Chapter

# Biological Characteristics of Native Grape Cultivars of Crimean Region and Availability of Their Use in Breeding

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## Abstract

In the context of the global climate change, manifested in a rapid increase in environment temperature and a constant increase in freshwater deficiency, the problem of breeding new grapevine cultivars that would correspond to the present-day biosphere conditions emerged. The endurance of native cultivars to adverse soil and climatic conditions and their drought tolerance are of particular value in development of generative breeding. It is known that most of the Crimean native cultivars have a functionally female type of flower, low resistance to biotic environmental factors that affects the stability of fertilization, yield and directly depends on the climatic conditions of cultivation. The adaptive ability of Crimean native grape cultivars is possible to increase by method of hybridization. So, the specific objectives of the study include, definition of agrobiological parameters of native grape cultivars of Crimean region; assessment of vegetative and generative potential; calculation of the profitability of cultivation of Crimean native grape cultivars in comparison with the classic cultivars. The result of the research was the selection of genotypes from the group of native cultivars - traits donors and obtaining hybrids of the first generation, which are improved analogs of the Crimean native cultivars.

**Keywords:** cultivars, grapes, genotype, agrobiological parameters, resistance

## 1. Introduction

The introduction of varieties and hybrids with high stable yields, high quality products, resistant or tolerant to drought, low temperatures, the most aggressive pathogens and pests, low agricultural background is used in solving problems of resource conservation and environmental protection from destruction and pollution, contributes to the production of environmentally clean products [1–3].

In the process of evolution, native varieties of Crimea developed the properties to grow and produce good quality crops in the conditions of arid climate on poor rocky soils and on soils with a high level of salinity and liming [4, 5]. Changes of climate on our planet lead to the modification of adaptability of plants to the effects

of biotic and abiotic environmental factors [3, 5–7]. In its turn it is expressed in changes of phenology, agrobiology and crop quality parameters [8–11]. The adaptive ability of Crimean native grape cultivars is possible to increase by method of hybridization.

Selection program of grape varieties in the Institute "Magarach" is based on the study of the world gene pool and world trends [8, 12]. In this light, the creation of a new generation of grape varieties - analogues of the Crimean local varieties - highly productive and high quality, carrying genetic adaptability to environmental conditions, while possessing genetically determined signs of resistance to biotic and abiotic factors, is relevant for today. The study of the issue of grape plant resistance, development of practical breeding ways, the study of variability and heredity, the main economic-valuable traits allows us to eventually create and introduce adaptive grape varieties into the industry. New varieties should play an important role in ecologization of viticulture industry.

## 2. Materials and methods gene pool diversity investigation

The studies were carried out in the Laboratory of Generative and Clonal Selection All-Russian Research Institute of Viticulture and Winemaking "Magarach" on the experimental fields of the Ampelographic Collection Magarach at village of Vilino, Bakhchisarai district, Crimea (44°51′14.8"N 33°38′58.1″E). The area is characterized moderately warm, semi-humid climate: an average annual air temperature of 12,1°C, the sum of active temperatures (above 10 °C) – 3650 - 3680 °C, the number of days with a temperature above 10°C – 197-209, the annual amount of precipitation –380-450 mm. Each cultivar was represented by 10 bushes. Planting scheme of grape plants was 3.0 x 1.5m. Forming –2branch cordon. Grape plants were grafted to the rootstock Kober 5BB. The age of the vineyards is more than 30 years. Agricultural technology system of the ampelographic collection was in accordance with the technological map adopted for each cultivar in the area. The study included native grape varieties of Crimea, related to the direction of use in three groups: wine, table-wine and table.

Assessment of agrobiological and phonological traits was conducted according to the method of Lazarevsky [13] and to the standard OIV method [14]. In short, for each genotype the following trait were recorded: number of latent buds, number of developed shoots, number of fertile shoots, number of inflorescence, number of bunches, average bunch weight (g) and yield per plant (kg). Phytopathological field evaluation was conducted by the examination of untreated plants against a natural infection pressure. In each season, two counts were carried out: the first - after flowering of grapes, the second - at the beginning of grape ripening. The nature and percentage of damage of leaves were scored according to the recommended method [14]. Precisely, on each counting bush up to 30 leaves were evaluated from both sides for signs of infestations. The percentage of affected leaves and the degree of disease development on the leaf were determined using a scale:

- 0—no signs of infestation;
- 1—single, hardly visible spots on leaves (OIV resistance – 9 point);
- 2—up to 10% of leaf surface is affected (OIV resistance – 7 point);
- 3—11-25% of leaf surface is affected (OIV resistance – 5 point);

- 4—26-50% of leaf surface is affected (OIV resistance – 3 point);
- 5—more than 50% of leaf surface is affected (OIV resistance – 1 point).

The study used a laboratory method for testing of frost resistance based on the methodology Chernomorets [15] with some modernization [16].

The data was mathematically processed with the help of statistical software package SPSS Statistics 10.0.

## 3. Agrobiological and economic assessment of Crimean native grape varieties

The study includes the number of 11 native grape varieties of Crimea and 2control varieties 'Cabernet Sauvignon 'and 'Rkatsiteli'. The study of varieties was carried out with 10 registered bushes in each study in the period of 2010–2012.

The degree of agrobiological characteristics of the variety depends on climatic conditions in the area of cultivation. Taking into consideration the fact that most of the native varieties of Crimea have a functionally female type of flower, weather conditions (in particular, precipitation, strong winds during the blossom period) influenced the processes of inflorescences, formation and berry-filling and, as a result, the mass of bunches and the yield in general.

The beginning of sap flow period was observed from the third decade of March to the first decade of April (**Table 1**).

On average, the beginning of budding was observed from 23 to 26 of April. In 2012 this parameter shifted by 3–4 days in the direction of earlier dates. The earliest bud pushing is the characteristic of the varieties 'Krona', 'Sary Pandas', 'Kok Pandas' and the control variety 'Rkatsiteli'. Blooming in this zone begins after 42–47 days

| Variety | Beginning of bud pushing, date | Beginning of blooming, date | Beginning of berries ripening, date | Industrial ripeness, date | Production period, date |
|---|---|---|---|---|---|
| Kefesiya | 24.04 | 7.06 | 8.08 | 18.09 | 146 |
| Gevat Kara | 26.04 | 7.06 | 9.08 | 16.09 | 145 |
| Krona | 23.04 | 3.06 | 6.08 | 17.09 | 146 |
| Ekim Kara | 24.04 | 7.06 | 8.08 | 18.09 | 147 |
| Cabernet Sauvignon (c) | 25.04 | 9.06 | 8.08 | 19.09 | 147 |
| Kapselski Belyi | 24.04 | 6.06 | 7.08 | 18.09 | 147 |
| Sary Pandas | 22.04 | 4.06 | 9.08 | 15.09 | 146 |
| Solnechnodolinskii | 24.04 | 5.06 | 7.08 | 17.09 | 143 |
| Kok Pandas | 23.04 | 4.06 | 5.08 | 15.09 | 146 |
| Soldaiya | 24.04 | 6.06 | 7.08 | 16.09 | 145 |
| Shabash | 23.04 | 6.06 | 6.08 | 18.09 | 148 |
| Kokur Belyi | 24.04 | 5.06 | 4.08 | 14.09 | 145 |
| Rkatsiteli (c) | 23.04 | 5.06 | 6.08 | 15.09 | 145 |

