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Modern methods of introduced and domestic grape varieties in the climatic conditions of the South and Southeast Kazakhstan

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ABSTRACT

The work aimed at studying the behavior of introduced and domestic grape varieties in the conditions of Southeastern Kazakhstan. The biological characteristics, disease resistance, winter hardiness, and ripening periods were evaluated. Based on the results of long-term observations, promising varieties were identified and recommended for industrial cultivation in the foothill and lowland regions of the region. A comparative study of introduced foreign grape varieties and domestic breeding forms was conducted to assess their agrobiological characteristics and resistance to abiotic and biotic factors. It has been established that some local varieties are more resistant and productive than their introduced counterparts, which confirms the feasibility of their further zoning and implementation. The study provides a comparative analysis of the introduced and domestic grape varieties for the period 2022-2024 in the ecological and climatic conditions of the Saryagash District of the Turkestan Region in the regional branch of Saryagash and the Talgar District of the Almaty Region in the regional branch of Talgar. As a result of the conducted yield studies, grape varieties and hybrid forms KV-2/9 (8.5 kg), DV-10/11 (7.8 kg), Azim (8.0 kg), DV-7/17 (8.0 kg), Aisulu (7.7 kg), Mereitoy-50 (7.3 kg) were isolated from the bush. The lowest yield was noted in grape varieties and hybrid Hungarian muscat (st; 4.7 kg), Goat carcass (4.4 kg), DX-17/90 (4.4 kg), KII-1/29 (4.8 kg). In the course of the molecular genetic analysis of the Kazakhstani varieties and hybrids of grapes, samples were identified that have resistant alleles to the main fungal diseases: powdery (*Oidium*) and downy mildew (mildew). Markers to the loci Run1, Ren1, Rpv3, Rpv10 and Rpv12 were used. According to the results of the study, six genotypes were identified (including the reference varieties Muscat Hungarian, Tayfi Pink, Zhemchug Saba, and hybrids DV-10/11, KII-1/29, and KV-2/9), which have complex resistance at several loci. These forms are of significant interest for use in breeding programs to create resistant grape varieties.

Keywords: Variety, Grape, Gene pool, Winter hardiness, Adaptation, Ripening period.
Article type: Research Article.

INTRODUCTION

In Kazakhstan, the crop is concentrated in the Turkestan and Almaty regions, where the soil and climatic conditions (serozems, ≥2800 °C GDD) are optimal for the Kishmish Luchistyi and Talisman varieties. The yield is 8-10 ton ha^{-1} with a planting pattern of 3 × 2 m and drip irrigation. The agricultural practices require erosion control (slope terracing) and NPK application (80:40:60 kg ha^{-1}). The Institute of Viticulture (Almaty) maintains a national gene bank collection of 120 samples adapted to local stressors (salinity, and drought). The origin of

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the species is associated with the regions of Transcaucasia and Western Asia, where its domestication began (6,000 BC). The breeding of the 20th and 21st centuries is aimed at increasing the sugar content, resistance to *Phylloxera* and fungal pathogens (*Plasmopara viticola*). Genome studies (such as the *Vitis vinifera* Genome project) have identified genes responsible for resveratrol synthesis and frost resistance. Breakthrough methods for breeding table grapes include the use of CRISPR/Cas9 technology to create seedless varieties. For example, editing the VviAGL11 and VviSEEDSTICK genes has led to the development of seedless hybrids with preserved flavor (Yang *et al.* 2009; Reynolds 2017; Sabir *et al.* 2019). In parallel, marker-assisted breeding is being developed: SNP markers associated with resistance to *Oidium* have been identified in Kishmish varieties (Food & Nations 2020; Wang *et al.* 2022; Baghdasaryan *et al.* 2023). Spray-induced gene silencing (SIGS) is an emerging tool for crop pest protection. It utilizes exogenously applied double-stranded RNA to specifically reduce pest target gene expression using endogenous RNA interference machinery. In this study, SIGS methods were developed and optimized for powdery mildew fungi, which are widespread obligate biotrophic fungi that infect agricultural crops, using the known azole-fungicide target cytochrome P450 51 (CYP51) in the *Golovinomyces orontii-Arabidopsis thaliana* pathosystem (McRae *et al.* 2023). A population derived from a cross between grapevine breeding strain Gf.Ga-52-42 and cultivar 'Solaris' consisting of 265 F1-individuals was genetically mapped using SSR markers and screened for downy mildew resistance (Schwander *et al.* 2012). The high susceptibility of European grapevine cultivars (*Vitis vinifera*) to downy mildew (*Plasmopara viticola*) leads to the intensive use of fungicides in viticulture. To reduce this input, breeding programs have introgressed resistance loci from wild *Vitis* species into *V. vinifera*, resulting in new fungus-resistant grapevine cultivars (FRC; Wingerter *et al.* 2021). Based on comparative microscopic, metabolomic and transcriptomic analyses, our results show that the Rpv3-1-mediated resistance is associated with a defense mechanism that triggers synthesis of fungi-toxic stilbenes and programmed cell death (PCD), resulting in reduced but not suppressed pathogen growth and development (Eisenmann *et al.* 2019). *Plasmopara viticola* is geographically widespread in grapevine-growing regions. Grapevine downy mildew disease, caused by this biotrophic pathogen, leads to considerable yield losses in viticulture annually (Peng *et al.* 2024).

Analysis of volatile compounds in 38 table grape varieties revealed a variety of flavor profiles, including fresh green, floral, and fruity notes. These data can be used to select new varieties with improved taste, which will increase their appeal to consumers (Barata *et al.* 2011; Bonello *et al.* 2024). Low light is a major limiting factor in greenhouse grapevine cultivation, particularly during winter and early spring (Ji *et al.* 2025). Fruit set is the transformation of flower ovaries into berries. Fruit set rate determines the number of berries produced per bunch, which is a major component of yield in grapevines (Calderón *et al.* 2025). The selection of appropriate grapevine grafts and optimizing irrigation practices for enhancing water use efficiency are critical for viticulture production in the arid regions of UAE, apart from mitigating the effects of changing environmental conditions (Krishankumar *et al.* 2025). Compared to the susceptible variety ‘Merlot’, the partially resistant varieties showed reduced IFR, longer LP, smaller LS, fewer SPOR and SPOR’, shorter IP, and lower INF. At leaf development, IFR, SPOR, and INF were higher and LP was shorter than at flowering and fruit development. RCs analysis through monocyclic experiments provides reliable assessments of the resistance response of grapevine accessions (Bove & Rossi 2020). Cultivation of disease-resistant grape varieties carrying genes that enhance defense against pathogens is an approach that helps reduce the amount of fungicides applied in viticulture (Bhattarai *et al.* 2021). Principal component analysis results pointed to a differential behavior versus the control and treated Sauvignon blanc plants in terms of disease resistance. Based on production results, despite the youth of the plantation, the excellent potential of Sauvignon Kretos variety was observed (Casanova-Gascón *et al.* 2019). A multitude of diverse breeding goals need to be combined in a new cultivar, which always forces to compromise. The biggest challenge grapevine breeders face is the extraordinarily complex trait of wine quality, which is the all-pervasive and most debated characteristic (Töpfer & Trapp 2022). Several traits, including morphological, physiological, and molecular aspects, have been shown to be crucial in adapting to environmental stresses such as drought and heat. By studying the abundant grapevine intervarietal diversity, the potential for viticulture adaptation to climate change through varietal selection is immense (Baltazar *et al.* 2025). The integration of these modern approaches into the breeding and agricultural practices of table grapes is contributing to the development of varieties with improved characteristics that meet both the requirements of producers and the preferences of consumers. Modern research is focused on creating stress-resistant varieties, implementing sustainable storage technologies, and enhancing nutritional value. The integration of genetics, biochemistry, and climate-adaptive practices is shaping the future of viticulture.

MATERIALS AND METHODS

The research was carried out on a sample of 2 introduced grape varieties of medium maturity — Italy, July and 7 domestic varieties and 5 flexible forms of medium maturity — Mereitoy-50, Akmaral, Azim, Kazakhstan-20, Kara koz, Aisulu, DV-10/11, DV-7/17, KII-1/29, DX-17/90, KV-2/9 growing in the collection of LLP "Kazakh Scientific Research Institute of Fruit and Vegetable Growing", RF "Talgar" and RF "Saryagash". The control varieties were Muscat Hungarian (st). 10 bushes of each variety were studied. Eight varieties (including reference varieties as a control) and five hybrids were used to assess the resistance of the studied varieties to fungal diseases. The samples were collected in Talgar, in the pomological garden of the Kazakh Research Institute of Horticulture. The leaves of the following grape varieties and hybrids were collected: Mereita-50, Muscat Hungarian (control), Zhemchug Saba, Tayfi Pink, Akmaral, Azim, Kazakhstan-20, Kara Koz, Aysulu, Akdidar, DV-10/11, DV-7/17, KII-1/29, DX-17/90, and KV-2/9. 12 varieties (including reference varieties as a control) and 5 hybrids were used to assess the resistance of the studied varieties to fungal diseases. The leaves of the following grape varieties and hybrids were collected: Mereita-50, Muscat Hungarian (control), Akmaral, Azim, Kazakhstan-20, Karakoz, Aysulu, Akdidar, Iyulsky, Sochny, Zhemchug saba, Tayfi pink, DV-10/11, DV-7/17, KII-1/29, DX-17/90, KV-2/9. In the ampelographic collection of the regional branch "Saryagash" of the Kazakh Research Institute of Horticulture in 2022-2024 and the regional branch "Talgar" in 2022-2024, a comparative study of introduced grape varieties of different ripening periods was conducted.

The varieties were studied in a covered, rootstock culture. The planting pattern was 3.0 × 1.5 m. The culture was irrigated and furrowed. In the process of studying grape varieties, phenological observations were conducted, and the load of bushes with buds, shoots, and yield, as well as the fruitfulness of the bushes, the growth rate, and the degree of ripening of annual shoots, were determined using well-known methods and guidelines (Lazarevsky 1963; Guguchkina *et al.* 2020; Maistrenko *et al.* 2020). Genomic DNA from grape leaves was isolated using a modified method (Aubakirova *et al.* 2014). At first, 100 mg of leaves were homogenized in 1 mL of a buffer consisting of: 100 mM Tris-HCl pH = 8.0; 20 mM EDTA, pH = 8.0; 1.4 M NaCl, 2% CTAB, PVP, and 2-mercaptoethanol were added to a final concentration of 2% and 0.2%, respectively, before use. The homogenate was incubated at 60 °C for 30 minutes and then extracted with chloroform. Then, 0.5 volume of 5M sodium chloride and 2 volumes of 96% ethanol were added to the aqueous phase. The mixture was incubated at 4 °C for 15-20 minutes and centrifuged for 15 minutes at 15,000 g. The DNA precipitate was washed with 70% ethanol and dissolved in bi-distilled water. The DNA was dissolved in 100 μL of water and treated with RNase. The DNA was precipitated with 96% ethanol in the presence of 0.3 M sodium acetate.

The DNA precipitate was dissolved in 50 μL water. The DNA concentration was measured using a NanoDrop 2000C spectrophotometer (Thermo Scientific). The purity of the obtained DNA preparations was determined by the ratio of absorption at wavelengths of 260 and 280 nm (A260/280). A preparation with an A260/280 ratio between 1.7 and 1.9 was considered to be pure DNA. Eleven molecular markers were used to assess the resistance of the studied varieties to downy mildew and powdery mildew. For the corresponding characteristics of grape varieties, Table 1 shows the sequence of 11 microsatellite markers used at 6 loci: Run1- GF12-22, GF12-07; Ren3- GF15-30, GF15-28; Ren1- GF13-13, VMC9H4.2; Rpv3- GF18-08, GF18-06; Rpv10- GF09-46, GF09-48; Rpv12- GF14-28 (Schwander *et al.* 2012). Multiplex PCR was performed in a 25 μL reaction mixture containing 1 μL genomic DNA (1 ng μL^{-1}), 2.5 μL Master Mix QIAGEN, 0.01 μL (100 pmol μL^{-1}) of each forward and reverse primer for the markers (Table 1), and 1.38 μL of deionized sterile water. The markers were divided into two groups: the first group had five markers (GF15-28, GF12-22, GF12-07, GF18-08, GF15-30), and the second group had seven markers (GF13-13, GF18-06, VMC9H4.2, GF09-48, GF09-46, GF14-28, sc36_7). Amplification was performed according to the following program: one cycle of 15 min. at 95 °C; 30 cycles, consisting of the following steps – 30 seconds at 94 ℃, 1.5 min at 60 °C and 1 min at 72 ℃; and finally 1 cycle of 30 min at 72 ℃. At the end of PCR, the products were diluted twice and 4 μL was taken, mixed with a standard of sizes labeled with LIZ dye (Size standard 500 LIZ Applied Biology), the total volume of the mixture was 14.5 μL. Capillary electrophoresis of PCR products was carried out on a DNA analyzer 3500 (Applied Biosystems). The program GeneMapper 4.0 was used to analyze the obtained PCR fragments. Data processing was carried out manually in MSExcel.

Table 1. Molecular markers used to characterize loci associated with resistance to *Oidium* and mildew in Vitis vinifera.

