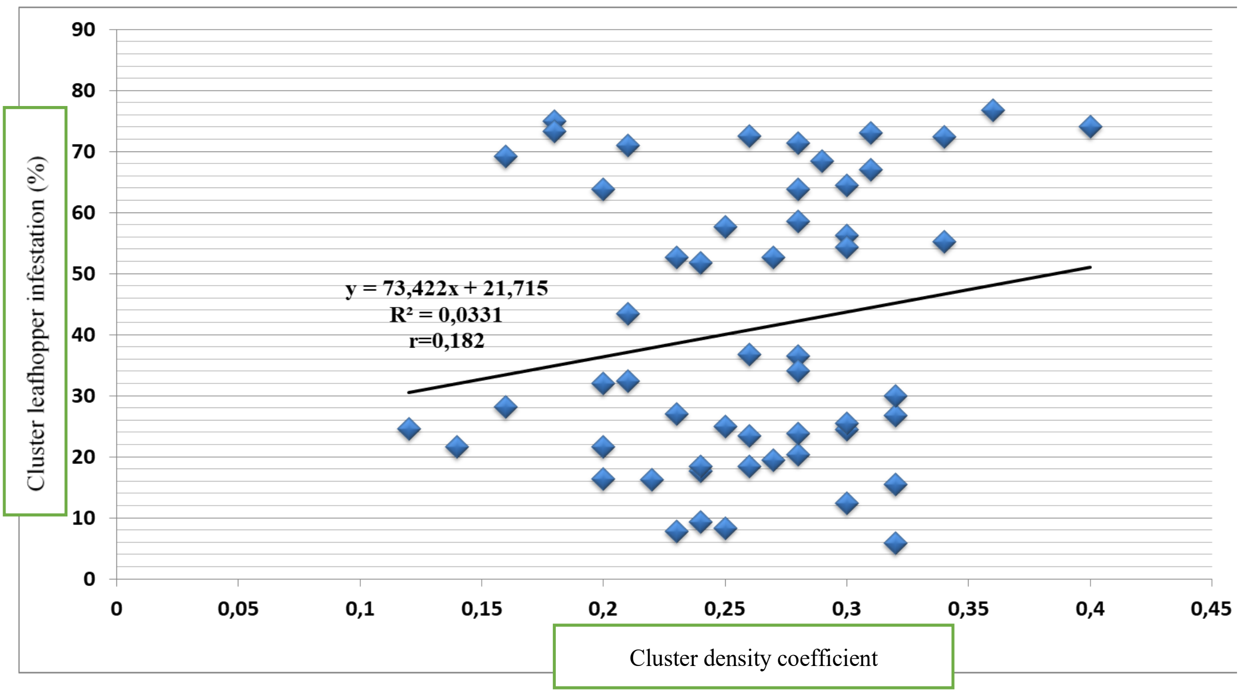

Figure 2. Dependence of the cluster density coefficient on the degree of susceptibility to grape berry moth