**Table 1.**
*Transit of the main phenological phases in native grape varieties.*

from 3 to 9 of June. The group of early flowering includes varieties 'Krona', 'Kok Pandas' and 'Sary Pandas'. The varieties 'Kefesiya', 'Gevat Kara', 'Ekim Kara' and 'Cabernet Sauvignon' (c) are characterized by late flowering. It is necessary to note that 'Solnechnodolinskii' and 'Kokur Belyi' varieties, prone to late budding, entered the flowering phase early. The ripening of berries in studied and control varieties usually occurs after two months, about 59–64 days. The earliest softening of berries is observed in 'Kokur Belyi' variety and occurs on average over the years of study on August, 4; the latest - in the variety 'Sary Pandas'. The earliest coloring of berries begins in 'Krona' variety, latest – 'Gevat Kara'. The onset of industrial ripeness in white varieties is observed the earliest in 'Kokur Belyi' variety (September, 14), the latest in 'Kapselski Belyi' (September, 18). Speaking of the black varieties, the earliest in this group was 'Gevat Kara' (September, 16), the latest was 'Cabernet Sauvignon' (c). On average, the industrial ripeness of the studied varieties practically did not differ and was observed from 14 to 19 of September.

The variety 'Solnechnodolinskii' has the shortest production period of 143 days, and variety 'Shabash' has the longest one of 148 days.

For the period of study, the load of eyes on the bush was distributed as follows: the smallest number was observed in the varieties 'Kefesiya' and 'Ekim Kara', and the biggest - in the variety 'Kokur Belyi' (**Table 2**). The largest percentage of vigorous shoots was observed in the varieties 'Shabash', 'Kapselski Belyi', 'Kokur Belyi', 'Ekim Kara' with share exceeding 90%.

In the variety 'Solnechnodolinskii' the proportion of sterile fruitless shoots does not exceed 50%. Varieties 'Kefesiya', 'Krona', 'Soldaiya', 'Ekim Kara' are characterized by a low number of fruit-bearing shoots – 50-60%. In other native grape

| Variety | Bush loading of | | | Coefficient of | |
|---|---|---|---|---|---|
| | eyes, pcs. | shoots, % | | fruiting, C1 | fertility, C2 |
| | | vigorous | fruit-bearing | | |
| Grape varieties with black berry | | | | | |
| Kefesiya | 14.0 | 82.4 | 53.3 | 0.66 | 1.02 |
| Ekim Kara | 14.5 | 91.8 | 61.2 | 0.67 | 1.00 |
| Gevat Kara | 19.7 | 86.8 | 73.3 | 0.94 | 1.11 |
| Krona | 20.3 | 91.8 | 58.1 | 0.64 | 1.01 |
| Cabernet Sauvignon (c) | 19.5 | 82.9 | 75.7 | 0.95 | 1.04 |
| LSD05 | 2.6 | 21.9 | 21.1 | 0.17 | 0.03 |
| Grape varieties with white berry | | | | | |
| Kapselski Belyi | 24.0 | 95.2 | 71.7 | 0.79 | 1.05 |
| Solnechnodolinskii | 22.3 | 93.5 | 46.6 | 0.51 | 1.02 |
| Sary Pandas | 25.7 | 88.5 | 76.7 | 0.88 | 1.02 |
| Kok Pandas | 25.0 | 88.4 | 70.7 | 0.81 | 1.01 |
| Kokur Belyi | 29.0 | 94.0 | 75.2 | 0.97 | 1.21 |
| Shabash | 24.9 | 98.7 | 79.9 | 0.89 | 1.10 |
| Soldaiya | 22.3 | 85.2 | 58.9 | 0.69 | 1.00 |
| Rkatsiteli (c) | 21.0 | 89.6 | 77.4 | 0.92 | 1.06 |
| LSD05 | 1.9 | 8.9 | 11.5 | 0.19 | 0.02 |

**Table 2.**
*Agrobiological parameters of grape varieties under study.*

varieties the parameters of growth of fruit-bearing shoots do not differ significantly from the control varieties and range from 70 to 80%. The highest fruiting coefficient (C1), approaching the one, had 'Kokur Belyi' and 'Cabernet Sauvignon'. According to the parameter of fruit fertility coefficient (C2) the control variety 'Kokur Belyi' (1.21) significantly differs from the whole group of varieties. Crimean native varieties 'Gevat Kara', 'Shabash' have significant differences in this parameter with the control varieties 'Cabernet Sauvignon' and 'Rkatsiteli'. The highest values of fruiting and fertility coefficients belong to the varieties 'Gevat Kara' (0.94; 1.11), 'Kokur Belyi' (0.97; 1.21). Over the period of study the values of shoot productivity were determined (**Table 3**).

According to the scale of productivity of grape varieties it was established that its level by the parameter of wet raw bunch weight in varieties 'Gevat Kara', 'Kokur Belyi' is characterized as average and do not significantly differ from the control, and in 'Korona' variety, the parameter of shoot productivity is very poor. Low level of shoot productivity in the range from 147 g/shoot to 75.5 g/shoot was noted in all other native varieties under study. The highest crop yield among the black-berried varieties belong to 'Gevat Kara' (62.2 centner/ha) and 'Cabernet Sauvignon' (58.7 centner/ha).

In the group of white-berried varieties the highest yield was observed in 'Kokur Belyi' variety (48.9 centner/ha). By the weight of the bunch, all the studied black-berried varieties are inferior to the control variety 'Cabernet Sauvignon' –176.9 g and variety 'Gevat Kara' –177.9 g. In the group of white-berried varieties the 'Kapselski Belyi', 'Solnechnodolinskii', 'Kokur Belyi' and 'Rkatsiteli' varieties do not differ from the average weight of the bunch. During the onset

| Variety | Average weight of the bunch, g | Mass concentration of | | Crop yield, centner/ha | Index of productivity, g/shoot |
|---|---|---|---|---|---|
| | | sugars, Brix | titratable acids, g $L^{-1}$ | | |
| Grape varieties with black berry | | | | | |
| Kefesiya | 133.9 | 22.0 | 8.4 | 22.2 | 88.4 |
| Ekim Kara | 112.7 | 21.0 | 8.4 | 22.2 | 75.5 |
| Gevat Kara | 177.9 | 21.5 | 8.4 | 62.2 | 167.2 |
| Krona | 109.7 | 22.1 | 7.5 | 28.9 | 70.2 |
| Cabernet Sauvignon (c) | 176.9 | 20.6 | 9.7 | 58.7 | 168.1 |
| LSD05 | 22.8 | 1.05 | 1.14 | 1.3 | 18.2 |
| Grape varieties with white berry | | | | | |
| Kapselski Belyi | 186.2 | 22.5 | 6.8 | 44.4 | 147.1 |
| Solnechnodolinskii | 173.5 | 22.0 | 7.5 | 40.0 | 88.1 |
| Sary Pandas | 125.4 | 22.5 | 6.8 | 28.9 | 110.4 |
| Kok Pandas | 112.9 | 22.4 | 7.0 | 24.4 | 91.4 |
| Kokur Belyi | 185.6 | 22.1 | 7.7 | 48.9 | 180.0 |
| Shabash | 154.3 | 19.7 | 10.2 | 37.8 | 137.3 |
| Soldaiya | 167.0 | 22.2 | 7.4 | 37.8 | 115.2 |
| Rkatsiteli (c) | 187.9 | 20.0 | 10.0 | 44.4 | 172.9 |
| LSD05 | 14.5 | 0.74 | 0.94 | 2.6 | 17.3 |