Marker	Stability	Locus	Chromosome	The allele	Source of sustainability	References
GF12-22	*Oidium*	Run1	12	187	VRH	Schwander (2011)
GF12-07	*Oidium*	Run1	12	284/288	VRH	Fechter (2009)
GF15-28	*Oidium*	Ren3	15	342	The Regent	Schwander (2011)
GF15-30	*Oidium*	Ren3	15	452	The Regent	Schwander (2011)
GF13-13	*Oidium*	Ren1	13	214	Kish mish vatkana	Zhang *et al.* 2009
VMC9H4.2	*Oidium*	Ren1	13	283	Kish mish vatkana	Angelakis-Roubelakis & Lefort (1999)
GF18-06	Mildew	Rpv3	18	389	The Regent	Schwander (2010)
GF18-08	Mildew	Rpv3	18	399	The Regent	Schwander (2010)
GF09-46	Mildew	Rpv10	09	416	Solaris	Schwander (2010)
GF09-48	Mildew	Rpv10	09	359	Solaris	Schwander (2010)
GF14-28	Mildew	Rpv12	14	150	*V. amurensis*	Schwander (2011)

RESULTS AND DISCUSSION

The climate of the Turkestan region is continental, which is one of its distinctive features. These climatic conditions have an impact on various agricultural sectors in the region, particularly on horticulture and viticulture. The region's distinctive climatic features create favorable conditions for crop production, but require proper application of agricultural practices. The weather in the Turkestan region is sharply continental, with very hot and dry summers and cold winters. These climatic factors significantly influence the growth and development of plants. In the region under consideration, the duration of the period with an average daily temperature above 0 ºC is 8-10 months, which creates favorable conditions for plant growth throughout the year. The average duration of the frost-free period is between 185 and 205 days, which is essential for the maturation of most agricultural crops. The meteorological conditions in 2022 confirmed this climate trend. The spring was cool, while the summer was very hot. In July, the temperature reached a maximum of 28.8 °C. The minimum temperature was recorded in March at 7.4°C. In 2023, the rainfall was slightly higher compared to 2022. For example, in March, the total amount of precipitation was 11.4 mm, while in March 2022, it reached 50.2 mm. In June, the amount of precipitation decreased to 0.4 mm, indicating the dry nature of the summer season. In 2024, the amount of precipitation was higher compared to 2022-2023. In March, the amount of precipitation was 52.1 mm, significantly exceeding the previous years. However, in August, the amount of precipitation was extremely low, at only 0.05 mm, which clearly reflects the lack of moisture in the last months of the season. According to the results of the study, several significant changes and features were observed in the climatic conditions of the Turkestan region between 2022 and 2024. The differences in air temperature, humidity levels, and precipitation are particularly noteworthy. The maximum temperature was recorded in July, reaching 40.7 °C, indicating the high summer heat typical of the region. In March, the temperature dropped to 9.4 °C, which is typical for the early spring season. Compared to long-term indicators, there has been a 2-3-fold decrease in temperatures, indicating a drop in the average annual temperature compared to previous years (Fig. 1).

Relative humidity. In summer, relative humidity was low. In March, it reached a maximum of 70.5%, while in July it dropped to a minimum of 26.9%. These figures are 1-2 times lower than long-term values, which indicates significantly lower humidity in summer compared to the norm (Fig. 2).

Compared to 2024, precipitation was lower in 2022 and 2023. In March 2024, 52.1 mm of precipitation fell, which is above average. However, in September, only 0.3 mm precipitation was recorded, indicating an extremely low level of precipitation (Fig. 3). Climate change in the Turkestan region between 2022 and 2024 has led to an increase in air temperature, a decrease in humidity, and a reduction in rainfall. These changes have exacerbated water scarcity and negatively impacted agriculture. Therefore, it is crucial to implement effective irrigation systems and choose crops that are well-suited to the current climate conditions (Mustafayev *et al.* 2023). In order to avoid the negative impact of unfavorable weather conditions on the growth, development, and formation of the yield of grape varieties and hybrids, appropriate agrotechnical measures were taken (optimization of the irrigation regime, additional nutrition, etc.). According to meteorological data from the regional branch of Saryagash LLP Kazakh Research Institute of Horticulture, the growing season was accompanied by reduced relative humidity, which was 7.15% lower than the long-term average over a three-year period. Thus, the long-term climatic conditions in the South Kazakhstan can be summarized as follows:

The climate covers long-term indicators, while the meteorological data of the growing season for grape varieties and hybrids in a specific year or years is the data on the weather during that period.

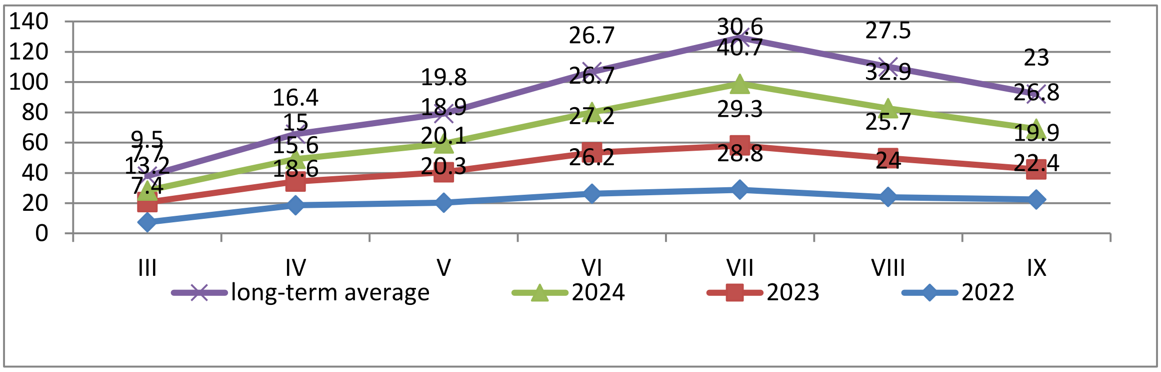


Fig. 1. Air temperature (°C) during the growing season in Turkestan Region in 2022–2024 (according to the Turkestan Region weather station).

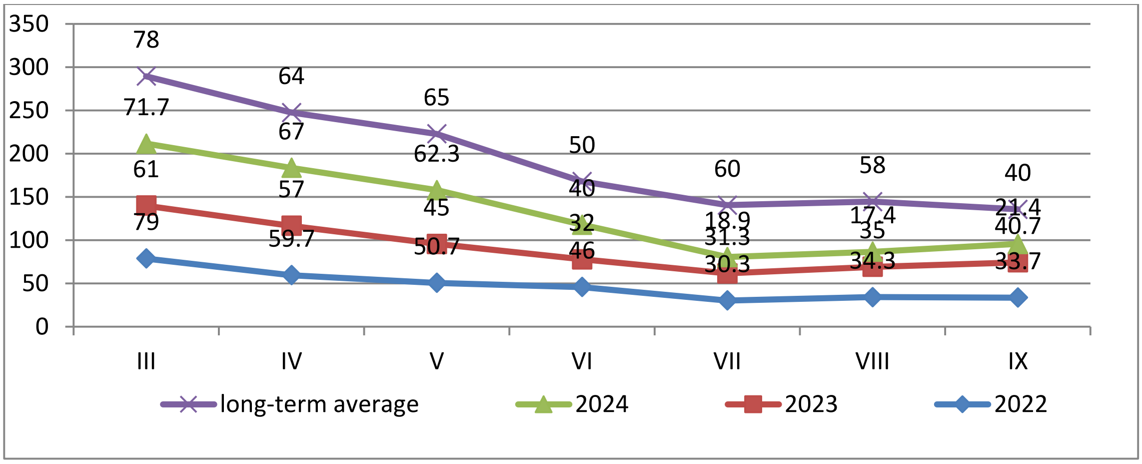


Fig. 2. Relative humidity of the air during the growing season in Turkestan Region in 2022–2024 (according to the Turkestan Region Weather Station).

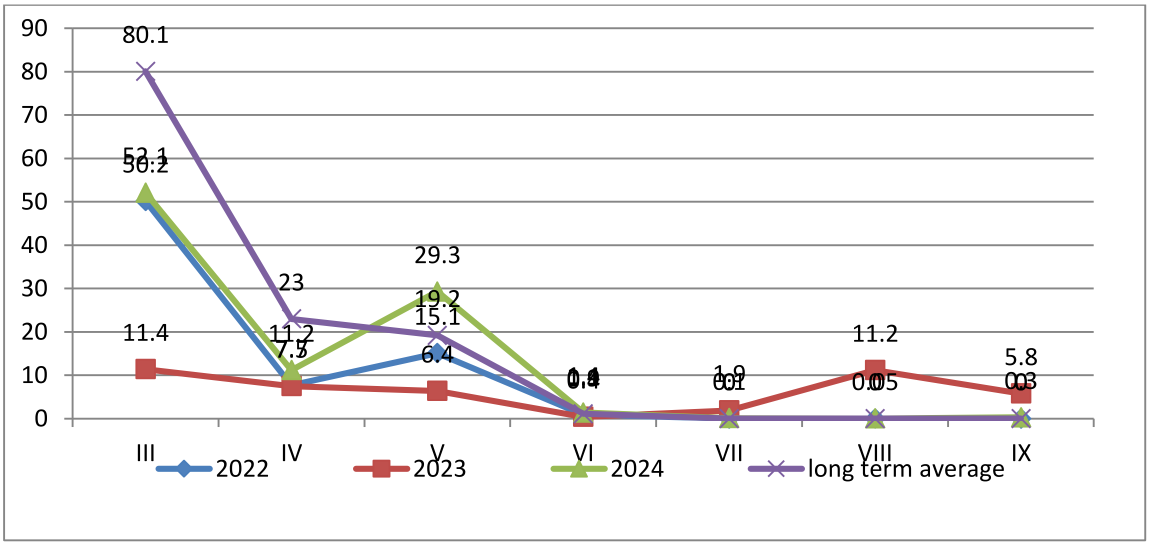
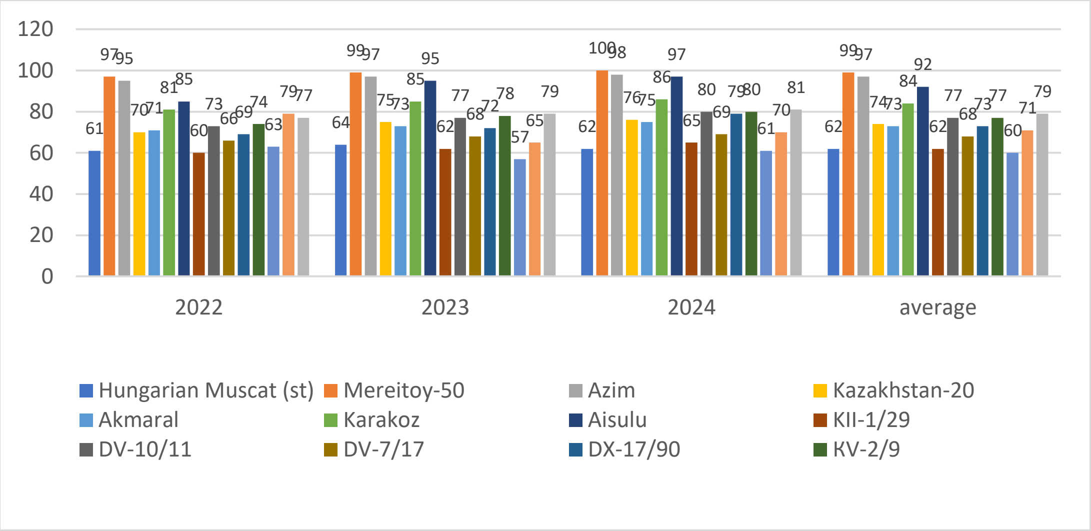


Fig. 3. Rainfall (mm) during the growing season in Turkestan Region in 2022–2024 (according to the Turkestan Region Weather Station).