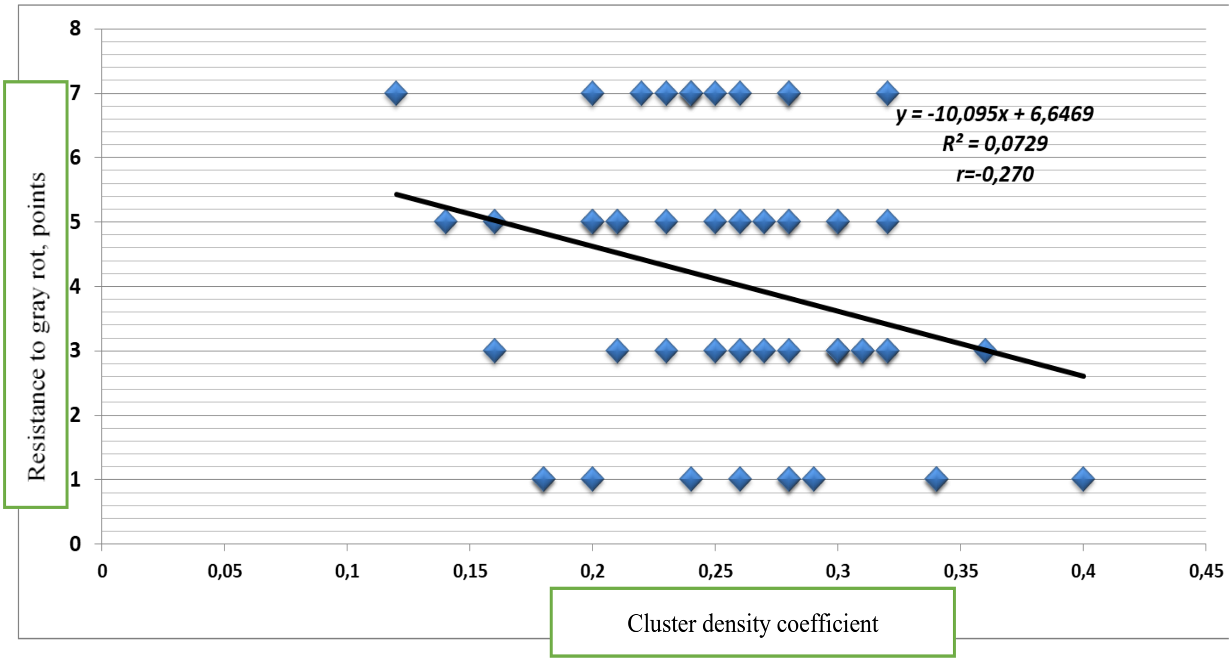

Figure 3. Dependence of the cluster density coefficient on the degree of susceptibility to grey mould

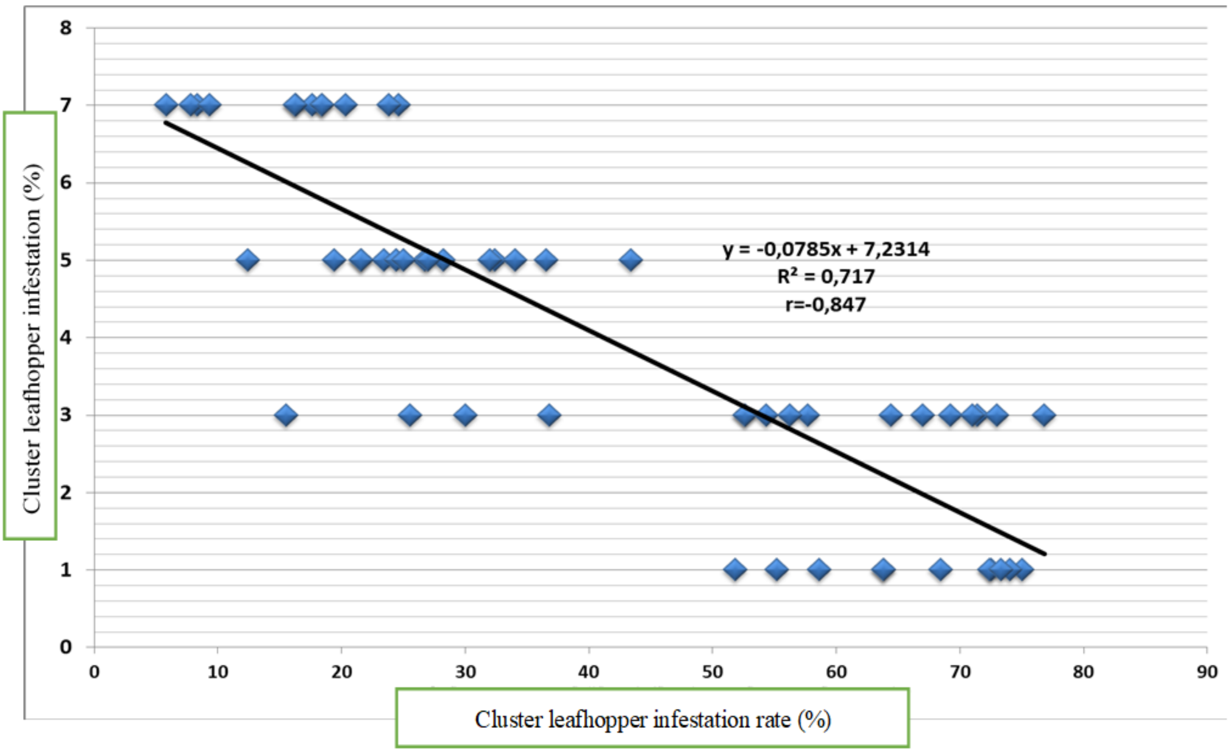

Figure 4. Relationship between the degree of infestation by grape berry moth and infection by grey mould

In varieties with dense bunches, the berries deform each other, leading to cracking and creating ideal conditions for the development of *Botrytis cinerea* [29].