**Table 3.**
*Productivity and grape quality of varieties under study.*

of technological ripeness, with almost same mass concentration of sugars from 20.6 to 22.1 g $L^{-1}$, the content of titratable acids significantly decreases from 7.5 to 8.4 g $L^{-1}$ in black varieties compared to the control (9.7 g $L^{-1}$). In white-berried varieties the sugar content significantly exceeded their concentration in the control variety 'Rkatsiteli' (20.0 Brix), excluding 'Shabash' variety (19.7 Brix). The higher the parameter of the structure (the ratio of the weight of berries to the weight of the stems), the higher the economic value of the variety. To determine this parameter during the study period, the mechanical composition of the crop was studied (**Table 4**).

The smallest proportion of the stem weight in the bunch was observed in the varieties 'Kefesiya' and 'Gevat Kara', the biggest in the varieties 'Ekim Kara' and 'Kok Pandas'. The seeds in the structure of bunch had different quantity and weight, reflected in the percentage of the mechanical composition. It should be noted that Crimean native white-berried grape varieties have low seed weight. According to the parameter of skin weight, following groups may be distinguished: with the lowest value up to 4 percent of the content in the bunch: 'Kapselski Belyi', 'Shabash', 'Soldaiya', 'Kok Pandas'. The highest value of this parameter is observed in the varieties 'Kokur Belyi' and 'Rkatsiteli'. Content of pulp and juice in berries differs by variety: from 82.6 to 91.6%. The highest content of pulp and juice in berries was observed in 'Kapselski Belyi' variety. The highest structural parameter was observed in varieties 'Kefesiya' – 46.7.

Main parameters characterizing the economic value of the variety are: crop yield, cost of production, net income of the product obtained, and level of production profitability. According to the indexed calculation of the above parameters, all native varieties are profitable (**Table 5**).

Due to the low yield and high net cost of the cultivated grapes the varieties 'Ekim Kara' and 'Kefesiya' have a low profitability. The most profitable varieties are 'Gevat Kara' – 273.1%, 'Kokur Belyi' – 144.6%, 'Kapselski Belyi' – 122.0%.

| Variety | Weight of | | | | Parameter of structure |
|---|---|---|---|---|---|
| | stem, % | seeds, % | skin, % | pulp and juice, % | |
| Kefesiya | 2.1 | 5.2 | 7.9 | 84.8 | 46.7 |
| Gevat Kara | 2.9 | 5.8 | 7.0 | 84.3 | 33.4 |
| Ekim Kara | 4.3 | 4.6 | 6.0 | 85.1 | 22.3 |
| Krona | 3.0 | 5.1 | 7.5 | 84.4 | 32.2 |
| Cabernet Sauvignon (c) | 3.8 | 5.9 | 7.7 | 82.6 | 25.2 |
| Kapselski Belyi | 3.0 | 2.0 | 3.4 | 91.6 | 31.8 |
| Solnechnodolinskii | 3.9 | 3.3 | 6.8 | 86.0 | 246 |
| Sary Pandas | 3.5 | 3.5 | 5.1 | 87.9 | 27.5 |
| Kok Pandas | 4.7 | 3.2 | 4.0 | 88.1 | 20.2 |
| Soldaiya | 3.8 | 1.8 | 3.9 | 90.5 | 25.2 |
| Kokur Belyi | 3.4 | 2.3 | 10.0 | 91.0 | 28.4 |
| Shabash | 3.0 | 3.6 | 3.5 | 89.9 | 32.3 |
| Rkatsiteli (c) | 3.8 | 6.8 | 10.9 | 78.4 | 25.1 |

**Table 4.**
*Mechanical composition of bunches of varieties under study.*

| Variety | Crop yield, centner/ha | Cost of production of 1c, RUB. | Net income of 1c, RUB. | Profitability of production, % |
|---|---|---|---|---|
| Kefesiya | 22.2 | 2252 | 748 | 33.2 |
| Ekim Kara | 22.2 | 2252 | 748 | 33.2 |
| Gevat Kara | 62.2 | 804 | 2196 | 273.1 |
| Krona | 28.9 | 1730 | 1270 | 73.4 |
| Cabernet Sauvignon (c) | 60.0 | 833 | 1167 | 140.1 |
| Kapselski Belyi | 44.4 | 1126 | 1374 | 122.0 |
| Solnechnodolinskii | 40.0 | 1250 | 1250 | 100.0 |
| Sary Pandas | 28.9 | 1730 | 770 | 44.5 |
| Kok Pandas | 24.4 | 2049 | 451 | 22.0 |
| Kokur Belyi | 48.9 | 1022 | 1478 | 144.6 |
| Shabash | 37.8 | 1323 | 1177 | 88.9 |
| Soldaiya | 37.8 | 1323 | 1177 | 88.9 |
| Rkatsiteli (c) | 44.4 | 1126 | 674 | 59.9 |

**Table 5.**
*Economic effectiveness of cultivation of native grape varieties of Crimea.*

## 4. Variability of crossbreeding of Crimean native grape varieties

Previous studies have determined advisable parameters for assessment of the effectiveness of hybridization of grapes [17–19]. Broadly speaking, the analysis of the effectiveness of hybridization includes an assessment of the crossing ability of the initial forms, risk of loss of a valuable genotype and combination ability, heterosis and transgression [20]. For practical work following evaluation parameters are used:

- setting ability of seeds during self-pollination and cross pollination;
- effectiveness of pollination;
- biological effectiveness of hybridization;
- breeding effectiveness of hybridization.

Setting ability of seeds is estimated as a ratio of the number of seeds to the number of inflorescences taken into consideration [20, 21]. The pollination efficiency expresses the yielding of seeds relative to the theoretically possible number of seeds from all pollinated inflorescences of a particular cross-combination. Biological efficiency of hybridization reflects the efficiency of pollination, vitality and germinating ability of seeds, survival rate of seedlings in a hybrid nursery-garden, the yield of seedlings. Breeding efficiency of hybridization reflects the efficiency of pollination, the vitality and germination of seeds, survival rate of seedlings in a hybrid nursery-garden, the total yield of seedlings and the yield of economically valuable hybrids and may be used as a final assessment of the efficiency of hybridization, but it is somewhat subjective. 142 combinations of crossing of intraspecific and interspecific hybridization performed in the period 2005–2019 were analyzed

| Female form | Number of inflorescences | Number of berries formed | Seeds total | Number of seeds per cross-combination | Total of yearlings | Number of seedlings per 1 cross-combination |
|---|---|---|---|---|---|---|
| ♀ Aibatly | 26 | 249 | 325 | 23.2 | 227 | 16.2 |
| ♀ Kefesiya | 48 | 2873 | 4775 | 227.4 | 1917 | 91.3 |
| ♀ Krona | 29 | 663 | 847 | 60.5 | 379 | 27.1 |
| ♀ Kok Pandas | 90 | 3688 | 6093 | 196.5 | 1636 | 52.8 |
| ♀ Sary Pandas | 91 | 2468 | 3605 | 112.7 | 1466 | 45.8 |
| ♀ Tashly | 32 | 1176 | 2566 | 285.1 | 947 | 105.2 |
| ♀ Khersonesskii | 22 | 137 | 151 | 16.8 | 65 | 7.2 |
| ♀ Kokur Chernyi | 9 | 300 | 364 | 91.0 | 33 | 8.3 |
| ♀ Misgiuli Kara | 11 | 555 | 626 | 156.5 | 157 | 39.3 |
| ♀ Misket | 9 | 243 | 295 | 73.8 | 104 | 26.0 |
| Total | 367 | 12352 | 19647 | | 6931 | |