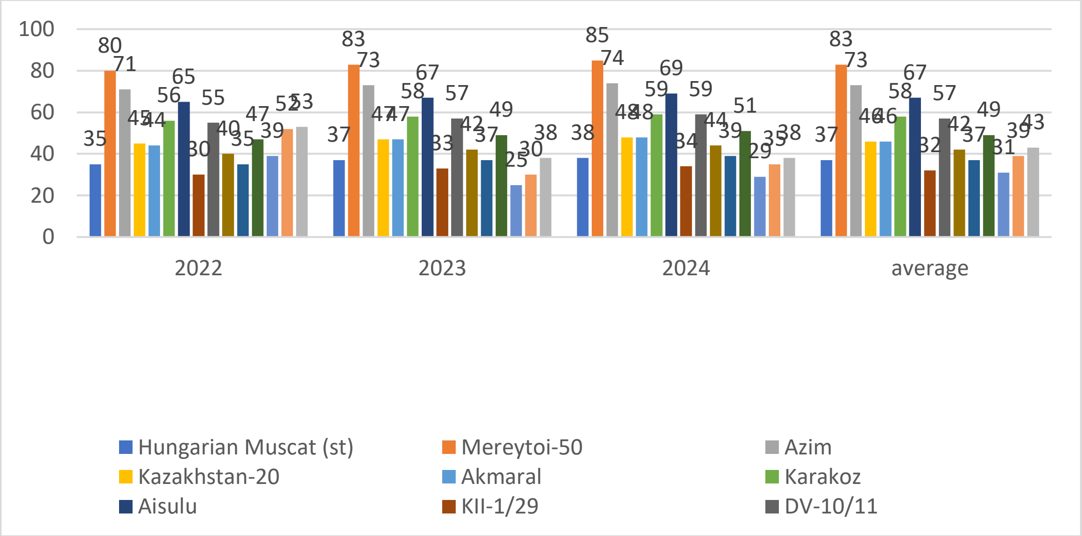
The grape varieties and hybrids were exposed to drought and high temperatures, which affected their development. These fluctuations in weather conditions are typical for the Turkestan region, suggesting that this study was conducted under typical meteorological conditions (Mustafayev *et al.* 2023). In 2022, the best degree of overwintering was noted among the varieties with the highest resistance to wintering (above 70%): Akmaral (92.0%), Mereitoy-50 (82.4%), Aisulu (76.4%), Azim (74.8%) and among hybrids: DV-10/11 (75.3%). The control variety Muscat Hungarian (st; 57.3%) as well as the hybrids KII-1/29 (50.0%), and DX-17/90 (50.8%) showed the lowest results. The average wintering rates were found in the varieties Kara Koz (69.1%), Sochny (68.9%), Kazakhstan-20 (64.2%), KV-2/9 (63.5%) and the hybrid DV-7/17 (60.7%). In 2023, the best winter hardiness (above 70%) was shown by the following varieties: Mereytoy-50 (83.9%), Azim (75.2%), and Aisulu (70.5%). Among the hybrids, DV-10/11 showed the best winter hardiness (74.0%). The control variety Muscat Hungarian (st; 57.9%), Akdidar (43.8%), Iyulsky (46.1%), Sochny (48.1%), as well as hybrids including DX-17/90 (51.3%), and KII-1/29 (53.2%) exhibited the lowest indices. The average values were observed for the varieties Kara Koz (68.2%), Akmaral (64.3%), Kazakhstan-20 (62.7%), KV-2/9 (62.9%), and DV-7/17 (61.8%). In 2024, the best winter hardiness was observed above 70% for the varieties Mereytoy-50 (85.0%), Azim (75.5%), and Aisulu (71.1%) as well as among the hybrid: DV-10/11 (73.8%). The lowest indices were for the Muscat Hungarian variety (st; 61.2%), Akdidar (47.5%), Iyulsky (50.0%), and Sochny (54.3%), as well as the hybrids DX-17/90 (49.3%), KII-1/29 (52.3%). The average overwintering was observed in Kara Koz (68.7%), Kazakhstan-20 (64.4%), Akmaral (64.0%), KV-2/9 (63.8%), and DV-7/17 (63.8%). In the period from 2022 to 2024, the following research results were obtained:

The best degree of overwintering was noted. The percentage of resistance to winter conditions ranged from 50.7% (DX-17/90 hybrid) to 83.77% (Mereita-50 variety). Varieties and hybrids demonstrated more than 70% winter hardiness: Mereytoy-50 (83.8%), Azim (75.2%), DV-10/11 (74.0%), and Aysulu (72.9%). The control variety Muscat Hungarian (st) showed 59.6%, KII-1/29 (51.7%), and DX-17/90 (50.7%). Thus, compared to Muscat Hungarian (st), the varieties Mereita-50, Azim, DV-10/11, and Aisulu showed higher results (1.42); 1.28–1.24 times, respectively. The KII-1/29 and DX-17/90 hybrids demonstrated lower indices: 0.88 and 0.86 times, respectively (Fig. 4). At the same time, the percentage of winter hardiness does not change significantly, which indicates the stability of these indices. The increase in the number of productive shoots is associated with improved agricultural practices, such as the use of fertilizers, irrigation, and favorable climate changes (Fig. 4). The number of fruit-bearing shoots in 2022 also varied significantly depending on the variety or hybrid. The varieties Mereita-50 (15 pcs. bush^{-1}), Aisulu (13 pcs. bush^{-1}), and the hybrid forms KV-2/9 (14 pcs. bush^{-1}), DV-10/11 (12 pcs. bush^{-1}) showed the highest values, indicating high yields. At the same time, the lowest yields were recorded for the Muscat Hungarian variety (st): (7 pcs. bush^{-1}), Akdidar: (9 pcs. bush^{-1}), and the KII-1/29 hybrid: (6 pcs. bush^{-1}). The number of fruit-bearing shoots in 2023 also varied significantly depending on the variety or hybrid. For example, the varieties including Mereita-50 (17 shoots bush^{-1}), Azim (15 shoots bush^{-1}), and Aisulu (16 shoots bush^{-1}), as well as the hybrid forms including KV-2/9 (18 shoots bush^{-1}), and DV-10/11 (16 shoots/bush) showed the highest values, indicating high yields. At the same time, the lowest values were recorded for the Muscat Hungarian variety (st; 9 pcs. bush^{-1}), Akdidar (7 pcs. bush^{-1}), and the KII-1/29 hybrid (8 pcs. bush^{-1}). The number of fruit-bearing shoots in 2024 also varied significantly depending on the variety or hybrid. The varieties Mereytoy-50 (19 pcs. bush^{-1}), Azim (17 pcs. bush^{-1}), Aisulu (17 pcs. bush^{-1}), and the hybrid forms KV-2/9 (20 pcs. bush^{-1}), DV-10/11 (19 pcs. bush^{-1}) showed the highest values, indicating high yields. At the same time, the lowest yields were recorded for the Muscat Hungarian variety ((st; 12 pcs. bush^{-1}), Akdidar (10 pcs. bush^{-1}), and the KII-1/29 hybrid (9 pcs. bush^{-1}). In the period from 2022 to 2024, the following research results were obtained: The number of fruit-bearing shoots also varied significantly depending on the variety or hybrid. For example, the Meriteita-50 variety (17 shoots/bush) and the DV-10/11 hybrid (16 shoots bush^{-1}) showed the highest values, indicating high yields. At the same time, the varieties Muscat Hungarian (st; 9 pcs. bush^{-1}), Akdidar (9 pcs. bush^{-1}), and the hybrid KII-1/29 (8 pcs. bush^{-1}) exhibited the lowest values (Fig. 4). In conclusion, the varieties and hybrids Mereita-50, Azim, and DV-10/11 showed the best results in all the main indices. The variety Muscat Hungarian (st) exhibited the lowest values. In 2022, the earliest bud break was observed on March 20-22 in the varieties Aisulu, Mereita-50, and the hybrid DV-10/11. The latest bud break was observed on April 12-17 in the varieties Akdidar, Iyulsky, and Sochny. In the other varieties, the buds began to open between March 23 and April 3 (Fig. 5). In 2023, the earliest bud opening was observed in the varieties Aisulu, Muscat Hungarian (st), Mereita-50, and the hybrid DV-10/11 on March 17-20. The latest bud opening occurred between April 10 and April 15 in the varieties Akdidar, Iyulsky, and Sochny. The remaining varieties began to bloom from March 22 to April 1 (Fig. 5). In 2024, the earliest bud break was observed on March 16–17 in the DV-10/11 hybrid and the Aisulu variety. The latest bud break was observed on April 11–15 in the Akdidar, Iyulsky, and Sochny varieties. The remaining varieties began to bloom between March 20 and April 4 (Fig. 5). The following data was obtained from the 2022–2024 studies. The earliest bud break was observed on March 17-18 in the hybrid forms DV-10/11 and

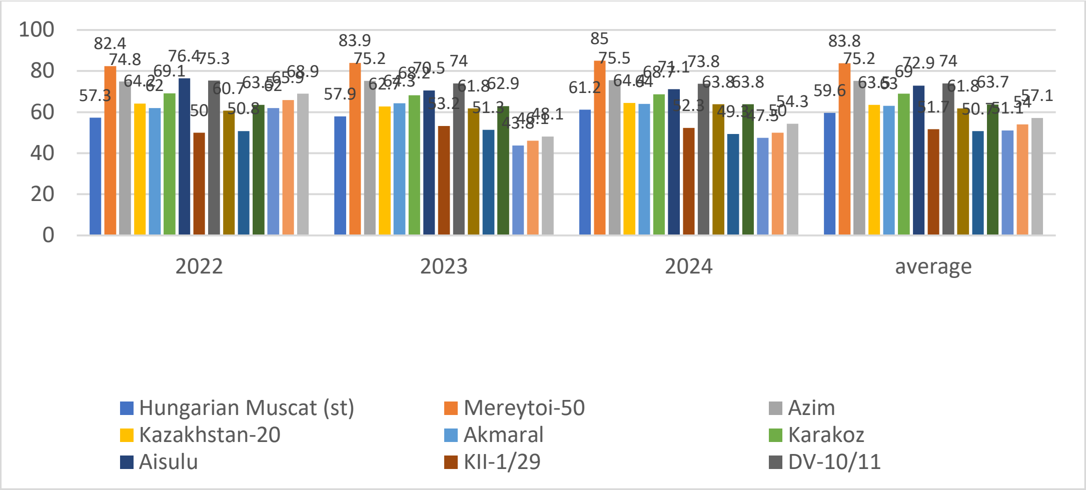
Aisulu. The latest bud break was observed on April 11-16 in the varieties Akdidar, Iyulsky, and Sochny. In other varieties and hybrids, bud break occurred between March 20 and April 3 (Fig. 5). Productivity per bush increases naturally depending on the age of the plant and the expansion of the feeding area. The yield is determined by simultaneously counting the bunches in each repetition of the experiment and weighing them. Then, the average yield per bush is determined for each variant, and the total yield in centners per hectare is calculated by multiplying the number of bushes per hectare. It is determined by dividing the total weight of the bunches per bush by the number of bunches, depending on the variety/hybrid.According to experimental observations in 2022, the ripening of the grape harvest was assessed. Highest indices: Mereytoy-50 (22 pcs. bush^{-1}), Akdidar (19 pcs. bush^{-1}), Azim (17 pcs. bush^{-1}), KV-2/9 (16 pcs. bush^{-1}), and Aisulu (16 pcs. bush^{-1}). Lowest: Muscat Hungarian (st; 11 pcs. bush^{-1}), and KII-1/29 (9 pcs. bush^{-1}). Compared to Muscat Hungarian (st): Mereita-50 was 1.87 times, Akdidar 1.51 times, Azim 1.47 times, KV-2/9, 1.45 times, and Aisulu 1.42 times higher, while KII-1/29 was 0.87 times lower. The average weight of one bunch varied from 280 g to 502 g. The DV-7/17 hybrid had the highest average bunch weight of 502 g, while the DV-10/11 hybrid had the lowest average bunch weight of 280 g. The highest yields per plant were obtained from the following varieties: KV-2/9 (7.5 kg), DV-7/17 (7.0 kg), Aysulu (6.8 kg), Mereytoy-50 (6.6 kg), and Akdidar (6.5 kg). The lowest values were recorded for Muscat Hungarian (st; 4.0 kg), Kara Koz (4.0 kg), DX-17/90 (3.8 kg), and KII-1/29 (3.9 kg). In terms of yield per hectare, the highest values were shown by: KV-2/9 (166.7 c ha^{-1}), Azim (157.8 c ha^{-1}), DV-7/17 (155.5 c ha^{-1}), DV-10/11 (153.3 c ha^{-1}), Aisulu (151.0 c ha^{-1}) and Akdidar (144.4 c ha^{-1}).



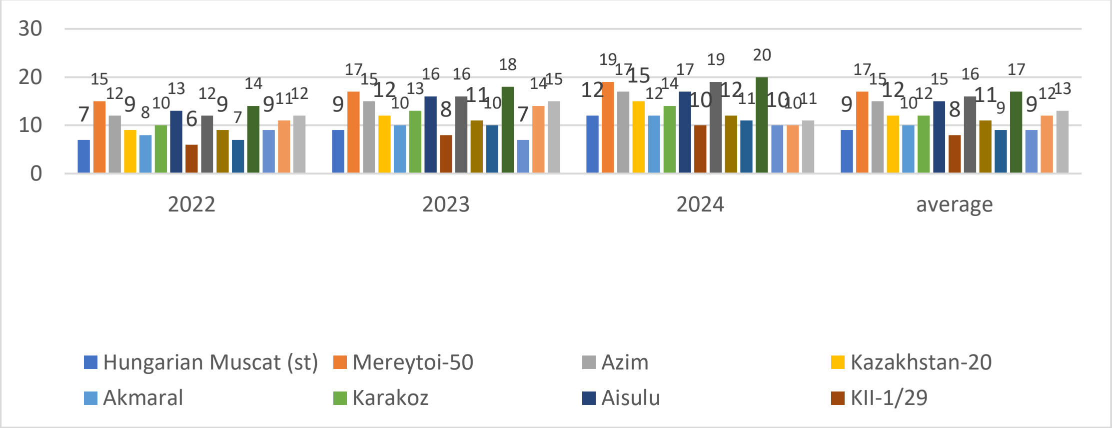
A: Total number of eyes (pcs. bush^{-1}).



B: Live eyes (pcs. bush^{-1}).



C: The degree of overwintering (%).



D: Number of fertile shoots

Fig. 4. Biological features of overwintering of grape varieties and hybrid forms (2022–2024); A- total number of buds (pcs. bush^{-1}); B- live buds (pcs. bush^{-1}); C- degree of overwintering (%); D: Number of fertile shoots.