It has been found that dense clusters have poor aeration (air movement) between the berries, high humidity, and the berries deform, leading to bursting. When chemical pesticides are applied, their effect does not extend to the entire berry surface and does not prevent the development of harmful organisms. Research has shown that clusters with high berry density contribute to increased infestation by *Lobesia botrana* larvae and the development of gray mold (*Botrytis cinerea*). (Bunches with a density of less than 0,200 g/cm^3 are considered very loose, 0.201 to 0.300 g/cm^3 are considered loose, 0.301 to 0.400 g/cm^3 are considered dense, and above 0.401 g/cm^3 are considered very dense).

Based on the results (on healthy harvest) obtained against the background of chemical protection measures for grape varieties, their prospects were assessed using a modern, innovative model. In this case, 25 OIV descriptors were used (Table 2).

It was found that the studied varieties differed significantly in each studied indicator. Thus, out of 54 studied varieties, the onset of bud break (OIV 301) was defined as late (7 points) in 19 varieties (Arna-grna, Kahraba, Shamakhy Marandisi, etc.), average (5 points) in the vast majority of varieties (Ag Khalili, Ag Shany, Nagshabi, etc.), and early (3 points) in only five varieties (Ala Shany, Mahmudu, etc.).

In terms of the duration of the vegetation period (OIV 629), the studied varieties differed sharply from each other. According to this indicator, nine varieties (Pobeda, Chahrai taifi, Muscat of Alexandria, etc.) were rated at 1 point, 31 varieties (Ichkimar, Prima, Muscat of Italy, etc.) at 5-7 points, 13 varieties (Bandi, Emin, Dekabrsky, etc.) at 3 points, and only one variety (Novrast) at 9 points.

The indicator of the beginning of shoot ripening (OIV 305) in 18 varieties (Gyrmyzy saabi, Mahmudu, etc.) was noted as relatively late (3 points), in 24 varieties (Alphonse Lavalle, Ag Huseyni, etc.) as medium-term (5 points), 10 varieties (Gara khatyny, Elmin, etc.) as early (7 points), and two varieties (Absheron khatynysy, Absheron gelinbarmagy) as very late (9 points).

The studies also showed differences between varieties in the degree of shoot ripening (OIV 604-1). Thus, 26 varieties had shoots ripening well (7 points), seven varieties had very good (9 points), 20 varieties had satisfactory (5 points), and one variety (Bandi) had a poor shoot ripening degree (3 points).

According to the degree of development, or the number of opened eyes (OIV 630), which is an important biological indicator, no sharp difference was recorded between the varieties. In 16 varieties (Gyozal uzum, Surmei, Gara kechimemesi, etc.), this indicator was assessed as average (5 points), in 26 varieties (Ala shany, Tabrizi, Ag Derbendi, etc.) as high (7 points), and in three varieties (Ganjavi, Emin, Elmin) as very high (9 points).

As we know, grape yield largely depends on fruit-bearing shoots and the number of inflorescences developed on them. Depending on the botanical origin, biological characteristics, cultivation techniques, etc., the fruiting characteristics of the fruit-bearing shoots formed on the bush may be different, and from one to five or more bunches may develop on them. In the studied varieties, the number of inflorescences on fruit-bearing shoots (OIV 153) varied significantly; 13 varieties were found to have developed one bunch, 27 varieties had 1-2 bunches on the shoots, and 14 varieties developed 2-3 bunches.

One of the indicators directly influencing the formation of the grape harvest is the average weight of the bunch. During the research, we also determined the value of this indicator (OIV 502). It turned out that the average weight of the bunch of the studied varieties differed significantly from each other. In seven varieties (Ag Khalili, Gara shany, etc.), the bunches were relatively small (100-300 g, 3 points), in the majority (28) of varieties (Novrast, Oguz uzumu, Sarygilya, etc.), the weight of one bunch varied within 300-500 g (5 points), in 12 varieties (Ganjavi, Ikijinsli ag shany, etc.) this indicator was 500-700 g (7 points), and in seven varieties (Katta-kurgan, Surmei, etc.) the bunch weight was very high (700-900 g or more, 9 points).

In 22 of the studied varieties (Ala shany, Absheron khatynysy, Agadai, etc.), the yield per 1 ha varied from 40-80 to 90-120 centners. Other varieties were distinguished by high and very high yields: in 22 varieties (Ag Derbendi, Danlas, etc.), the yield was 130-160 c/ha (7 points), and in 9 varieties, 170 c/ha and higher (9 points).