**Table 6.**
*The results of hybridization 2005–2018.*

(**Table 6**). The study included: as female forms - 10 native varieties of Crimea with a functional female type of flower; as male forms - the pollen of 25 complex interspecific hybrids, 7 varieties of the West European ecological-geographical group and 9 native varieties of the Don were used.

The selection of female forms was carried out on the basis of a complex analysis of prospects of the variety (productivity, crop quality). Since the formation of berries (and setting of seeds) carries the nature of biological features of original female variety and depends on the male form to a small extent [18, 22], it is important to study these parameters in native varieties and distinguish those with the maximum potential for reproduction.

The number of 19647 seeds and 6931 yearlings were obtained as a result of hybridization during pollination of 367 inflorescences. The biggest number of crossings was carried out with the participation of the female parents 'Sary Pandas' and 'Kok Pandas'. At the same time, the maximum number of seeds and hybrid seedlings per one cross-combination was obtained with the participation of the varieties 'Tashly' and 'Kefesiya'. Minimum number of seeds and hybrid seedlings per one combination of crossing was noted in the varieties 'Khersonesskiy' and 'Aibatly'. In combinations involving varieties 'Sary Pandas' and 'Kok Pandas', with the maximum number of inflorescences involved in hybridization, the percentage

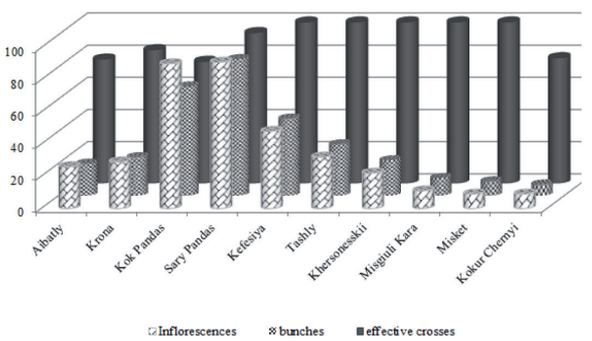


**Figure 1.**
*Crossing efficiency of native varieties of Crimea.*

of successful crossings was 93.4 and 75.6% respectively (**Figure 1**). Estimating the percentage of successful crosses, there is a tendency to its decrease with an increase in the number of cross-combinations (Pearson's pair correlation coefficient 0.9604).

Analysis of the results in the context of years showed that the most successful according to the parameters of crossbreeding were 2012 and 2016, and the least favorable were 2015 and 2018 (**Table 7**). Evaluating the variability of the parameter of setting ability of seeds in different years, it was noted that different varieties have high values, as presented in **Figure 2**.

From data presented in **Table 8** it follows that on average over the years of study maximum number of berries and seeds was obtained in cross-combinations involving 'Kok Pandas' variety. In different cross-combinations the female form of 'Kok Pandas' provides the biggest number of berries in one bunch – 62.0 pcs., by the number of fully formed seeds it has average value range - 1.25 pcs., but it still has the smallest fully formed seeds percentage of the total number- 66.7.

Varieties 'Khersonesskii' and 'Aibatly' form the smallest number of berries per one bunch of all studied grapevine cultivars – 5.8 and 8.3 pcs respectively. The number of fully formed seeds per one berry in combination with 'Aibatly' variety is quite high – 1.31 pcs. Combinations involving the varieties 'Kefesiya' and 'Tashly' provide a fairly high number of berries in one bunch – 59.1 and 48.1 pcs, the highest number of fully formed seeds per bunch is 1.59 and 1.77 pcs and the percentage of fully formed seeds is more than 90 of the total.

| Parameter | 2005 | 2012 | 2015 | 2016 | 2018 | 2019 | Total |
|---|---|---|---|---|---|---|---|
| Number of: | | | | | | | |
| experiments* | 8 | 4 | 3 | 6 | 4 | 8 | 33 |
| cross-combinations | 32 | 38 | 15 | 25 | 32 | 56 | 198 |
| inflorescences | 75 | 74 | 63 | 75 | 80 | 138 | 505 |
| seeds | 4311 | 5121 | 1303 | 7486 | 1428 | 3816 | 23465 |
| Setting ability of seeds: | | | | | | | |
| average | 49.6 | 68.9 | 21.3 | 107.1 | 32.4 | 43.4 | 53.8 |
| error of average | 15.59 | 11.41 | 5.51 | 22.24 | 8.65 | 11.1 | 12.4 |
| standard deviation | 85.38 | 70.33 | 21.35 | 106.64 | 37.72 | 38.44 | 60.0 |
| range of variation | 435 | 272 | 73 | 319 | 161 | 136 | 233 |

**- number of experiments is equal to the number of female varieties involved in hybridization.*

**Table 7.**
*Setting ability of seeds in different years of study.*

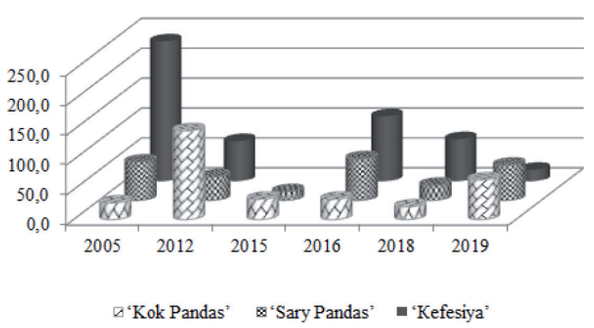


**Figure 2.**
*Changes in setting ability of seeds of 'Sary Pandas', 'Kok Pandas' and 'Kefesiya' grape varieties*

| Female form | Number of berries | | Number of seeds | | | Fully formed seeds, % of the total number |
|---|---|---|---|---|---|---|
| | total | per one bunch | total | fully formed | fully formed per one berry | |
| ♀ Aibatly | 249 | 8,3 | 325 | 313 | 1.31 | 83.0 |
| ♀ Kefesiya | 2873 | 59.1 | 4775 | 4486 | 1.59 | 95.6 |
| ♀ Krona | 663 | 23.9 | 847 | 779 | 1.19 | 84.8 |
| ♀ Кок Pandas | 3688 | 62.0 | 6093 | 4421 | 1.15 | 66.7 |
| ♀ Sary Pandas | 2468 | 26.8 | 3605 | 3130 | 1.25 | 83.5 |
| ♀ Tashly | 1176 | 48.1 | 2566 | 2408 | 1.77 | 93.7 |
| ♀ Khersonesskii | 137 | 5.8 | 151 | 122 | 0.79 | 75.6 |
| ♀ Kokur Chernyi | 300 | 22.1 | 364 | 347 | 0.96 | 84.4 |
| ♀ Misgiuli Kara | 555 | 40.9 | 626 | 564 | 0.93 | 80.6 |
| ♀ Misket | 243 | 21.0 | 295 | 276 | 0.80 | 72.0 |
| Average value | 1235 | 32 | 1965 | 1685 | 1.00 | 82.0 |
| Coefficient of variation | 104.7 | 62.30 | 110.43 | 104.93 | 27.62 | 10.88 |
| Percentage error of average | 33.1 | 19.70 | 34.92 | 33.18 | 8.73 | 3.44 |
| Confidence range (+/–) | 801.5 | 12.28 | 1344.7 | 1095.6 | 0.20 | 5.53 |