Date of budding

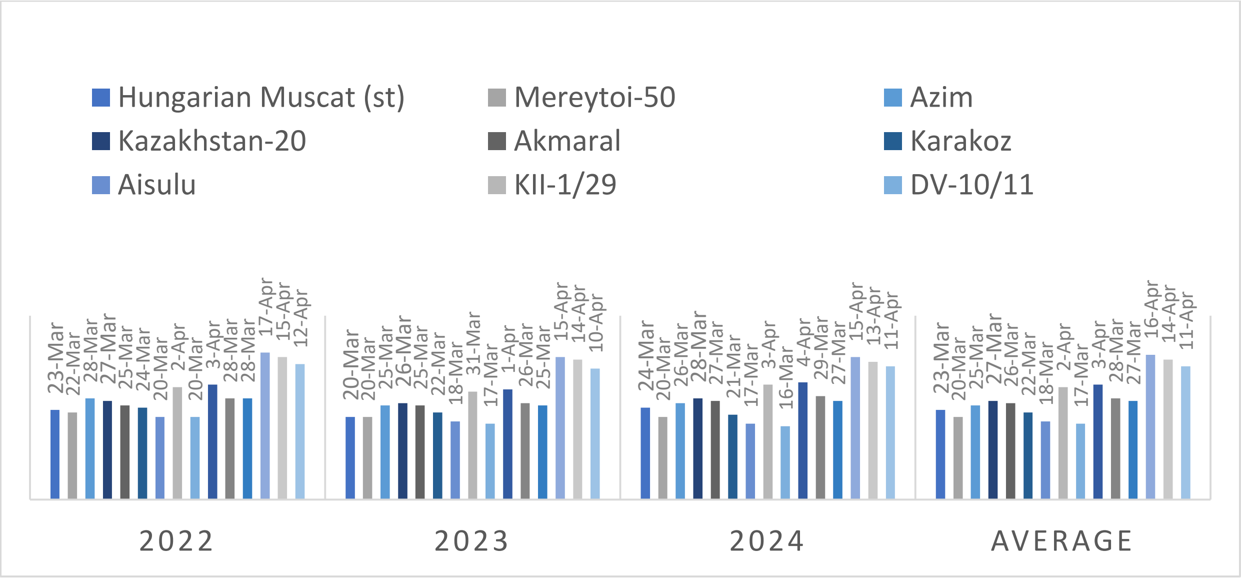


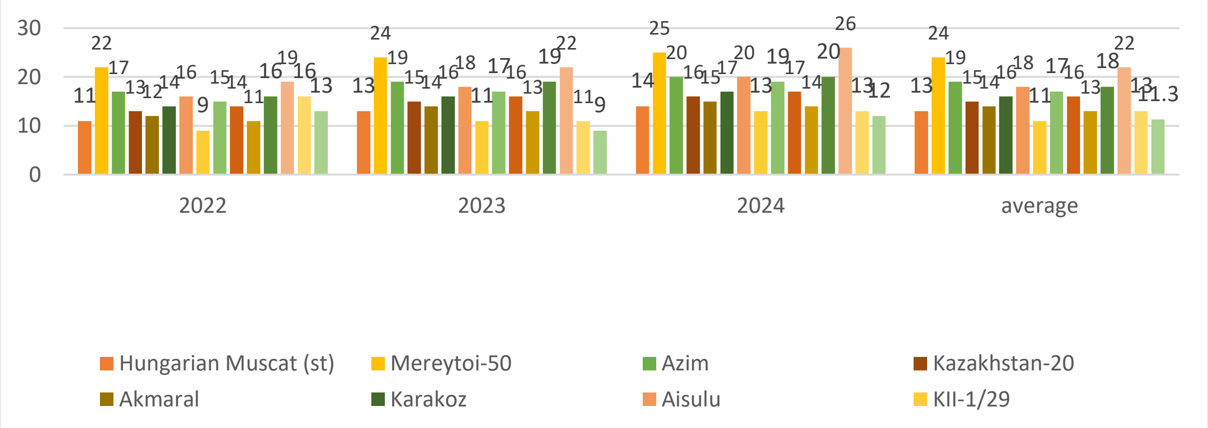
Fig. 5. Bud break dates for grape varieties and hybrid forms (2022 – 2024).

The lowest yields were related to DX-17/90 (84.4 kg ha^{-1}), Muscat Hungarian (st; 88.9 kg ha^{-1}), KII-1/29 (86.7 kg ha^{-1}), and Kara Koz (88.9 kg ha^{-1}). The ripening periods of the berries were noted at different times: the varieties Iyulsky (04.08), Kara Koz (12.08), Sochny (14.08), Akmaral (15.08), Aysulu (15.08), the KV-2/9 hybrid (11.08), and DV-10/11 (14.08) are classified as early-ripening. Late ripening was observed in the DV-7/17 hybrid on 03.09 (Fig. 6). Based on a combination of economically valuable traits, the following grape varieties and hybrid forms were selected: Mereytoy-50, Aysulu, Azim, Akdidar, KV-2/9, DV-7/17, and DV-10/11. According to experimental observations in 2023, an assessment of the ripening time of the grape harvest was carried out. The highest indices were related to: Mereitoy-50 (24 pcs. bush^{-1}), Akdidar (22 pcs. bush^{-1}), Azim (19 pcs. bush^{-1}), KV-2/9 (19 pcs. bush^{-1}), and Aisulu (18 pcs. bush^{-1}). The smallest: Muscat Hungarian (st; 13 pcs. bush^{-1}), KII-1/29 (11 pcs. bush^{-1}), and Sokochny (9 pcs. bush^{-1}). Compared to Muscat Hungarian (st): Mereita-50 was 1.82 times, Akdidar 1.50 times, Azim 1.41 times, KV-2/9 1.43 times, and Aisulu 1.39 times higher, while KII-1/29 was 0.82 times lower. The average weight of one bunch ranged from 239 g to 498 g. The DV-7/17 hybrid had the heaviest bunches, weighing 498 g and 460 g, while the Kara Koz variety had the lightest bunches, weighing 282 g and 239 g. In terms of yield per bush, the highest indices were shown by: KV-2/9 (9.0 kg), DV-7/17 (8.0 kg), Azim (8.0 kg), Aisulu (7.7 kg) and Mereitoy-50 (7.4 kg). The lowest values were recorded for Muscat Hungarian (st; 4.9 kg), DX-17/90 (4.4 kg), KII-1/29 (4.8 kg), Kara Koz (4.5 kg), Iyulsky (2.6 kg), and Sochny (2.3 kg). In terms of yield per hectare, the highest results were: KV-2/9 (200.0 c ha^{-1}), Azim (177.8 c ha^{-1}), DV-7/17 (177.8 c ha^{-1}), DV-10/11 (175.5 c ha^{-1}), and Aisulu (171.0 c ha^{-1}). The lowest yield was 97.8 kg ha^{-1} for DX-17/90, 57.8 kg ha^{-1} for Iyulsky, and 53.3 kg ha^{-1} for Sochny. The ripening periods of the berries varied: the early-ripening hybrids were KV-2/9 (09.08), DV-10/11 (11.08), the July variety (05.08), the Kara Koz variety (10.08), the Sochny variety (12.08), and the Aisulu variety (12.08). Late ripening was recorded in the DV-7/17 hybrid on 01.09 (Fig. 6). Based on a combination of economically valuable traits, the following grape varieties and hybrid forms were selected: Mereytoy-50, Aysulu, Akdidar, Kazakhstan-20, Azim, KV-2/9, DV-7/17, and DV-10/11. Based on experimental observations in 2024, the ripening time of the grape harvest was assessed. Highest indices were related to: Mereytoy-50 (25 pcs. bush^{-1}), Akdidar (26 pcs. bush^{-1}), Azim (20 pcs. bush^{-1}), KV-2/9 (20 pcs. bush^{-1}), Aisulu (20 pcs. bush^{-1}), while lowest to: Muscat Hungarian (st; 14 pcs. bush^{-1}), KII-1/29 (13 pcs. bush^{-1}), Sochny (12 pcs. bush^{-1}). Compared to Muscat Hungarian (st): Mereita-50 was 1.80 times, Akdidar 1.49 times, Azim 1.39 times, KV-2/9 1.41 times, and Aisulu 1.37 times higher, while KII-1/29 is 0.80 times lower. The average weight of one bunch ranged from 280 g to 495 g. The highest weight was shown by bunches DV-7/17 (495 g) and DV-10/11 (455 g), while the lowest in varieties Kara Koz (280 g), July (289 g). In terms of yield per bush, the highest values were recorded for: KV-2/9 (9.4 kg), DV-10/11 (8.7 kg), Aisulu (8.5 kg), Azim (8.4 kg) and DV-7/17 (8.4 kg). The lowest scores were recorded for Muscat Hungarian (st; 4.9 kg), Kara Koz (4.8 kg), DX-17/90 (4.8 kg), Iyulsky (3.7 kg), and Sochny (3.9 kg). In terms of yield per hectare, the highest results were shown by: KV-2/9 (208.9 c ha^{-1}), DV-10/11 (193.3 c ha^{-1}), Aisulu (188.9 c ha^{-1}), DV-7/17 (186.7 c ha^{-1}) and Azim (186.7 c ha^{-1}). The lowest yields were recorded for Muscat Hungarian (st; 108.9 kg ha^{-1}), Kara Koz (106.7 kg ha^{-1}), DX-17/90 (106.7 kg ha^{-1}), Iyulskiy (82.2 kg ha^{-1}), and Sochniy (86.6 kg ha^{-1}). The ripening periods of the berries varied. Early-ripening varieties include Iyulsky (05.08), KV-2/9 (07.08), Kara Koz (07.08), DV-10/11 (09.08), Aysulu (10.08), and Sochny (11.08). Late ripening was recorded for the DV-7/17 hybrid on August 31 (Fig. 6). Based on a combination of economically valuable traits, the following grape varieties and hybrid forms were selected: KV-2/9, DV-10/11, Aysulu, Akdidar, Azim, and DV-7/17. According to research data from 2022 to 2024: in terms of number of clusters per bush, highest results were as follows: Mereytoy-50 (24 clusters bush^{-1}), Akdidar (22 clusters bush^{-1}), Azim (19 clusters bush^{-1}), KV-2/9 (18 clusters bush^{-1}), and Aisulu (18 clusters bush^{-1}). The smallest were related to Muscat Hungarian (st; 13 pcs. bush^{-1}), KII-1/29 (11 pcs. bush^{-1}), and Sochny (11.3 pcs. bush^{-1}). Compared to Muscat Hungarian (st): Mereita-50 was 1.80 times, Akdidar 1.48 times, Azim 1.37 times, KV-2/9 1.40 times, Aisulu1.35 times higher, while KII-1/29 was 0.79 times lower. The average weight of one bunch ranged from 281g to 498g. The highest values were for: DV-7/17 (498 g), KV-2/9 (473 g), DV-10/11 (458 g), Kazakhstan-20 (453 g), while the lowest values for July (289g), Kara koz and (281g). Thus, compared to the Muscat Hungarian variety (st), the DV-7/17 hybrid is 1.38 times, the KV-2/9 hybrid 1.31 times, the DV-10/11 hybrid 1.27 times, and the Kazakhstan-20 hybrid 1.26 times higher, while the Kara Koz hybrid is 0.78 times, and the Iyulsky hybrid 0.75 times lower. Thus, there is a positive correlation between bunch weight and total yield: varieties with heavier bunches tend to have higher yields. In terms of yield per bush, highest yields were related to: KV-2/9 (8.5 kg), DV-10/11 (7.8 kg), Azim (8.0 kg), DV-7/17 (8.0 kg), Aisulu (7.7 kg), and Mereytoy-50 (7.3 kg). The lowest scores were found in: Muscat Hungarian (st; 4.7 kg), Kara Koz (4.4 kg), DX-17/90 (4.4 kg), and KII-1/29 (4.8 kg). Compared to Muscat Hungarian (st): KV-2/9 is 1.88 times, and DV-10/11, Azim, DV-7/17 are 1.70 times higher. In addition, Aisulu 1.67 times, and Mereita-50 1.59 times higher, while KII-1/29 1.04 times, Kara Koz