It was determined that the sugar content of the berries of the studied varieties (OIV 505) was at the average (17-20 g/100 cm^3) and high (23 g/100 cm^3) levels. Only the varieties Absheron khatynysy, Ag shany, and Kahraba had a high sugar content in the berry juice.

The density of the bunch (OIV 204) is an indicator that affects the commercial appearance of the bunch. In viticulture, very dense and very loose bunches are not considered satisfactory. During the research, it was found that among the studied varieties, there were no varieties with very loose, dense, or very dense bunches. The bunches were mainly of medium density (7 points for 27 varieties) and loose (9 points for 19 varieties). Only the Bandi and Shamakhy Marandisi varieties had very dense bunches.

The length of the berry stalk (OIV 206), the firmness of the stalk, and the comb are the commercial indicators of table grape varieties. Significant differences were also noted between the studied varieties for these indicators. Of these varieties, only Bandi had a relatively short stalk (3-5 cm, 3 points). Most other varieties (Ala shany, Agadai, Mahmudu, etc.) had stalk lengths that were noted as medium-short (5-7 cm, 5 points) and long (7-9 cm, 7 points), and two varieties (Kahraba and Muscat of Hamburg) had stalks that were very long (9-11 cm, 9 points).

The most important indicator influencing the formation of the mass of grape bunches is the number and size of berries (OIV 220). The studies revealed significant differences in the studied varieties by this feature. Thus, in the Absheron Khatynysy variety, the size of the berries varied within 13-18 mm and was estimated at 5 points. In the absolute majority of other varieties (Ag Khalili, Gara Shany, Arna-Grna, Ichkimar, etc.), this indicator fluctuated between 18-23 and 23-28 mm and was estimated at 7 and 9 points, respectively.

Table 3. Resistance of local and introduced table grape varieties to diseases and pests

Grouping of Varieties by Resistance Index	OIV 401	OIV 403	OIV 451	OIV 452	OIV 453	OIV 454	OIV 455	OIV 456	OIV 458	OIV 459	OIV 461	OIV 462	Degree of Susceptibility to Grape Leaf Roller, in Points
1-very unstable	3	5	8	8	-	5	5	2	-	11		15	1
3-unstable	12	25	14	14	5	8	12	13	-	16		36	22
5-tolerant	17	17	31	31	16	18	26	26	16	15	-	3	11
7-stable	20	7	1	1	32	23	11	13	38	12	54		20
9-very stable	2	-	-	-	1	-	-	-	-	-	-	-	-

Table 4. Economic efficiency of grape varieties with different degrees of resistance, with or without protective measures against diseases and pests

Grouping of Varieties by Resistance Index	Number of Chemical Treatments	Total Costs per 1 ha, AZN	Average Yield for the Studied Varieties, c/ha	Crop Losses, % (Rotten Crop)	Standard Yield Obtained, tons	Cost Price of 1 ton, AZN	Total Income from 1 ha, AZN	Net Profit per 1 ha, AZN	Profitability, %
Disease and pest control were not carried out									
1-very unstable	none	3200.00	10.0	78.5	2.15	1488.0	1075	-2125	-142.8
3-unstable	-	3200.00	10.0	64.4	3.56	898.8	1780	-1420	-158.1
5-tolerant	-	3200.00	10.0	56.4	4.36	733.9	2180	-1020	-138.9
7-stable	-	3200.00	10.0	50.6	4.94	647.0	2470	-730	-112.8
9-very stable	-	3200.00	10.0	42.2	5.78	553.6	2890	-310	-55.9
Disease and pest control were carried out									
1-very unstable	6	4250.00	10.0	2.5	9.75	453.8	7312	3062	702.6
3-unstable	5	4075.00	10.0	3.6	9.64	422.7	7230	3155	746.3
5-tolerant	4	3900.00	10.0	4.8	9.52	409.6	7140	3240	791.0
7-stable	3	3725.00	10.0	5.8	9.42	395.4	7065	3340	844.7
9-very stable	2	3550.00	10.0	6.2	9.38	378.4	7035	3485	920.9

Note: Under free market prices, the price for 1 ton of table grapes without pest and disease control is 500 AZN, and with pest and disease control, 750 AZN.

One of the requirements for table grapes is the similarity in appearance and size of berries in a bunch (OIV 222). This indicator significantly affects the commercial appearance of the crop. Research has shown that out of 54 studied varieties, except for only 11 (Agadai, Dnestrovsky, Tuya Tish, etc.), all other varieties have berries similar in appearance and size (2 points). Berry shape (OIV 223) is one of the most important indicators of the commercial and organoleptic quality of the crop. Table varieties have berries of various shapes, but ovoid, cylindrical, and oblong oval shapes are considered preferable. The studied varieties did not have flat (1 point), flattened (2 points), or inversely ovoid (7 points) berries. The varieties had berries of round (Red Globe, Gara shany, etc.), short elliptical (Alphonse Lavalle, Ag Khalili, etc.), cylindrical (Dekabrsky), and oblong oval (Ichkimar, Pobeda) shapes (Table 3).