**Table 8.**
*Viability of hybrid seeds.*

Germination of seeds depends on hereditary strength, consisting in the fact that the necessary tissues and organs are formed and matured to ensure germination in appropriate conditions. Obtaining of seeds of low viability is determined by the female genotype long before the pollination [18, 22, 23].

Considering the parameters of seed germination with the participation of various native varieties, high data variability is noted (**Table 9**).

So in the cross-combinations with the participation of 'Aibatly' and 'Khersonesskii' varieties, the average number of seedlings per one cross-combination has a very low level - 7.2-16.2 pcs. Moreover, the seedlings obtained from fully formed seeds amount a very high percentage - more than 60.

In the total selection of the studied varieties, the female form 'Tashly' stands out, as it provides in hybridization the maximum number of seedlings per 1 combination of crossing, more than 100 pcs. The average percentage of seedlings obtained from full seeds is very low – 30.7 and the maximum level is 48%. The maximum variability of parameters of seed viability was noted in varieties 'Kok Pandas' and 'Sary Pandas'. Further, during the analysis of data for practical determination of the effectiveness of hybridization, we dwelt on the definition of 3 complex parameters: seeds setting; pollination efficiency; biological effectiveness of hybridization. **Table 10** presents these parameters in numerical terms, specific for the group of varieties under study and showing the range of variation of these parameters.

Analyzing the clustering results of the studied group of autochthonous varieties (**Figure 3**), we see that the varieties divided into 2 separate clusters: I – group,

| Female form | Total yearlings | Number of seedlings per one cross-combination | Seedlings, % of fully formed seeds | |
|---|---|---|---|---|
| | | | average (x) | limits (x max – x min) |
| ♀ Aibatly | 227 | 16.2 | 64.0 | 16.6–100.0 |
| ♀ Kefesiya | 1917 | 91.3 | 51.6 | 9.1–70.0 |
| ♀ Krona | 379 | 27.1 | 51.2 | 28.7–88.5 |
| ♀ Кок Pandas | 1636 | 52.8 | 42.3 | 2.6–100.0 |
| ♀ Sary Pandas | 1466 | 45.8 | 48.0 | 1.5–93.8 |
| ♀ Tashly | 947 | 105.2 | 30.7 | 4.2–48.0 |
| ♀ Khersonesskii | 65 | 7.2 | 60.8 | 40.0–100.0 |
| ♀ Kokur Chernyi | 33 | 8.3 | 21.9 | 5.6–38.1 |
| ♀ Misgiuli Kara | 157 | 39.3 | 30.9 | 23.7–36.2 |
| ♀ Misket | 104 | 26.0 | 48.3 | 36.1–58.8 |

**Table 9.**
*Variability of parameter "germination of seeds".*

| Female form | Setting of seeds | Pollination efficiency | Biological effectiveness of hybridization |
|---|---|---|---|
| ♀ Aibatly | 14.4 ± 7.76<br>40.5 | 0.0002<br>0.0005 | 0.0001<br>0.0003 |
| ♀ Kefesiya | 101.1 ± 45.10<br>436.0 | 0.0009<br>0.003 | 0.0004<br>0.001 |
| ♀ Krona | 32.1 ± 14.01<br>76.5 | 0.0005<br>0.001 | 0.0003<br>0.0006 |
| ♀ Кок Pandas | 97.9 ± 38.07<br>316.2 | 0.002<br>0.007 | 0.0007<br>0.003 |
| ♀ Sary Pandas | 39.0 ± 13.87<br>141.0 | 0.0009<br>0.003 | 0.0004<br>0.002 |
| ♀ Tashly | 106.0 ± 63.49<br>321.3 | 0.0006<br>0.002 | 0.0002<br>0.001 |
| ♀ Khersonesskii | 6.4 ± 3.37<br>14.3 | 0.0004<br>0.001 | 0.0002<br>0.001 |
| ♀ Kokur Chernyi | 35.2 ± 13.96<br>79.0 | 0.0006<br>0.0001 | 0.0001<br>0.00013 |
| ♀ Misgiuli Kara | 44.7 ± 31.12<br>97.8 | 0.001<br>0.003 | 0.0004<br>0.001 |
| ♀ Misket | 25.5 ± 12.84<br>91.0 | 0.0004<br>0.001 | 0.0002<br>0.0004 |
| Average of variants of crossing | 59.7 ± 13.82<br>436.0 | 0.0009<br>0.007 | 0.0004<br>0.003 |

*In denominator indicates the range of variation of the value.*

**Table 10.**
*Effectiveness of hybridization of native varieties.*

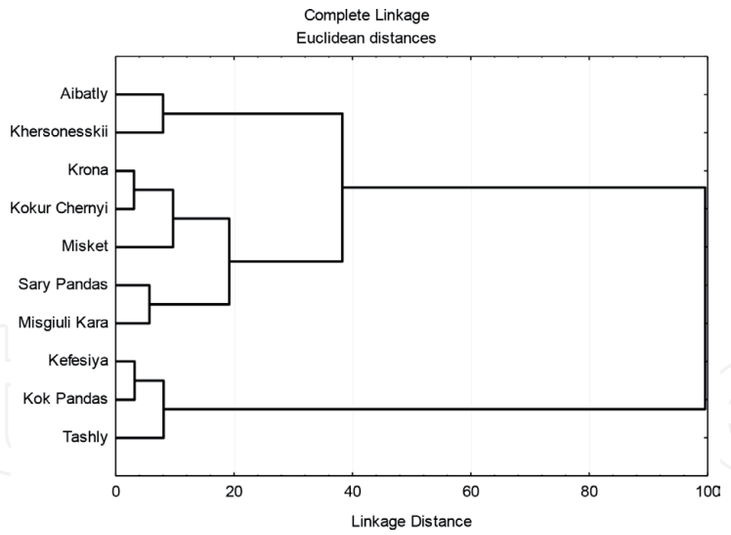


**Figure 3.**
*Multifactorial hierarchic classification of genotypes under study by the effectiveness of their hybridization.*

consisting of 3 varieties: 'Kok Pandas', 'Kefesiya' and separate variety 'Tashly';
II – group, including 7 varieties – divided into 2 big subclusters: a) varieties 'Aibatly' и 'Khersonesskii'; b) 'Krona', 'Kokur Chernyi' and separate varieties 'Sary Pandas', 'Misgiuli Kara' and 'Misket'.