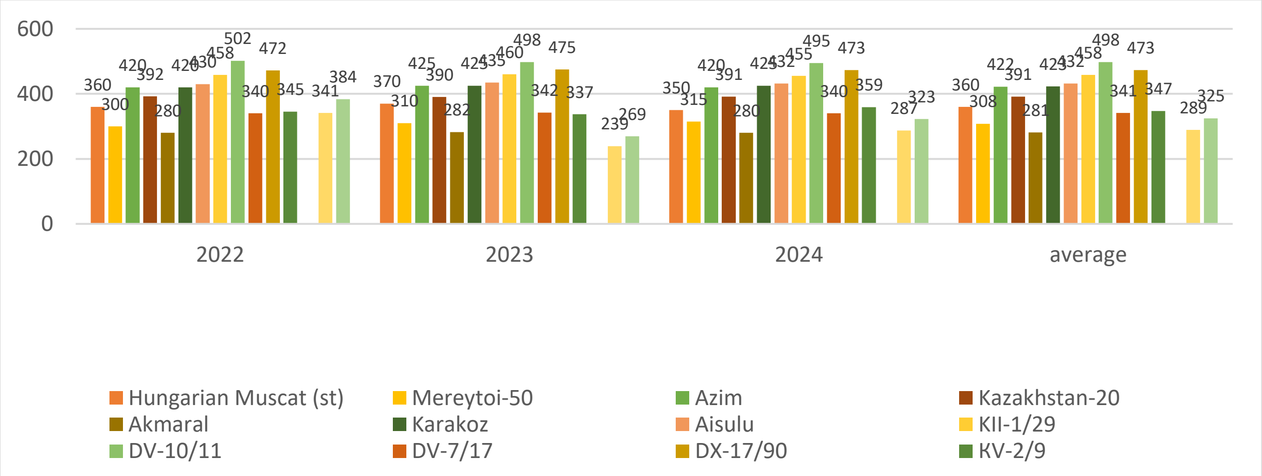
0.96 times, and DX-17/90, 0.94 times lower. In terms of yield (c ha^{-1}): the highest indices were demonstrated by the hybrid KV-2/9 (191.87 c ha^{-1}), DV-10/11 (174.03 c ha^{-1}), DV-7/17 (173.33 c ha^{-1}), as well as varieties Azim (174.1 c ha^{-1}), Aisulu (170.3 c ha^{-1}) and Mereitoy-50 (162.2 kg ha^{-1}). The lowest yields were recorded for the Muscat Hungarian variety (st) at 102.23 kg ha^{-1}, the Kara Koz variety at 98.53 kg ha^{-1}, and the DX-17/90 hybrid at 96.3 kg ha^{-1}. These data confirm the differences in yield potential between the varieties. Thus, compared to the Hungarian Muscat variety (st), the following varieties demonstrated higher yields: KV-2/9 (1.87 times), DV-10/11 (1.70 times), DV-7/17 (1.69 times), Azim (1.70 times), Aisulu (1.67 times), and Mereita-50 (1.59 times). At the same time, the Kara goat varieties and the DX-17/90 hybrid had lower yields, by 0.97 and 0.94 times respectively. The ripening time of the grape harvest was recorded by variety. The ripening phase of the berries was noted at different times depending on the variety: Early ripening was observed in: Iyulsky (05.08), KV-2/9 (10.08), DV-10/11 (13.08), Kara Koz (11.08), and Sochny (12.08), while late ripening in the DV-7/17 hybrid (02.09; Fig. 6). Statistical significance: The *p* value (≤ 0.05) indicates the statistical significance of all factors. This means that the effect of each factor (variety, year, and number of bunches) on yield is statistically significant and not random. Thus, the influence of varieties on the average weight of one bunch and the number of bunches are clearly expressed. The varieties Mereita-50 and KV-2/9 showed high yields, which is confirmed by their high number of bunches and average weight of one bunch. The higher the number of bunches, the higher the yield, and all these factors affect the overall volume of production. According to the complex of economic and value characteristics, the varieties and hybrid forms of grapes are divided as follows: Mereytoy-50, Aysulu, Azim, Akdidar, KV-2/9, DV-7/17, and DV-10/11.

Yield per vine (Q vetki) and average weight of one bunch (Srves): There may be a positive correlation between yield per vine (Q vetki) and average weight of one bunch (Srves). This means that there is a direct relationship between the two indices:

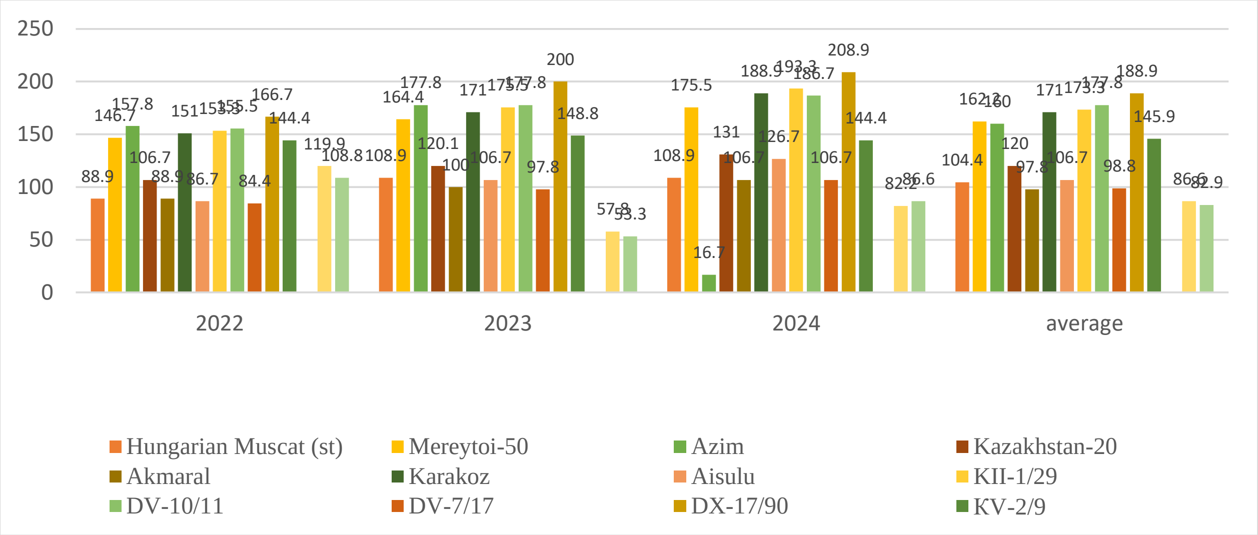
Normal situation: if the average weight of one bunch is high, then the yield per vine will also be higher. This means that as the number and weight of berries increase, the overall yield also upraises.



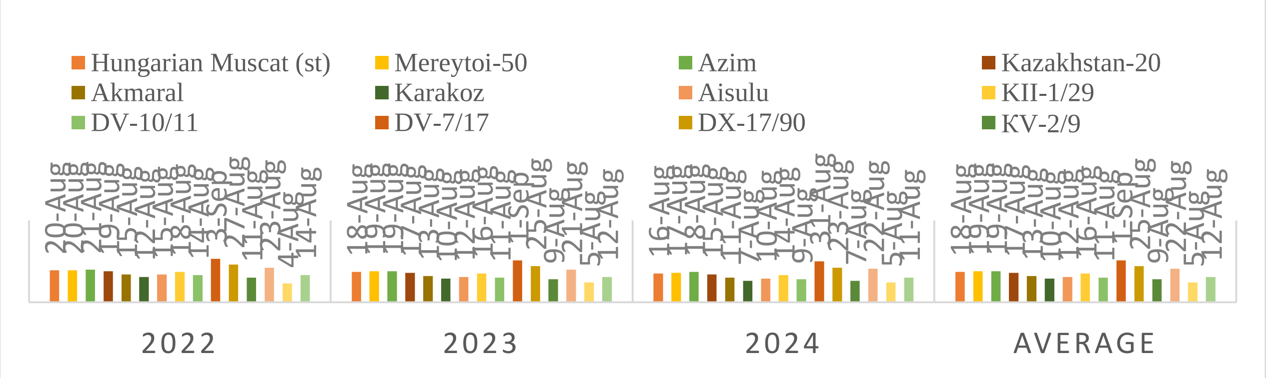
A: Number of clusters (bunches; pcs. bush^{-1}).



B: Average weight of bunches (g).



C: Yield (c ha^{-1}).



D: Date of removal

Fig. 6. Production and biological characteristics of the studied grape varieties (medium for 2022-2024); a: number of bunches of brushes; pcs bush^{-1}); b: average weight of bunches (g); c: yield (c ha^{-1}); d: date of removal.

Conclusion: r > 0. Thus, we can say that there is a positive relationship between these two indices. Usually, as the weight of the bunch increases, the total weight of the harvest also raises, as the weight of each berry is higher.

Yield per vine (Q vetki) and titrated acidity (Acid): The relationship between these indices may be complex and likely to have a negative correlation: Increased acidity affects the taste, sweetness, and, consequently, the weight of the product. Products with high titrated acidity are often less sweet and lighter in weight. The experiment shows that products with high acidity usually have a lower weight, while those with higher sweetness have a higher weight, which can lead to a decrease in yield.

Conclusion: r < 0. If the acidity is high, the yield per plant may decrease. Products with low acidity and high sweetness tend to grow larger and weigh more.

Average weight of one bunch (Srves) and titrated acidity (Acid): There may be a negative or weak correlation between these variables: The increase in acidity affects the appearance and properties of the product, reducing its weight. In particular, clusters with high acidity tend to be lighter and smaller in size.

Conclusion: r < 0. If the acidity is high, the average weight of the cluster is likely to decrease. This decrease is associated with a reduction in mass. Thus, there is a positive correlation (r > 0) between the yield per bush (Q vetki) and the average weight of one bunch (Srves). This usually shows that berries with a higher weight yield a higher yield. There is a negative correlation between yield per bush (Q vetki) and titrated acidity (Acid; r < 0). This means that products with high acidity usually have a lower yield. There is also a negative correlation between the average weight of one bunch (Srves) and titrated acidity (Acid) (r < 0), meaning that berries with high acidity have a lower weight.

Yield per vine (Q vetki) and number of clusters (Srves): There is probably a positive correlation between these two indices: The more clusters, the higher the yield per vine. By an increase in the number of berries, the total volume of production also will be elevated.

In addition, the number of clusters affects the yield, as the weight of each cluster is also important.

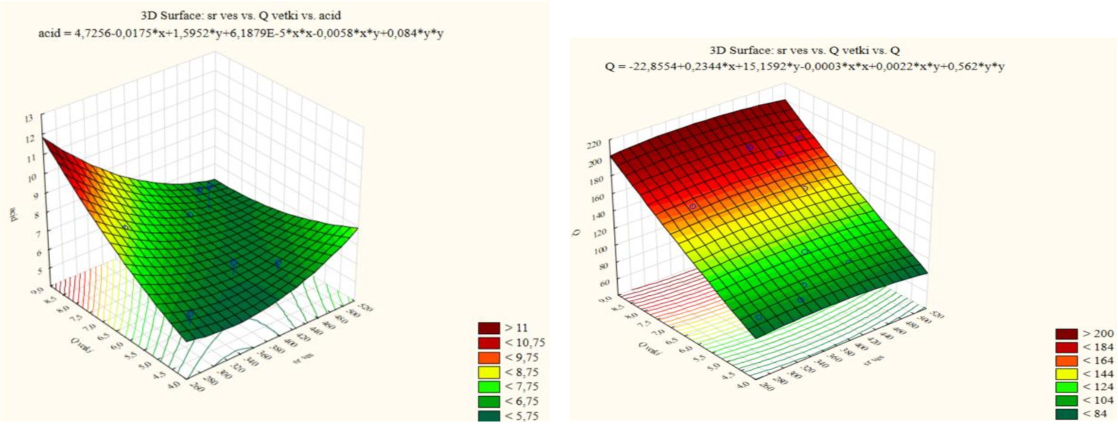
Thus, there is a positive relationship between these two variables (r > 0), which means that as the number of clusters increases, the yield per bush also upraises.

Yield per bush (Q vetki) and titrated acidity (Acid): There may be a negative correlation between titrated acidity and yield per bush: Berries with high acidity usually produce less yield, as high acidity affects mass and sweetness. In addition, it is more difficult for products with high acidity to achieve a large weight and yield. They are often lighter in weight but have a good taste. These indices may have a negative correlation (r <0). By a high acidity, the yield volume may decrease.

Number of bunches (Srves) and titrated acidity (Acid): Between the number of bunches and acidity, there may be a weak or negative correlation: Berries with high acidity are usually smaller, and although their number may be large, their weight decreases. In this case, by an elevation in the number of bunches, acidity may increase, but the mass of each berry drops (Fig. 7). There may be a weak negative correlation between these variables (r < 0).

Results: There is a positive correlation (r > 0) between the yield per bush (Q vetki) and the number of bunches (Srves). That is, as the number of bunches increases, the yield also will be elevated.

There is a negative correlation between bush yield (Q vetki) and titrated acidity (Acid; r < 0). By a high acidity, yields may decrease. There is a weak or negative correlation between the number of bunches (Srves) and the titrated acidity (Acid).