Among those studied were varieties with berries of various colours: green, red (Red Globe), black (Alphonse Lavalle, Shamakhy marandisi, etc.), amber (Ag Khalili, Tabrizi, etc.), and pink (Chahrai taifi).

One of the main indicators determining the organoleptic value of grapes is the thickness of the berry skin (OIV 228). If the berry skin is not felt when eating, this is considered an advantage during tasting. It was found that of the studied varieties, 10 berries have thick skin (3 points), 31 have medium-thick skin, and 13 varieties have thin skin.

Morphological and organoleptic studies have shown that the studied varieties also differ in the aroma inherent to the berries (OIV 236). The introduced varieties Muscat of Hamburg, Muscat of Italia, and Muscat of Alexandria have a muscat aroma (4 points), while the berries of local grape varieties of Azerbaijan have a unique aroma characteristic of the variety (3 points) and a neutral taste.

One of the reliable indicators of the quality of table grapes is their suitability for transportation and storage. The force applied to tear the berry from the stalk (OIV 240) plays a major role in the formation of these indicators. Too easy a tearing of the berry from the stalk is not considered a positive characteristic for table grape varieties, but, on the other hand, when eating or if it is necessary to tear the berries from the stem, it is appreciated if a weak or medium force is required to tear them off. The studied varieties required a medium (5 points) or light (7 points) force to tear the berries from the stalk. Some varieties (Ganjavi, Arna-grna, Shamakhy Marandisi) required a great force to tear them off (3 points).

Among the requirements for table grape varieties, the characteristic that the seeds are not felt when eating is particularly notable. The local variety Huseyni had many seeds; the varieties Shamakhy marandisi, Tabrizi, and others had large (long) seeds; the varieties Gyozal Uzum, Ganjavi, and others had medium-sized seeds.

Phytopathological studies have shown that the introduced hybrid varieties have a higher resistance to fungal diseases (downy mildew, powdery mildew, grey rot - OIV 452, 453, 459) compared to others, including local Azerbaijani varieties.

The prospects of the studied varieties were assessed by the 25 most important features and indicators (Table 2). Since all the studied varieties were table, one of the most famous and widely distributed varieties, Ala shany, was taken as a control for both local and introduced varieties. As we can see, depending on the agrobiological and economic-technological characteristics of the studied varieties, the ampelodescriptor codes of features and indicators differed significantly. The prospects indicator in points changed in the range of 83.6-149.2, with the lowest indicator for the Bandi variety in the control of 121.7 (Ala shany), and with the highest indicator for the Ikijinsli ag shany variety of 149.2. The morphological, agrobiological (vegetation period, accounting of yield elements, etc.), and mechanical and chemical composition of the crop were studied using traditional and modern methods. If in a certain zone the total score for 25 indicators for table grape varieties is more than 15 points lower than the control (< 15), the variety is considered unpromising, and if the score is equal to the score of the control variety or the difference is within 15 points (± 15), the variety is considered at the control level, i.e. satisfactory, and if more than 15 points (> 15), the variety is considered more promising (Table 4).

The studies showed that 13 varieties (Absheron gelinbarmagy, Absheron khatynysy, Muscat of Italy, Cardinal, etc.) had a score lower than the control by more than 15 points, and these varieties were considered unpromising, 14 varieties (Ag Khalili, Muscat of Alexandria, Nagshabi, etc.) had a difference with the control within 15 points and were considered satisfactory, and another 27 varieties (Tabrizi, Ikijinsli ag shany, Kahraba, Katta-kurgan, Oguz uzumu, Sarygilya, etc.) exceeded the control by more than 15 points and were considered promising.

Cluster analysis based on OIV descriptors was performed using software Past4.16c (https://past.en.lo4d.com/windows). The dendrogram was constructed using the Ward method by Euclidean distance (Figure 5 and Table 3).