A group of varieties including 'Kefesiya', 'Kok Pandas' and 'Tashly', was selected in the analysis and demonstrates high hybridization efficiency in intraspecific crossing and in crossing with complex interspecific hybrids. Varieties 'Sary Pandas' and 'Misgiuli Kara' are distinguished by low setting ability of seeds, however, the biological effectiveness of hybridization remains at the level of group 1. Thus, we can confirm that female parent varieties 'Sary Pandas' and 'Misgiuli Kara' are specific in issues of crossing ability and viability of hybrid seeds.

## 5. Features of breeding of grape genotypes resistant to oidium in crossing of Crimean native varieties with complex interspecific hybrids

Analysis of the laws of inheritance of resistance to oidium in hybrid progeny makes it possible to carry out scientific selection of initial forms for immunoselection programs realization. These objective laws are established on the basis of the study on a fixed infection background of representational material of hybrid populations obtained in the process of crossing of various parental forms with resistance to the pathogen. In different cross-combinations the variability of feature of oidium resistance was revealed.

A significant number of highly susceptible to oidium seedlings, up to 7%, was obtained in crossings with participation of varieties 'Sary Pandas' and 'Misgiuli Kara'. The biggest percentage rate of highly resistant seedlings (9 points) was recorded in the combination of 'Khersonesskii' x 'JS 26–205' (22%). Crossings of 'Kok Pandas' x 'Tsitronnyi Magaracha' (4.5 points), 'Kokur Chernyi' x 'Ifigenia' (4.3 points), 'Misket' x 'Ifigenia' (4.3 points), 'Muscat Jim' x 'Kokur Belyi' (4.5 points) mostly followed to the formation of medium-resistant to oidium forms. It should be noted that the average score of resistance to oidium in all populations was higher than in the initial Crimean native varieties.

The breeding value shows the possibility of distinction of highly-resistant, resistant and medium-resistant to oidium plants in hybrid population in the contrast to the sensitive Crimean native varieties. It was determined as the

| Cross-combination | | Breeding value, % | Coefficient of variation, % | Dominance degree, % | Heterosis hypothetic, % |
|---|---|---|---|---|---|
| **Magarach No. 31–77-10'** | **Gevat Kara** | **3.5** | **32.7** | **2.19** | **36.5** |
| Kok Pandas | Spartanets Magaracha | 0.0 | 33.1 | 0.76 | 30.3 |
| Muscat Jim | Shabash | 10.7 | 40.0 | 0.75 | 30.0 |
| Kefesiya | Spartanets Magaracha | 2.0 | 36.8 | 0.60 | 24.0 |
| Sary Pandas | Spartanets Magaracha | 7.8 | 37.1 | 0.38 | 15.1 |
| Misgiuli Kara | Spartanets Magaracha | 7.4 | 36.6 | 0.07 | 1.9 |
| Kokur Chernyi | Ifigenia | 0.0 | 37.2 | −0.26 | −6.5 |
| Misket | Ifigenia | 0.0 | 22.8 | −0.32 | −8.0 |
| Kok Pandas | Tsitronnyi Magaracha | 0.0 | 20.3 | −0.46 | −11.5 |
| Khersonesskii | JS 26–205 | 0.0 | 21.9 | −0.78 | −13.0 |
| Tashly | Krymchanin | 0.0 | 16.8 | −2.00 | −50.0 |

**Table 11.**
*Breeding characteristics of hybrid populations by oidium resistance.*

percentage of seedlings in populations with 5, 7 and 9 points of oidium resistance. Cross-combinations (**Table 11**) involving complex interspecific hybrids of varieties 'Muscat Jim', 'Spartanets Magaracha' and 'Magarach No. 31-77-10' had the highest breeding value. The most effective was the combination of 'Muscat Jim' x 'Shabash' with the yield of resistant and highly-resistant seedlings 10.7 percent. Degree of the dominance reflects the contribution of parent components to the variability of the trait. Negative values of the degree of dominance show that the deviation of the traits of resistance to oidium goes to the direction of more susceptible parental form. The degree of dominance shows that in 'Tashly' x 'Krymchanin' there is a hybrid depression, in the population of 'Kokur Chernyi' x 'Ifigeniya', 'Misket' x 'Ifigenia', 'Kok Pandas' x 'Tsitronnyi Magaracha', 'Khersonesskii' x 'JS 26–205' - there is a deviation to a more susceptible parent. In populations 'Kok Pandas' x 'Spartanets Magaracha', 'Muscat Jim' x 'Shabash', 'Kefesiya' x 'Spartanets Magaracha', 'Sary Pandas' x 'Spartanets Magaracha' - there is a slight dominance of more stable parent. Only in one population 'Magarach No. 31–77-10' x 'Gevat Kara' (2.19%) there was a deviation to a more stable parental form.

In populations with the participation of Crimean native varieties 'Misgiuli Kara', 'Sary Pandas', 'Kefesiya', 'Shabash', 'Kok Pandas', 'Gevat Kara' and 'Magarach No. 31-77-10' x 'Gevat Kara', hypothetic heterosis from 1.9 to 36.5 percent was noted. The transgressive recombinants were not observed in the studied combinations.

One of the main parameters characterizing the genetic potential of parental forms is the hereditability of breeding traits. The effectiveness of breeding selection in the studied populations is characterized by the parameter of hereditability of the trait, which is determined by the method of dispersion analysis of single-factor complexes. To calculate the hereditability indices, 13 single-factor complexes, including from 2 to 6 cross-combinations, were organized (**Table 12**). The lowest

| Variety | Number of seedlings in the complex, pcs | Average score of resistance to oidium in the complex | Parameter of the power of influence of the variety | Parameter of reliability of the influence of the variety | Standard values of the criterion of Fisher |
|---|---|---|---|---|---|
| Female forms | | | | | |
| Sary Pandas | 269 | 3.8 | 0.0 | 6.5 | {1.6–2.0 – 2.6} |
| Muscat Jim | 105 | 4.2 | 0.1 | 4.3 | {2.0–2.6 -3.4} |
| Kok Pandas | 81 | 3.9 | 0.0 | 3.1 | {1.7–2.0 – 2.7} |
| Magarach No. 31–77-10 | 131 | 4.1 | 0.1 | 2.5 | {1.6–2.0 – 2.6} |
| Misgiuli Kara | 139 | 3.7 | 0.0 | 1.6 | {1.6–2.0 – 2.6} |
| Kefesiya | 161 | 3.7 | 0.0 | 1.6 | {1.6–2.0 – 2.6} |
| Kokur Chernyi | 53 | 4.2 | 0.0 | 0.1 | {2.0–2.7 – 3.5} |
| Male forms | | | | | |
| Spartanets Magaracha | 249 | 4.4 | 0.1 | 7.7 | {1.6–2.0 – 2.6} |
| Ifigenia | 369 | 3.9 | 0.0 | 6.1 | {1.6–2.0 – 2.6} |
| Tsitronnyi Magaracha | 129 | 4.1 | 0.1 | 5.3 | {1.7–2.0 –2.6} |
| Gevat Kara | 111 | 3.8 | 0.0 | 5.1 | {1.7–2.0 – 2.7} |
| Shabash | 68 | 3.9 | 0.0 | 5.0 | {1.7–2.0 – 2.7} |
| Kokur Belyi | 57 | 3.7 | 0.0 | 0.1 | {1.7–2.0 – 2.7} |