A B

Fig. 7. A: dependence of the yield per vine (kg; Q vetki), average weight of one bunch (g; Srves) and titrated acidity (g L^{-1}; Acid); B – dependence of the yield per vine (kg; Q vetki), number of bunches (pcs.; Srves) and titrated acidity (g L^{-1}; Acid)

Biochemical indicators of grape varieties and hybrid forms: The two main quality indices of grapes are the sugar content and acidity of the berry juice, which determine the direction of use of the crop. During ripening, the sugar content in individual berries of bunches harvested from the same bush varies and depends on the light exposure, terrain, soil composition, and other factors. The acidity of berry juice is highly variable and depends on the variety, agricultural practices, maturity, and environmental conditions. It is known that the acidity of juice increases geographically from south to north and by increasing altitude. According to experimental observations in 2022, the sugar content in berry juice ranged from 17-23%, the highest rate was observed in Akdidar varieties (23%), Juicy (22%), in the hybrid DV-10/11 (20.5%), while the lowest in Hungarian Muscat (st), Aisulu and KII-1/29 (17% each). The organoleptic (taste) score ranged from 4.0 to 5.3 points. Akdidar received the highest score with 5.3 points, Juicy with 5.2 points, DV-10/11 with 5.1 points, as well as Hungarian Muscat (st) and Aisulu with 4.0 points each. According to the content of titrated acidity, the first place was taken by the Mereitoy variety-50 (8.0 g L^{-1}). The values of the remaining varieties and hybrid forms were 1-3 units lower. According to the glucoacidometric index (GAP), the highest value in the Akdidar variety was 7.7, while the lowest in the KII-1/29 hybrid was 2.5 (Fig. 8). According to experimental observations in 2023, the sugar content in berry juice ranged from 17% to 22.6%, with the highest value of 22.6% for the Akdidar variety, 22.4% for the Sochny variety, 21% for the DV-7/17 hybrid, and 17% for the KII-1/29 variety. The organoleptic score ranged from 4.1 to 5.3 points. The highest scores were given to Akdidar, DV-10/11, and DV-7/17, which received 5.3 points each, while the lowest scores were given to Muscat Hungarian (st) and Iyulsky, which received 4.1 points each. In terms of titrated acidity, the highest scores were given to Mereytoy-50 and DV-10/11, which received 8.0 g L^{-1} each. The remaining varieties and hybrids had values with 1-3 units lower. According to the glucoacidometric index (GAP), the highest values were related to the Akdidar variety (5.7), while the lowest for the Mereitoy-50 variety were 2.3 (Fig. 8). According to experimental observations in 2024, the sugar content in the berry juice ranged from 16% to 23.5%, with the highest values being 23.5% for Akdidar, 22.5% for Sochny, 20% for Mereita-50 and DV-7/17, and 16% for KII-1/29. The organoleptic score ranged from 4.0 to 5.2 points. DV-7/17 received the highest score of 5.2, while Muscat Hungarian (st) received the lowest score of 4.0. In terms of titrated acidity, Mereita-50 and DV-10/11 again led the way with 8.0 g L^{-1}. The remaining varieties and hybrid forms had acid content with 1-3 units lower. According to the glucoacidometric index (GAP), the highest values in the Akdidar variety were 5.9, while the lowest values in the KII-1/29 hybrid (2.2; Fig. 8). According to research data for 2022-2024, The sugar content in berry juice ranged from 17-23%, with the highest rates in varieties Akdidar (23%), Juicy (22.3%), Kara koz (19.33%), and in hybrids DV-7/17 (20.33%), DV-10/11 (19.83%). The lowest yields were recorded for Muscat Hungarian (st) at 17%, DX-17/90 at 17%, Aisulu at 18%, and KII-1/29 at 17%. Thus, compared to the Muscat Hungarian variety (st), the DV-7/17 and DV-10/11 hybrids, as well as the Kara Koz, DX-17/90 and Aisulu varieties showd higher values of 1.18, 1.14, 1.12, 1.02, and 1.02, respectively, while the KII-1/29 variety exhibited a value of 0.96. The taste rating varies from 4.0 to 5.2 points, with the highest ratings for the varieties Mereita-50, Akdidar, and Sochny at 5.2 points, and the DV-10/11 and DV-7/17 hybrids at 5.2 points, while the lowest rating for the Hungarian Muscat (st) variety at 4.0 points. Compared to the Muscat Hungarian variety (st), the DV-10/11 and DV-7/17 hybrids exhibited a taste rating 1.14 points higher, and the Mereita-50 variety 1.07 points higher.

In terms of titrated acidity, the first place was taken by the Mereita-50 variety (8.0 g L^{-1}) and the DV-10/11 hybrid (7.7 g L^{-1}), while the Hungarian Muscat variety (st) by 5 g L^{-1}, and the other varieties and hybrids displayed values 1-3 units lower. Thus, compared with the Hungarian Muscat (st) variety, the Mereitoy-50 variety and the DV-10/11 hybrid exhibited values 3.0 and 2.67 times higher, respectively.

According to the glucoacidometric index (GAP), the highest values were in the Akdidar variety (6.4), while the lowest in the Mereitoy-50 variety (2.3; Fig. 8). Compared to the Muscat Hungarian variety (st), the Mereita-50 variety and the DV-7/17 hybrid showed a 0.36-fold higher GAP, while the KII-1/29 hybrid a 0.97-fold lower GAP.

Sugar content (%), taste score (points), and titrated acidity (g L^{-1})

Relationship between sugar content and taste score: A high sugar content generally corresponds to a sweet taste and high taste quality. There may be a positive correlation between these parameters, as an increase in sugar enhances the sweetness of the product, which positively affects the taste score.

For example, the DV-10/11 hybrid had a sugar content of 20% and a taste score of 5.2 points. Similarly, other varieties had a high sugar content, which corresponds to a high taste rating.

Relationship between titrated acidity and sugar content: The relationship between acidity and sugar can vary. Usually, when the acidity is high, the sweetness level decreases, meaning that products with high acidity have a relatively lower sugar content. There may be a negative correlation between these two parameters.

For example, the Meritey-50 variety exhibited a titrated acidity of 8.0 g L^{-1} and a sugar content of 19%, which shows a complex relationship between moderate acidity and high sugar content.

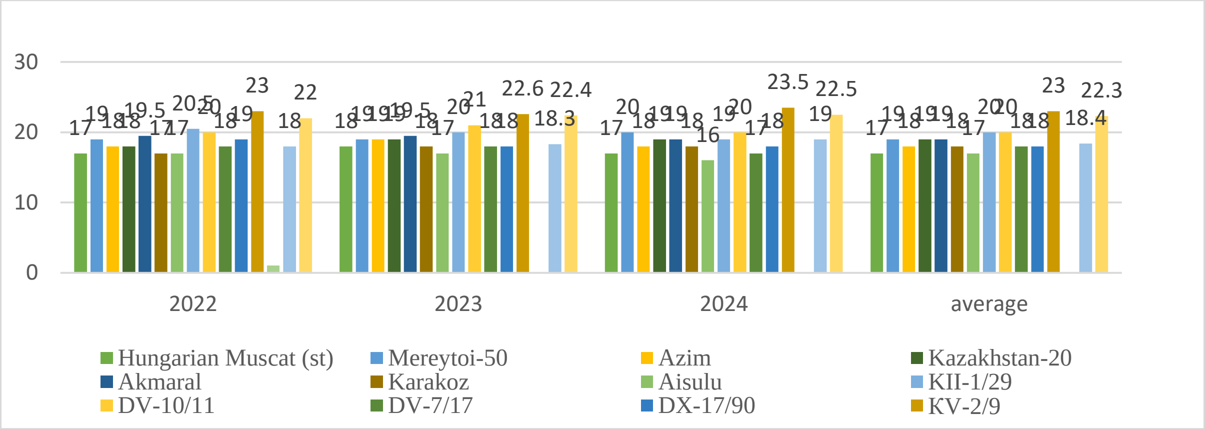
Glucoacidemetric index (GAP) and other variables

The relationship between GAP and sugar content: GAP reflects both the sweetness and acidity of a product. A high GAP indicates a balance between high sugar content and low acidity. High GAP values may be associated with higher sugar content and lower acidity. For example, the DV-7/17 hybrid has a GAP of 3.8, with a sugar content of 20% and a titrated acidity of 5.3 g L^{-1}, indicating a balanced sugar-to-acid ratio.

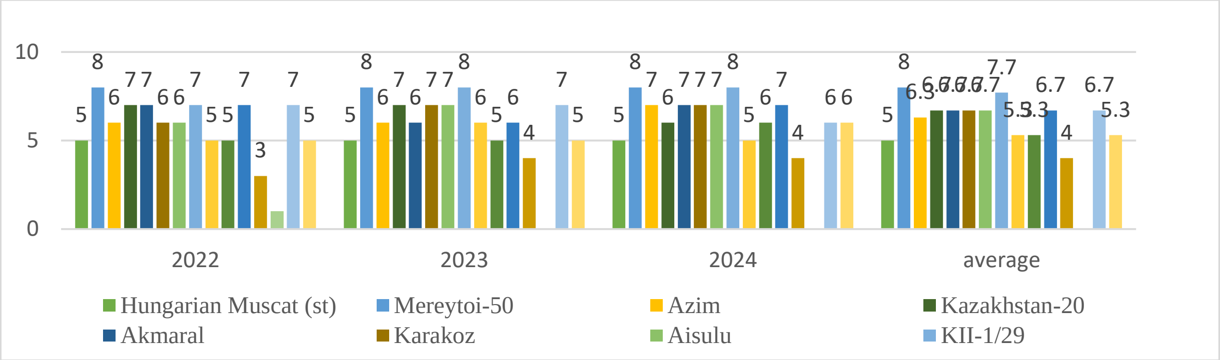
The relationship between GAP and taste evaluation: When the GAP value is high, the taste of the product is also evaluated as higher, as the optimal combination of sweetness and acidity enhances the taste of the product. There may be a positive correlation between these parameters. For example, the DV-7/17 hybrid has a high GAP value (3.8) and a high taste rating (5.2). As a result, there is a positive correlation between sugar content and taste rating: the higher the sugar content, the higher the taste rating.

There is a negative correlation between acidity and sugar content: when the acidity is high, the sugar content may be lower. There is also a positive correlation between GAP value and taste rating, meaning that a high GAP value has a positive effect on the taste of the product.

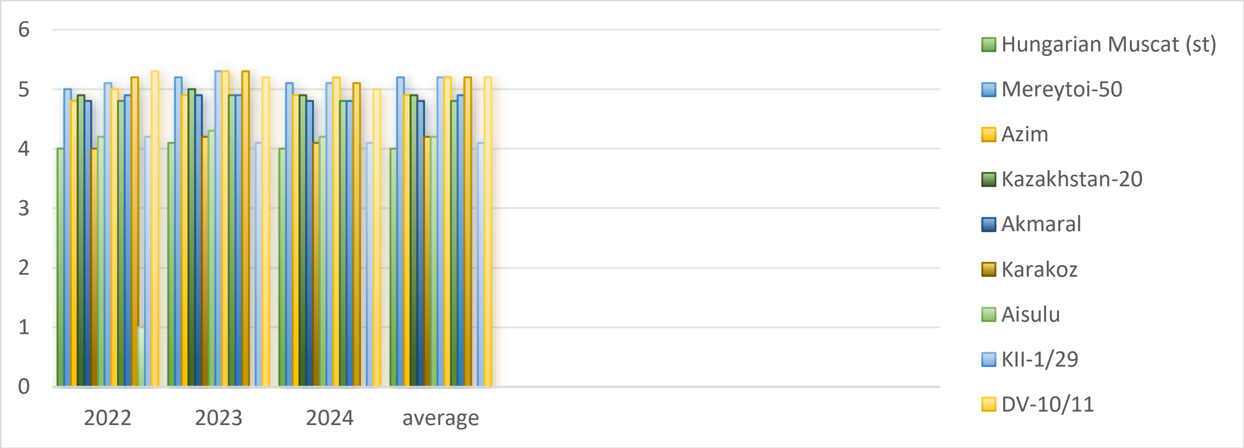
As a result of the molecular-genetic analysis of a number of grape varieties and hybrid forms for the presence of alleles associated with resistance to powdery mildew (*Oidium*), seven varieties and three hybrids were identified that have positive marker alleles at the Run1 (GF12-22, and GF12-07) as well as Ren1 (GF13-13, and VMC9h4.2) loci. Reference parent forms were used as control samples to track the inheritance of resistant alleles (Table 2). In the Aisulu variety (medium ripening period), which is a hybrid of Yagdon Belaya and Zhemchug Saba, despite its mediocre phenotypic resistance to *Oidium* and mildew, a 214-bp allele was found at the GF13-13 (Ren1) locus associated with resistance to *Oidium*, but no markers associated with resistance to mildew were identified. A similar allele (214 bp) was found in the parent variety Zhemchug Saba, which confirms the possibility of inheriting the stable Ren1 locus from the mother. An interesting case was the variety Kara Koz (a hybrid of Madeleine Angevine × Senso), which, according to literature data, does not have a pronounced resistance to fungal pathogens, but demonstrates the presence of a stable allele at the GF13-13 locus (Ren1, 214 bp), which requires additional phenotypic evaluation.



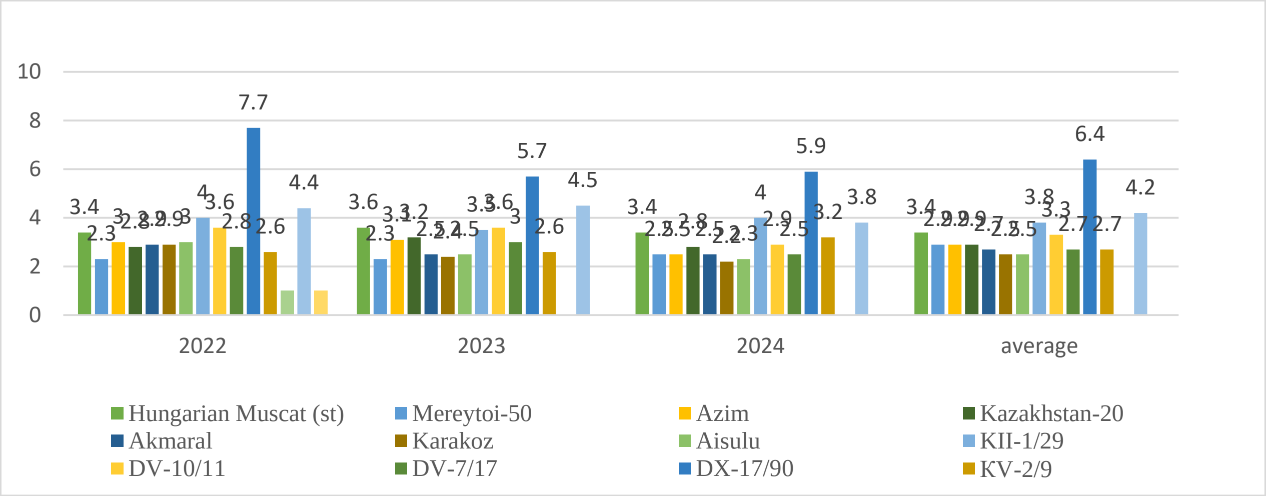
A: Sugar content (%).