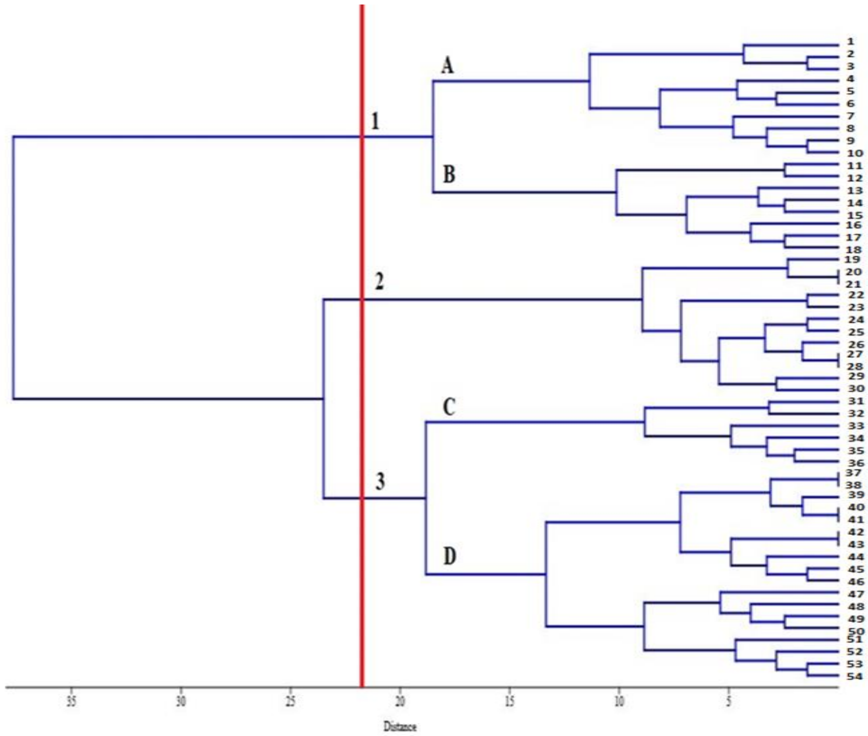

Figure 5. Cluster analysis based on OIV descriptors from grape varieties

1-Huseyni; 2-Gara kechimemesi; 3-Bandi; 4-Ag Khalili; 5-Ag Derbendi; 6-Arna-grna; 7-Tabrizi; 8-Muscat of Italy; 9-Cardinal; 10-Katta-kurgan; 11-Gyrmyzy saabi; 12-Novrast; 13-Tuya tish; 14-Parkent; 15-Pobeda; 16-Ichkimar; 17-Ag Huseyni; 18-Chahrai tayfi; 19-Muscat of Hamburg; 20-Emin; 21-Elmin; 22-Oguz uzumu; 23- Shamakhy marandisi; 24-Black Magic; 25-Gara Shany;26-Ganjavi; 27-Gyozal uzum; 28-Mahmudu; 29-Absheron khatynysy; 30-Ala shany; 31-Kahraba; 32-Moldova; 33-Ikijinsli ag shany; 34-Agadai; 35-Ag shany; 36-Sarygila; 37-Janjal gara; 38-Michel Paleri; 39-Surmei; 40-Gara khatyny; 41-Nagshabi; 42-Dnestrovsky rozovy;43-Dekabrsky; 44-Shabrany;45-Alphonse Lavalle; 46-Red globe; 47-Absheron gelinbarmagy; 48-Prima; 49-Preobrajenye; 50-Muscat of Alexandria; 51-Prezentable; 52-Ora; 53-Danlas; 54-Viktoria

According to the studied indicator, cluster analysis was conducted based on OIV descriptors using the WARD method. In the compiled dendrogram shown in Figure 5, grape genotypes were grouped into 3 clusters, and the genotypes included in each cluster differed in terms of the degree of infection with the disease. As can be seen, 18 grape genotypes are concentrated in the first cluster, and this cluster is divided into clusters A and B. 10 varieties are grouped in cluster A, and 8 varieties in cluster B. Cluster A is also divided into 2 subclusters, each containing 3 (Huseyni, Gara Kechimemesi and Bandi varieties) and 7 (Ag Khalili, Ag Derbendi, Arna - grna, Tabrizi, Muscat of Italia, Cardinal, Katta - Kurgan varieties). In the first subcluster, 2 varieties (Gara kechimemesi and Bandi varieties) were located in the same sister clusters because they had closer disease resistance indicators than the Huseyni variety. In the second subcluster, 7 varieties were divided into 2 sister clusters, and in the first sister cluster, overlaps were observed in the disease infection rate in the Ag Khalili, Ag Derbendi, and Arna-grna varieties based on most OIV descriptors. In the second sister cluster, similarities were observed in the indicators of 3 varieties (Muscat of Italia, Cardinal, Katta - Kurgan varieties), while the Tabrizi variety differed slightly.