**Table 12.**
*Dispersive parameter of inheritance of resistance to oidium.*

average score of 3.7 by the complex trait of resistance to oidium of Crimean native female forms possessed combinations of 'Kefesiya' and 'Misgiuli Kara' varieties, the highest - 'Kokur Chernyi' variety (4.2%), but the data presented for the last variety was not reliable (0.1). Inaccuracy did not indicate the absence of the influence of parents on genetic diversity of the progeny, but was explained by the limited number of seedlings in populations and small number of cross-combinations in some single-factor complexes. Average values of the remaining female forms did not exceed 4 points, and ranged in 3.8 points for 'Sary Pandas' variety and 3.9 points for 'Kok Pandas'. In crossbreeding complexes with Crimean natives, where interspecific varieties 'Muscat Jim' and 'Magarach No. 31-77-10' were used as female forms, the resistance to oidium was 4.2 and 4.1 points respectively. The highest resistance among the complexes of male forms was observed in the variety 'Spartanets Magaracha'.

For female varieties strength of the influence (0.1) of interspecific varieties 'Muscat Jim' and 'Magarach No. 31-77-10' on the inheritance of resistance to oidium of the progeny in crossing with Crimean natives is reliably confirmed. Values of this parameter, 4.3 and 2.5, indicate that usage of these varieties as female forms in crossing with Crimean native varieties will make it possible to obtain stable seedlings in F1 depending on the specific combining ability of the parental components. The dispersion complexes of the Crimean natives 'Sary Pandas', 'Kok Pandas', 'Migiuli Kara', 'Kefesiya' and 'Kokur Chernyi' are characterized by zero influence on the progeny's resistance to oidium, as confirmed by parameters of reliability. The use of these varieties as parental forms with various donors of resistance to oidium will not allow to obtain a significant number of resistant genotypes in F1.

It is established reliably that high proportion of genotypically determined inheritance of the trait of resistance to oidium is observed in crossing with male forms of interspecific origin 'Spartanets Magaracha', 'Tsitronnyi Magaracha'. In other words, these donors of oidium resistance, regardless the stability of another parental component, provide a high yield of oidium resistant forms in hybrid populations. Local varieties of Crimea 'Gevat Kara', 'Shabash' and 'Kokur Belyi' do not affect the oidium resistance of their progeny.

## 6. Frost resistance of Crimean native grape varieties and their hybrids

Determination of frost-resistant native varieties of Crimea to identify sources of relative frost resistance and selection to the elite of the most frost-resistant genotypes obtained by crossing of native varieties of Crimea and hybrid varieties of complex interspecific origin is a promising direction of breeding work. The research objectives included: assessment of frost resistance of native varieties of Crimea by laboratory methods; selection to the elite the most frost-resistant genotypes obtained as a result of hybridization of Crimean native grape varieties with the complex interspecific hybrids.

As a result of the study, the frost resistance of 15 original forms, local varieties of Crimea, was tested using the laboratory method of assessment (**Figure 4**). The least frost resistance among the studied parental forms, local varieties of Crimea, showed the varieties 'Shabash', 'Soldaiya' and 'Solnechnodolinskii'. The best frost resistance to minus 24°C among the analyzed local varieties of Crimea was shown by the varieties 'Khersonesskii' and 'Kapselski'.

The results of our researches correspond to the results of assessment of the reaction of 84 Crimean native grape varieties of the ampelographic collection of the Magarach Institute on the influence of extreme winter temperatures of 2006 (−22.5 °C) obtained by the field method. An assessment of the preservation of the main and base buds, as well as the analysis of regenerative ability of the bushes, allows us to divide the studied varieties by frost resistance into three groups:

- the first group of non-resistant grape varieties; loss of 100% of main buds; loss of 95–100% of base buds; includes 57 varieties: 'Kandavasta', 'Kozskiy Stolovyi'," Nasurla', 'Shabash' and others; recovery of bushes of the remaining

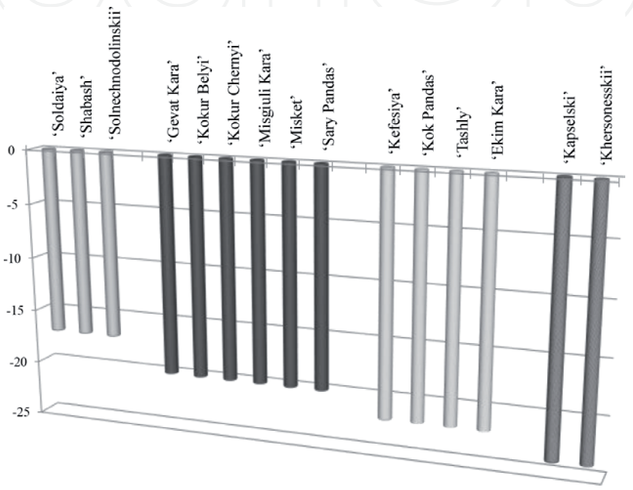


**Figure 4.**
*Differentiation of native grape varieties of the Crimea by resistance to frost.*

varieties was carried out with the help of base buds on fruit canes and sleeping buds of old wood of arms of the trunk and bush head;

- the second group of varieties: preservation of main buds in these varieties was 0%, base buds - 1-9%; 5% of budded shoots on fruit canes; 5% - 50% of budded shoots with the help of sleeping buds of perennial wood; consists of 20 varieties: 'Kanagyn Izium', 'Kefesiya', 'Kok Pandas', 'Solnechnaya Dolina 71/7', 'Firskii Ranniiy', 'Shira Izium' and others.

- the third group of relatively resistant grape varieties: preservation of main buds in these varieties was 0–7%, base buds - 3-25%; 25–50% of budded shoots on fruit canes; 5–50% of budded shoots with a help of sleeping buds of perennial wood; these are the varieties 'Chivsiz Sary', 'Dere Izium', 'Solnechnaya Dolina 41', 'Biyas Aibatly', 'Kutlakskii Chernyi', 'Kapselski' and 'Khersonesskii'.

All local varieties of Crimea belong to different ecological and geographical groups by their origin [5, 9]. Varieties 'Misgiuli Kara', 'Sary Pandas', 'Shabash' belong to the eastern ecological-geographical group - convar. *orientalis* Negr.; varieties 'Gevat Kara', 'Kokur Belyi', 'Misket', 'Tashly', 'Khersonesskii' belong to the ecological-geographical group of varieties of Black Sea Basin - convar. *pontica* Negr.; variety 'Kok Pandas' belongs to the west-european ecological-geographical group - convar. ossidentalis Negr. Separating the studied local varieties of Crimea into the groups of frost resistance, it should be noted that genotypes of convar. *pontica* Negr. and convar. ossidentalis Negr. possess high and average resistance to low temperatures, and varieties of the ecological-geographical group of convar. *orientalis* Negr. are classified as low frost-resistant and non-frost-resistant. In general, the data of resistance to low temperatures in various ecological-geographical groups correspond to the available literature sources.