B: Titrated acidity (g L^{-1}).



C: Taste assessment (score).



D: Glucoacidimetric indicator (GAI).

Fig. 8. Evaluation of biochemical indicators of grape varieties and hybrids (2022–2024); A: sugar content (%), B: titrated acidity (g L^{-1}), C: taste evaluation (point), D: glucose-acidity indicator (GAI)

The Kazakhstan-20 variety has positive alleles at two loci: Run1 (GF12-22) and Ren1 (VMC9h4.2), indicating its potential high genetic resistance to *Oidium*. The varieties Taifi Pink and Muscat Hungarian, which were included in the study as controls, also showed the presence of stable alleles at two loci: Run1 (GF12-22) and Ren1 (GF13-13 and VMC9h4.2). The DV-10/11 hybrid, which is derived from Taifi Pink, inherited a similar set of stable alleles, indicating stable trait transmission. The KII-1/29 hybrid had a positive allele only at the Run1 locus (GF12-07), while the KV-2/9 hybrid had stable alleles at both the Run1 locus (GF12-07) and the Ren1 locus (VMC9h4.2), which confirms its potential for breeding. Thus, the data obtained indicate the presence of genetic basis of powdery mildew resistance in a number of the studied forms and emphasize the importance of molecular marking in the selection of parental pairs and breeding lines aimed at the creation of new resistant grape varieties.

Identification of the loci of resistance to downy mildew of grapes. As a result of the molecular-genetic study of the Kazakhstani grape varieties for the presence of loci of resistance to downy mildew (Baghdasaryan *et al.* 2023), 3 varieties and 3 hybrids with positive alleles were identified. Some of the original parent varieties were used as controls to confirm the inheritance of sequences that correlate with resistance. Special attention was paid to the Rpv10 locus, which is located on chromosome 9 and is associated with introgression from *Vitis amurensis* (for example, in the Solaris variety; Phenotypical 1999).

Table 2. Sizes associated with microsatellite markers in the studied grape samples and correlated with powdery mildew resistance

Locus	**Powdery mildew *(Oidium)***											
	Run1				**Ren1**				**Ren3**			
Marker	**GF12-22**		**GF12-07**		**GF13-13**		**VMC9h4.2**		**GF15-28**		**GF15-30**	
Resistance alleles	**187**		**284 /288**		**214**		**283**		**342**		**452**	
Aisulu	183	183	290	296	214	214	262	274	356	368	436	436
Saba Pearl	183	201	296	296	205	214	262	286	369	377	437	470
Kara Koz	183	193	290	290	205	214	286	312	361	370	420	440
Tairi Pink	187	189	290	290	214	218	283	301	365	404	419	423
Mereytoy-50	197	207	294	296	194	226	274	312	362	370	421	423
Hungarian Muscat	187	201	290	294	206	214	260	283	360	372	442	424
Akmaral	193	193	294	296	205	209	283	289	362	376	421	469
Azim	193	207	290	296	193	218	259	262	362	369	421	440
Kazakhstan-20	187	193	294	294	212	226	283	312	383	394	434	447
Akdidar	185	189	288	298	202	210	287	301	352	368	438	446
July	181	191	276	282	208	216	275	293	348	366	424	442
Juicy	187	195	290	298	202	212	281	299	328	352	420	440
DV-10/11	187	195	268	290	214	224	289	297	352	364	436	452
DV-7/17	193	207	296	298	204	226	280	312	362	369	421	421
KII-1/29	201	209	284	296	205	226	286	312	339	377	421	469
DX-17/90	197	207	294	288	181	193	266	274	370	382	423	461
KV-2/9	193	201	284	290	178	226	283	312	339	394	421	458

According to the results of the analysis, the GF09-46 resistant allele with a length of 416 nucleotide pairs was identified in the Muscat Hungarian variety and in the KV-2/9 hybrid. These data are consistent with the results of previous studies (Abayeva *et al.* 2019), which indicate that Muscat Hungarian demonstrates moderate field resistance to mildew and *Oidium* and belongs to the technical varieties. In addition, markers for the Rpv3 locus (on chromosome 18) and the Rpv12 locus (on chromosome 14) were used (Pauquet *et al.* 2001). For the Rpv12 locus, none of the samples tested showed the presence of resistant alleles, indicating that there were no introgressions of this type of resistance in this sample. However, at the Rpv3 locus (marker – 389 bp), a positive result was recorded in two varieties (Zhemchug Saba and Tayfi Pink) and two hybrids (DV-10/11 and KII-1/29; Table 3). The inheritance of the Rpv3 resistant allele (389 bp) in the DV-10/11 hybrid can be attributed to its varietal origin from the Tayfi Pink parent, which confirms the transitive transmission of the resistance trait.

Table 3. Sizes associated with microsatellite markers in the studied grape samples and correlated with resistance to downy mildew.

Downy mildew (powdery mildew)										
Locus	**Rpv3**				**Rpv10**				**Rpv12**	
Marker	**GF18-08**		**GF18-06**		**GF09-46**		**GF09-48**		**GF14-28**	
Resistance alleles	**399**		**389**		**416**		**359**		**150**	
Aisulu	385	386	382	387	396	424	348	348	180	180
Saba Pearl	386	386	382	389	396	424	348	348	180	180
Kara Koz	387	387	376	376	423	423	348	348	168	180
Tairi Pink	385	389	389	400	395	424	347	348	164	180
Mereytoy-50	386	393	381	391	423	423	348	348	180	180
Hungarian Muscat	385	399	387	400	424	416	348	348	160	162
Akmaral	381	393	385	401	398	420	346	348	162	170
Azim	375	387	381	405	392	406	348	348	168	180
Kazakhstan-20	369	375	377	381	398	426	342	346	166	182
Akdidar	371	383	369	377	398	418	349	355	144	166
July	383	395	381	401	402	428	345	357	156	168
Juicy	379	387	385	413	404	420	341	351	148	162
DV-10/11	385	393	389	401	394	424	348	348	180	184
DV-7/17	377	391	375	381	386	408	340	352	172	188
KII-1/29	385	389	389	400	424	424	348	348	170	180
DX-17/90	385	395	387	401	396	424	344	350	168	172
KV-2/9	385	389	377	385	388	416	342	356	170	184

Note: Positive alleles are in bold.

Thus, the presence of positive alleles at the Rpv3 and Rpv10 loci in a number of varieties and hybrids confirms the effectiveness of using molecular markers in identifying sources of resistance to downy mildew. The obtained data allow us to identify genotypes with potential resistance, which can be used in breeding programs aimed at creating new grape varieties with resistance to mildew. This can also be used to expand the planting of promising resistant varieties, which will improve the quality and economic performance of the crop and reduce the environmental impact by reducing the use of fungicides. As part of the molecular genetic study of Kazakhstani grape varieties and hybrids, the presence of loci associated with resistance to the main fungal pathogens, powdery mildew (*Erysiphe necator*) and downy mildew (*Plasmopara viticola*), was assessed. The analysis included the use of markers for the Run1, Ren1 (resistance to *Oidium*) and Rpv3, Rpv10, Rpv12 (resistance to mildew) loci. As a result, 10 samples (7 varieties and 3 hybrids) were identified that possess positive alleles at one or more of the specified loci (Table 4). The analysis of the cross-distribution of alleles allowed us to identify six samples that possess alleles resistant to both powdery mildew and downy mildew. This makes them promising for use in breeding programs aimed at creating varieties with integrated resistance. According to the results of our research, the indices of overwintering grapes depend on both weather conditions and agrotechnical measures. This figure examines the relationship between the load of shoots (the number of eyes on the bush, the number of fruiting shoots and the number of inflorescences) and the degree of overwintering. An analysis of the correlation between the load of shoots (the number of eyes) and the degree of overwintering shows that with an elevation in the number of eyes, the degree of overwintering also increases. This indicates the good condition of the bushes and their ability to produce more fruit. In the Muscat Hungarian variety (st), an elevation in the shoot load (from 40 to 70 buds) led to a slight increase in the degree of overwintering, from 56.73% to 59.20%. In the Mereita-50 and KV-2/9 varieties, a similar trend was observed: as the load increased, the degree of overwintering also was elevated. For example, in the Mereita-50 variety, the degree of overwintering increased from 83.60% to 84.03% (Table 5).

Table 4. Genotypes with resistant alleles to powdery mildew and downy mildew.

№	**Variety / Hybrid**	**Resistance to *Oidium* (Run1 / Ren1)**	**Resistance to mildew (Rpv3 / Rpv10)**	**Potential for breeding**
1	Hungarian Muscat	Run1 (GF12-22), Ren1 (GF13-13, VMC9h4.2)	Rpv10 (GF09-46 – 416)	Very high
2	Typhee pink	Run1 (GF12-22), Ren1 (GF13-13, VMC9h4.2)	Rpv3 (389)	Very high
3	DV-10/11 (Hybrid)	Run1 (GF12-22), Ren1 (GF13-13)	Rpv3 (389)	High
4	KII-1/29 (Hybrid)	Run1 (GF12-07)	Rpv3 (389)	Medium
5	KV-2/9 (Hybrid)	Run1 (GF12-07), Ren1 (VMC9h4.2)	Rpv10 (GF09-46 – 416)	High
6	Saba Pearl	Ren1 (GF13-13 – 214)	Rpv3 (389)	Medium

Options for preserving the eyes under different loads: Mereita-50: 80 eyes (84.03%), 110 eyes (83.60%), 130 eyes (84.33%), which are higher than the control variety under all loads. KV-2/9: 80 eyes (63.60%), 110 eyes (63.43%), 130 eyes (62.67%), July: 80 eyes (58.30%), 110 eyes (64.20%), and 130 eyes (64.00%). Akdidar: 80 buds (55.60%), 110 buds (61.39%), and 130 buds (64.52%). The best preservation is observed at a load of 80–110 buds for the Mereita-50 variety and the KV-2/9 hybrid, while at 130 buds, the preservation rate decreases. The best preservation is observed in the July and Akdidar varieties when the load is 110-130 buds, and the index decreases when the load is 80 buds. Thus, compared to the Muscat Hungarian variety (st), these varieties showed 2.16-2.97 times better results. The increase in the number of fruiting shoots, in turn, leads to an increase in the number of inflorescences. This relationship between the indices is clearly visible: the more fruiting shoots, the more inflorescences, as each shoot forms new flowers and fruits. In the Muscat Hungarian variety (st), the number of fruiting shoots increased from 11.00 to 14.67 per bush, and the number of inflorescences increased from 17.00 to 22.00 per bush. The Meireitei-50 variety showed the following growth: Number of shoots: from 17.33 to 21.33 per bush, and number of inflorescences: from 25.67 to 32.00 per bush. The Akdidar variety showed the following growth: Number of shoots: from 10.00 to 15.44 per bush, and number of inflorescences: from 21.00 to 23.00 per bush (Table 4). Thus, the Meriteita-50 variety showed 1.4-1.5 times higher results at 55 and 70 buds load than at 40 buds load, and also higher than the Muscat Hungarian (st) variety. The Akdidar variety showed 1.0-1.3 times higher results at 55 and 70 buds load than at 40 buds load, and also higher and equal to the Muscat Hungarian (st) variety. Productivity elements also depend on the length of the shoots and varietal characteristics. Over the three years, the degree of overwintering was the highest for the Mereita-50 variety: 84.87–86.23% when pruned to 4–8 buds, and slightly lower at 83.20% when pruned to 12 buds. The degree of overwintering for the Mereita-50 variety was higher than that of the Muscat Hungarian variety (st) at all stages of observation. The average difference was about 25.5%, which indicates that the Meriteita-50 variety has better winter survival rates. The largest number of fruiting shoots and inflorescences was recorded in the KV-2/9 hybrid: when pruning into 8-12 eyes, the number of shoots was 32.3—34.3 pcs. bush^{-1}, the number of inflorescences was 19.3–21.0 pcs. bush^{-1}. There were no significant differences in performance between the medium and long pruning variants of this hybrid. However, with short pruning (4 eyes), the number of inflorescences in this hybrid decreased by 2 times. A similar dependence on the length of pruning was observed in the Meritey-50 variety. The Meritey-50 variety showed the best productivity results with medium and long pruning: 16.7–19.3 fruiting shoots per bush and 26.3–29.7 inflorescences per bush (Table 6). Compared to the control variety Muscat Hungarian (st), the varieties Mereita-50, Iyulsky, Akdidar, and the hybrid KV-2/9 had 7–8 more fruiting shoots per bush and 7–14 more inflorescences per bush. In general, the analysis of overwintering indices and grape productivity elements showed that the most viable and productive eyes of the Mereita-50 variety and the KV-2/9 hybrid are located in the lower and middle parts of the vine, at 4–8 eyes, while those of the Muscat Hungarian variety (st) are mainly located in the middle part (at 8–9 eyes). Long pruning also yielded good results (Fig. 9). This study shows that the plant's winter hardiness (survival after winter) depends on three factors: the number of buds, the load of shoots, and their relationship. The optimal ratio between the number of buds and the load ensures the best winter hardiness for the plant. Many eyes + high load → the plant is weakened, and its winter hardiness is reduced (Fig. 9). An average number of eyes + an average load → optimal winter hardiness. Thus, a balanced number of eyes and a load on the shoots improve the plant's ability to survive the winter. Intensive growth and excessive load have a negative impact, while an average load and number of eyes create the most favorable conditions.