According to the analysis, within cluster A, Gara kechimemesi, Bandi, Ag Khalili, and Muscat of Italia varieties were resistant to the disease according to the OIV 401 descriptor, while Huseyni, Gara kechimemesi, and Bandi varieties were tolerant to the disease according to the OIV 452 descriptor.

In cluster B, 8 grape varieties (Gyrmyzy Saabi, Novrast, Tuya Tish, Parkent, Pobeda, Ichkimar, Ag Huseyni, Chahrai taifi) were concentrated in 2 subclusters, and both subclusters were divided into 2 sister clusters. The second sister cluster combined different genotypes (Tuya Tish, Parkent, Pobeda, Ichkimar, Ag Huseyni, Chahrai taifi). In cluster B, except for the Gyrmyzy Saabi variety, other varieties were the most resistant to the disease according to the OIV 451 and OIV 452 descriptors.

The second cluster is divided into 2 subclusters and includes 12 genotypes (Muscat of Hamburg, Elmin, Emin, Oguz uzumu, Shamakhy marandisi, Black Magic, Gara shany, Ganjavi, Gyozal uzum, Mahmudu, Absheron khatynysy, Ala shany). Most representatives of this cluster were resistant and tolerant to the disease, and only the Elmin and Emin genotypes located in the first subcluster were highly resistant to the disease due to OIV 401 among all grape genotypes studied.

In the third cluster, 24 genotypes were collected in clusters C (Kahraba, Moldova universal, Ikijisli ag shany, Agadai, Ag shany, Sarygilya) and D (Janjal Gara, Michel Paleri, Surmei, Gara khatyny, Nagshabi, Dnestrovsky rozov, Dekabrsky, Shabrani, Alphonse Lavalle, Red Globe, Absheron Gelinbarmagy, Prima, Preobrajenie, Muscat of Alexandria, Prenentebl, Ora, Danlas, Victoria). The Kahraba and Moldova universal genotypes are sister clusters in the same subcluster, being resistant to disease based on most HIV descriptors. The Moldova universal genotype received the highest score for the HIV descriptor. The Ag Shany and Sarygilya varieties, located in the second subcluster of cluster C, were placed in the same group with closer indicators and were more tolerant to the disease than the Agadai variety, located in the other sister cluster. Cluster D, in turn, was divided into 2 subclusters, and it was determined that 10 grape genotypes localized in the first subcluster (Janjal Gara, Michel Paleri, Surmei, Gara khatyny, Naqshabi, Dnestrovsky rozov, Dekabrsky, Shabrani, Alphonse Lavalle, Red Globe varieties) differed from 8 grape genotypes located in the second subcluster (Absheron Gelinbarmagy, Prima, Preobrajenie, Muscat of Alexandria, Prenentebl, Ora, Danlas, Victoria) in terms of the degree of infection and were relatively resistant to the disease.

As a final result of the analysis, we can say that among the different grape genotypes, the varieties included in the second cluster were more resistant to the disease in terms of the degree of infection, the third cluster groups were moderately resistant, and the varieties of the first cluster were relatively resistant.

The formation of economic indicators of grape varieties is greatly influenced by their resistance to diseases and pests, since their impact not only causes a significant loss of the harvest, but also makes it difficult to obtain high-quality commercial grapes. For this reason, we calculated the economic efficiency of production, yield losses, profitability, profit, etc., for the studied grape varieties with varying degrees of resistance, with and without measures to combat diseases and pests. The results show that without disease and pest control, the losses were high and ranged from 42.2% (very resistant varieties) to 78.5% (very unstable). For resistant varieties, this figure was 50.6%, for tolerant varieties, 56.4%, and for unstable varieties, 64.4%. Due to high yield losses, the net profit value for these varieties was negative, and the price of the product was set at a high level. It should be noted that in this case, the resulting harvest was sold for 500 AZN per ton.

Although 54 native and introduced grape varieties were grown under the same agricultural conditions and evaluated against the same phytopathological background, the varieties demonstrated different resistance to some biotic and abiotic factors (according to 12 OIV descriptors, and by *Lobesia botrana*). Statistical analyses and cluster dendrogram data show that differences in biotic and abiotic factors are found in three large groups (Figure 5). The first group (cluster) comprises 18 varieties (Ag Khalili, Ag Derbendi, Agna-grna, Tabrizi, Italian Muscat, Cardinal, Katta-kurgan, Gara Kechimemesi, Bandi, etc.), highly sensitive to harmful organisms and pests; the second group includes 12 varieties (Muscat of Hamburg, Elmin, Emin, Oguz Uzumu, Shamakhy Marandisi, Black Magic, Gara Shany, Ganjavi, Gyozal Uzum, Mahmudu, Absheron Khatynysy, Ala Shany), which are relatively tolerant compared to varieties in other groups, and the third group includes 24 relatively resistant varieties (Kahraba, Moldova, Ikijinsli Ag Shany, Agadai, Ag Shany, Sarygilya, Janjal Gara, Michel Paleri, Surma, Gara Khatyny, Nagshabi, Dnestrovsky rozovyi, Dekabrsky, Shabrany, Alphonse Lavalle, Red Glob, Absheron Gelinbarmagy, Prima, Preobrazhenie, Muscat of Alexandria, Prenentable, Ora, Danlas Uzum, Victoria). Compared with existing research in drought-prone viticultural regions, the results indicate that irrigation conditions yield a more detailed characterisation of the biochemical traits of grape seeds, thereby enhancing the overall understanding of how water availability influences sustainable grape production in Azerbaijan [30].

When combating diseases and pests, i.e., when carrying out chemical spraying, the resistance features of the studied varieties were taken into account; spraying was performed 6 times on very unstable varieties, 5 times on unstable, 4 times on tolerant, 3 times on resistant, and 2 times on very resistant varieties. Against the background of these sprayings, yield losses were determined for the grape varieties included in the corresponding groups. It turned out that despite the chemical protection measures, very unstable varieties suffered a 2.5% yield loss, unstable varieties suffered 3.6%, tolerant varieties suffered 4.8%, resistant varieties suffered 5.8%, and very resistant varieties suffered 6.2% yield loss. The economic profit was quite high and amounted to 3062 to 3485 AZN per hectare, and the production profitability varied within the range of 702.6-920.9%. Although the total costs in the vineyards where chemical protection measures were carried out were 150-1050 AZN higher compared to the costs in the vineyards where this control was not carried out (3200 AZN), the economic parameters in the treated areas were formed at a higher level.

4. CONCLUSIONS

When assessing the prospects based on an innovative model for 25 OIV ampelodescriptors covering the most valuable morphological, biological and economic characteristics of grape varieties, it was revealed that, compared to the control, 13 varieties (Absheron gelinbarmagy, Absheron khatynysy, Italian Muscat, Cardinal, Bandi, Katta-kurgan, Tuya tish, etc.) are unpromising, 14 varieties (Ag Khalili, Muscat of Alexandria, Nagshabi, Ora, Janjal gara, Ichkimar, Gyrmyzy saabi, etc.) are sufficiently promising, and the remaining 27 varieties (Novrast, Tabrizi, Ikijinsli ag shany, Kahraba, Oguz uzumu, Sarygilya, Black Magic, Moldova, etc.) are highly promising. Widespread introduction of sufficiently and highly promising varieties (41 varieties in total) into production is economically feasible.

Research has confirmed a direct relationship between variable bunch density (bunch density coefficient) and the development of *Lobesia botrana* and *Botrytis cinerea*. *Botrytis cinerea* develops well on grape varieties with dense clusters, causing significant damage. There is a positive correlation between the cluster density coefficient and the degree of grapevine moth development ($r = 0.182$). The correlation between grapevine moth infestation and gray mold is negative and statistically significant ($r = -0.847$). This indicates that the pest *Lobesia botrana* stimulates the development of *Botrytis cinerea*.

After determining the degree of resistance of grape varieties and assigning them to relevant groups, the yield of commercial grapes was measured in variants with and without chemical treatment. It was found that in the variant without chemical treatment, losses were 78.5% in highly susceptible varieties, 64.4% in non-resistant varieties, 56.4% in tolerant varieties, 50.6% in resistant varieties, and 42.2% in very resistant varieties.

Based on the degree of resistance for each group of varieties, we determined the optimal number of chemical treatments. However, some, albeit minor, yield losses were observed across the groups. For very susceptible varieties, losses were 2.5% with six treatments, 3.6% with five treatments for non-resistant varieties, 4.8% with four treatments for tolerant varieties, 5.8% with three treatments for resistant varieties, and 6.2% with two treatments for very resistant varieties. Determining the optimal number of chemical treatments for each group of varieties based on the degree of their resistance to diseases and pests, while being cost-effective, also significantly reduces the pesticide load on the grape yield.

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