Table 5. Overwintering indicators and productivity elements of grape varieties and hybrid forms under various loads (media. for 2022-2024).

Shoot load (pcs. bush^{-1})	Left-but gl. (pieces)	The degree of overwintering (%)	Fruiting shoots per bush	Number of inflorescences (pcs. bush^{-1})
Hungarian Muscat (st)				
40	80	57.73	11.00	17.00
55	110	57.40	12.00	19.33
70	130	59.20	14.67	22.00
p-value		≤ 0.05	≤ 0.05	≤ 0.05
Mereytoi-50				
40	80	84.03	17.33	25.67
55	110	83.60	19.00	28.00
70	130	84.33	21.33	32.00
p-value		≤ 0.05	≤ 0.05	≤ 0.05
KV-2/9				
40	80	63.60	17.00	30.50
55	110	63.43	20.33	32.00
70	130	62.67	23.00	36.33
p-value		≤ 0.05	≤ 0.05	≤ 0.05
July				
40	80	58.30	13	18.00
55	110	64.20	12	20.05
70	130	64.00	15	24.00
p-value		≤ 0.05	≤ 0.05	≤ 0.05
Akdidar				
40	80	55.60	10.00	21.00
55	110	61.39	13.00	23.00
70	130	64.52	15.44	22.00
p-value		≤ 0.05	≤ 0.05	≤ 0.05

Table 6. Overwintering indicators and productivity elements when pruning grape shoots of different lengths (medium. for 2022-2024).

Length of pruning of fruit vines	The degree of overwintering (%)	Fruiting shoots per bush	Number of inflorescences (pcs. bush^{-1})
Hungarian Muscat (st)			
4 eyes	59.47	9.0	19.0
8 eyes	60.40	10.7	20.0
12 eyes	57.30	13.7	19.3
p-value	≤ 0.05	≤ 0.05	≤ 0.05
Mereytoi-50			
4 eyes	84.87	16.7	26.3
8 eyes	86.23	18.3	29.7
12 eyes	83.20	19.3	29.7
p-value	≤ 0.05	≤ 0.05	≤ 0.05
KV-2/9			
4 reyes	66.63	17.7	30.3
8 eyes	68.10	19.3	34.3
12 eyes	64.20	21.0	32.3
p-value	≤ 0.05	≤ 0.05	≤ 0.05
July			
4 reyes	58.3	13	18.00
8 eyes	64.2	12	20.05
12 eyes	64.0	15	24.00
p-value	≤ 0.05	≤ 0.05	≤ 0.05
Akdidar			
4 eyes	55.60	10.00	21
8 eyes	61.39	13.00	23
12 eyes	64.52	15.44	22
p-value	≤ 0.05	≤ 0.05	≤ 0.05

CONCLUSION

The best degree of overwintering has been noted. The percentage of resistance to winter conditions ranged from 50.7% (hybrid DX-17/90) to 83.77% (variety Mereitoy-50). More than 70% of winter hardiness was demonstrated by the following varieties and hybrids: Mereitoy-50 (83.8%), Azim (75.2%), DV-10/11 (74.0%) and Aisulu (72.9%). The control variety Muscat Hungarian (st) showed 59.6%, KII-1/29 (51.7%), and DX-17/90 (50.7%).

In terms of yield (c ha^{-1}): the highest indicators were demonstrated by the hybrid KV-2/9 (191.87 c ha^{-1}), DV-10/11 (174.03 c ha^{-1}), DV-7/17 (173.33 c ha^{-1}), as well as varieties Azim (174.1 c ha^{-1}), Aisulu (170.3 c ha^{-1}) and Mereitoy-50 (162.2 c ha^{-1}). The lowest yields were recorded for the Muscat Hungarian variety (st) at 102.23 c ha^{-1}, the Kara Koz variety at 98.53 c ha^{-1}, and the DX-17/90 hybrid at 96.3 c ha^{-1}. These data confirm the differences in yield potential between the varieties.

According to the complex of economic and value-added characteristics, the varieties and hybrid forms of grapes are divided as follows: Mereytoy-50, Aisulu, Azim, Akdidar, KV-2/9, DV-7/17, and DV-10/11.

The obtained results confirm the presence of a genetic basis for resistance to *Oidium* and mildew in a number of Kazakhstani grape varieties and hybrids. Particularly valuable genotypes, such as Muscat Hungarian, Tayfi Pink, DV-10/11, and KV-2/9, possess stable alleles at multiple loci, significantly enhancing the stability of the trait and reducing the risk of its loss in subsequent generations. The identification of resistance in hybrids (e.g., DV-10/11, and KII-1/29) also confirms the effective transmission of resistance from the parent forms (particularly from Tayfi Pink and Zhemchug Saba).

The absence of positive alleles at the Rpv12 locus in all the samples studied indicates a lack of genetic diversity in the material used for this locus and highlights the need to expand the gene pool by including additional sources of resistance, such as introduced forms or wild species.

In general, the analysis of overwintering indicators and elements of grape productivity showed that the most viable and productive eyes of the Mereita-50 variety and the KV-2/9 hybrid are located in the lower and middle parts of the vine, on 4-8 eyes, while those of the Muscat Hungarian variety (st) are mostly located in the middle part (on 8-9 eyes). Good results were also obtained with long pruning.

REFERENCES

Abayeva, AD, Kairova, GN, Kaz ybayeva, SZ, Urazayeva, MV & Abayeva, KT 2019, Improving the cultivation technology of Aport apple trees based on a complex of biological and agrotechnical innovations. *Eurasian Journal of Biosciences*, 13.

Aubakirova, K, Omasheva, M, Ryabushkina, N, Tazhibaev, T, Kampitova, G & Galiakparov, N 2014, Evaluation of five protocols for DNA extraction from leaves of Malus sieversii, Vitis vinifera and Armeniaca vulgaris. *Genetics and Molecular Research*, 13:1278–1287.

Baghdasaryan, Z, Babajanyan, A, Friedman, B & Lee, K 2023, Characterization of interaction phenomena of electromagnetic waves with metamaterials via microwave near-field visualization technique. *Scientific Reports*, 13:18457.

Baltazar, M, Castro, I & Goncalves, B 2025, Adaptation to climate change in viticulture: the role of varietal selection—A review. *Plants*, 14:104.

Barata, A, Campo, E, Malfeito-Ferreira, M, Loureiro, V, Cacho, J & Ferreira, V 2011, Analytical and sensorial characterization of the aroma of wines produced with sour rotten grapes using GC–O and GC–MS: identification of key aroma compounds. *Journal of Agricultural and Food Chemistry*, 59:2543–2553.

Bhattarai, G, Fennell, A, Londo, JP, Coleman, C & Kovacs, LG 2021, A novel grape downy mildew resistance locus from Vitis rupestris. *American Journal of Enology and Viticulture, 72:12–20*.

Bonello, F, Danieli, F, Ragkousi, V, Ferrandino, A, Petrozz iello, M, Asproudi, A, La Notte, P, Pirolo, CS & Roseti, V 2024, Aromatic profiling of new table grape varieties using gas chromatography/mass spectrometry and olfactometry. *Plants*, 13:1820.

Bove, F & Rossi, V 2020, Components of partial resistance to Plasmopara viticola enable complete phenotypic characterization of grapevine varieties. *Scientific Reports*, 10:585.

Calderón, L, Van Houten, S, Muñoz, C, Oroño, T, Bree, L, Bergamin, D, Sola, C, Segura, D, Carrillo, N & Gómez-Talquenca, S 2025, Natural genetic variation for fruit set rate within Malbec grapevine (Vitis vinifera L.) clones. *BMC Plant Biology*, 25:606.

Casanova-Gascón, J, Ferrer-Martín, C, Bernad-Eustaquio, A, Elbaile-Mur, A, Ayuso-Rodríguez, JM, Torres-Sánchez, S, Jarne-Casasús, A & Martín-Ramos, P 2019, Behavior of vine varieties resistant to fungal diseases in the Somontano region. *Agronomy*, 9:738.

Eisenmann, B, Czemmel, S, Ziegler, T, Buchholz, G, Kortekamp, A, Trapp, O, Rausch, T, Dry, I & Bogs, J 2019, Rpv3–1 mediated resistance to grapevine downy mildew is associated with specific host transcriptional responses and the accumulation of stilbenes. *BMC Plant Biology*, 19:343.

Food and Agriculture Organization of the United Nations 2020, World Food and Agriculture – Statistical Yearbook 2020. *FAO*, Rome, Italy.

Guguchkina, T, Antonenko, M & Yakimenko, Y 2020, New grape varieties for production of high-quality wines, and assessment methodology for varietal characteristics of the product. *BIO Web of Conferences*, 02016.

Ji, X, Shi, M, Liu, F, Wang, X, Wang, Z & Wang, H 2025, Mapping and identification of QTLs for low light tolerance traits in grapevine. *BMC Plant Biology*, 25:927.

Krishankumar, S, Hunter, JJ, Alyafei, M, Hamed, F, Subramaniam, S, Ramlal, A, Kurup, SS & Amiri, KM 2025, Physiological, biochemical and elemental responses of grafted grapevines under drought stress: insights into tolerance mechanisms. *BMC Plant Biology*, 25:385.

Lazarevsky, M 1963, Study of grape varieties. University Publishing House, Rostov-on-Don, Russia.

Maistrenko, A, Maistrenko, L, Duran, N & Matveeva, N 2020, Ampelographic description, ampelometric screening and agrobiological characteristics of the Donus grape variety. *E3S Web of Conferences*, 05008.

McRae, AG, Taneja, J, Yee, K, Shi, X, Haridas, S, Labutti, K, Singan, V, Grigoriev, IV & Wildermuth, MC 2023, Spray-induced gene silencing to identify powdery mildew gene targets and processes for powdery mildew control. *Molecular Plant Pathology*, 24:1168–1183.

Mustafayev, Z, Toletayev, A, Skorintseva, I & Aldazhanova, G 2023, Assessment of natural moisture availability of Turkestan Region of the Republic of Kazakhstan. *Indonesian Journal of Geography*, 55.

Pauquet, J, Bouquet, A, This, P & Adam-Blondon, AF 2001, Establishment of a local map of AFLP markers around the powdery mildew resistance gene Run1 in grapevine and assessment of their usefulness for marker-assisted selection. *Theoretical and Applied Genetics*, 103:1201–1210.

Peng, J, Wang, X, Wang, H, Li, X, Zhang, Q, Wang, M & Yan, J 2024, Advances in understanding grapevine downy mildew: from pathogen infection to disease management. *Molecular Plant Pathology*, 25:e13401.

Phenotypical French Grape Classification Institute 1999, Essai de classement des cépages français en écogéogroupes phénotypiques. *Journal International des Sciences de la Vigne et du Vin*, 33:105–110.

Reynolds, A 2017, The grapevine, viticulture, and winemaking: a brief introduction. In: Grapevine Viruses: *Molecular Biology, Diagnostics and Management*. Springer.

Sabir, FK, Sabir, A, Unal, S, Taytak, M, Kucukbasmaci, A & Bilgin, OF 2019, Postharvest quality extension of minimally processed table grapes by chitosan coating. *International Journal of Fruit Science*, 19:347–358.

Schwander, F, Eibach, R, Fechter, I, Hausmann, L, Zyprian, E & Töpfer, R 2012, Rpv10: a new locus from the Asian Vitis gene pool for pyramiding downy mildew resistance loci in grapevine. *Theoretical and Applied Genetics*, 124:163–176.

Töpfer, R & Trapp, O 2022, A cool climate perspective on grapevine breeding: climate change and sustainability are driving forces for changing varieties in a traditional market. *Theoretical and Applied Genetics*, 135:3947–3960.

Wang, Z, Wang, Y, Cao, X, Wu, D, Hui, M, Han, X, Yao, F, Li, Y, Li, H & Wang, H 2022, Screening and validation of SSR molecular markers for identification of downy mildew resistance in intraspecific hybrid F1 progeny (V. vinifera). *Horticulturae*, 8:706.

Wingerter, C, Eisenmann, B, Weber, P, Dry, I & Bogs, J 2021, Grapevine Rpv3-, Rpv10- and Rpv12-mediated defense responses against Plasmopara viticola and the impact of their deployment on fungicide use in viticulture. *BMC Plant Biology*, 21:470.

Yang, J, Martinson, TE & Liu, RH 2009, Phytochemical profiles and antioxidant activities of wine grapes. *Food Chemistry*, 116:332–339.

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