During an agrobiological study in the period 2012–2015 the numbers of 21 elite forms were selected from 296 promising seedlings of the Crimean native varieties crossed with the complex interspecific hybrids. The yielded vine passed similar to the above method of laboratory freezing tests. It is established that the buds of eight elite seedlings hold reduction of temperature to minus 22°C (**Figure 5**).

After freezing through at minus 24°C hardwood cuttings of the following populations were capable to green shoots formation: 'Magarach No. 7-08-15-3', 'Magarach No. 11-08-17-2', 'Magarach No. 10-08-16-1', 'Magarach No. 10-08-8-3', 'Magarach No. 11-08-15-2', 'Magarach No. 11-08-13-3', 'Magarach No. 10-08-14-2', 'Magarach No. 10-08-17-2', 'Magarach No. 4-08-17-3', 'Magarach No. 5-08-8-4', 'Magarach No. 4-08-3-3'.

Freezing through at temperature of minus 26 °C of hardwood cuttings of elite form 'Magarach No. 8-08-8-4' ('Kok Pandas' x 'Zeibel No. 6357') did not follow to the damage of buds, and gave normal shoots after the exit of dormant state. The forms selected to the elite in each population have different frost resistance. Such difference is observed in the population of 'Sary Pandas' x 'Tsitronnyi Magaracha' in the form 'Magarach No. 7-08-7-3': frost resistance is minus 22°C, and in the form 'Magarach No. 7-08-15-3' it reaches minus 24°C. Similar situation was revealed in the population 'Kefesiya' x 'Ifigenia', where the elite form 'Magarach No. 10-08-8-2' is characterized by frost resistance of minus 22°C, and 'Magarach No. 10-08-8-3' - of minus 24°C. In the population 'Misket' x 'JS 26205', the form 'Magarach No. 4-08-17-4' withstands freezing through to minus 22°C, and the forms 'Magarach No. 4-08-17-3' and 'Magarach No. 5-08-8-4' - to minus 24°C. Moreover, almost all elite forms, in contrast to the initial Crimean native varieties in populations, are characterized by frost resistance higher by 2 °C.

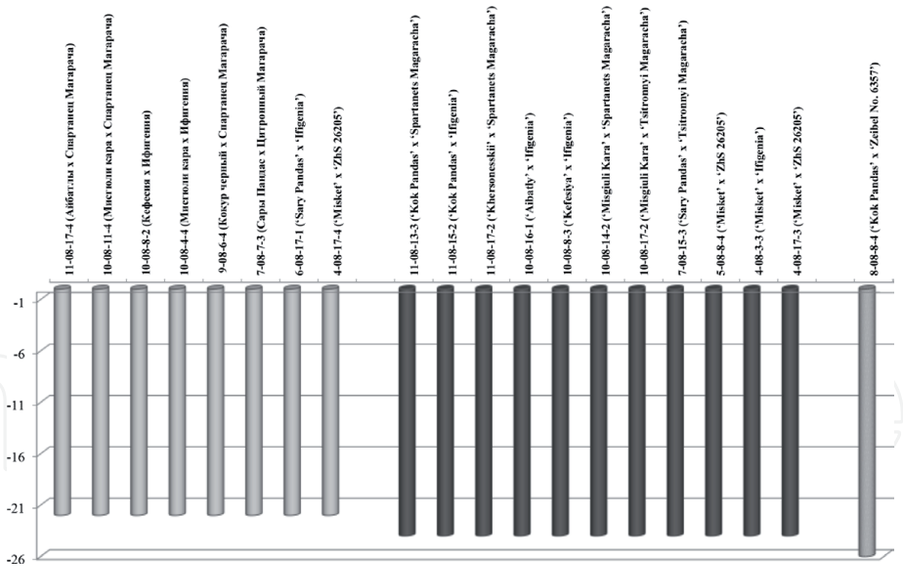


**Figure 5.**
*Resistance to frost in hybrids of native varieties of Crimea.*

## 7. Agrobiological specificity of breeding forms - analogues of Crimean native grape varieties

The production compatible in the internal and international market is a national patrimony; in viticulture and winemaking this is the production made of unique native grape varieties. The introduction of new grape varieties, analogues of the Crimean autochthones, having a genetically determined association of qualitative and quantitative traits in combination with resistance to environmental stress factors, will increase the economic efficiency of viticulture and winemaking industry. We studied on a combination of parameters 10 promising black-berried forms obtained in crossing of native grape varieties of Crimea with complex interspecific hybrids. Analyzing the production period of the hybrid forms highlighted as elite in comparison with the control variety 'Kefesiya', the dates of onset of phenological phases should be specially indicated (**Table 13**).

On average, in 2012–2015, the study of buds pushing in the researched hybrid forms began on April, 23. The coefficient of variation of this characteristic had an insignificant (10%) range of values of the trait in statistical population. The established standard deviation of 2,3 days allowed us to determine the varietal peculiarity of an earlier bud pushing for 3 days (April, 21) in the elite forms 'Magarach №10–08–8-2' and 'Magarach №10–08–8-3' compared to their initial form 'Kefesiya', studied as a control (April, 24). Blooming of the studied forms begins on average on June, 7 and coincides with the control variety. Range of the dates of blooming from June, 5 to June, 10 is determined by a coefficient of variation of 24.5%. Moreover, in 4 elite forms ('Magarach № 5-08-8-4', 'Magarach № 10-08-4-4', 'Magarach № 10-08-17-2', 'Magarach № 11-08-9-2') there is a deviation towards a later onset of blooming with an excess of the standard deviation (1.8 days) in comparison with the control. Totally the onset of blooming in the studied genotypes does not carry the character of significant difference. The beginning of the ripening period of berries in the studied forms was observed on average on August, 6. A significant difference between the genotypes was revealed at the stage of technological ripeness with the content of sugars in berries 21–22 Brix. The range of variability of onset of the technological ripeness (September, 16) in the average exceeded 33% and reached 39.4, which indicated the general dissimilarity of the whole in a trait.

| Hybrid form, Magarach No. | Cross-combination | | Onset of bud pushing, date | Onset of blooming, date | Onset of ripening of berries, date | Industrial ripeness, date | Productive period, days |
|---|---|---|---|---|---|---|---|
| | ♀ | ♂ | | | | | |
| 5–08–8-4 | Misket | JS 26205 | 25.04 | 9.06 | 7.07 | 9.09 | 140 |
| 10–08–8-2 | Kefesiya | Ifigenia | 21.04 | 6.06 | 5.07 | 9.09 | 143 |
| 10–08–8-3 | Kefesiya | Ifigenia | 21.04 | 6.06 | 5.07 | 9.09 | 143 |
| 10–08–4-4 | Misgiuli Kara | Ifigenia | 26.04 | 10.06 | 9.07 | 15.09 | 145 |
| 4–08–3-3 | Misket | Ifigenia | 20.04 | 5.06 | 3.07 | 9.09 | 145 |
| 9–08–6-4 | Kokur Chernyi | Spartanets Magaracha | 22.04 | 7.06 | 5.07 | 15.09 | 149 |
| 10–08–17-2 | Misgiuli Kara | Tsitronnyi Magaracha | 26.04 | 10.06 | 8.07 | 23.09 | 153 |
| 11–08–9-2 | Khersonesskii | Spartanets Magaracha | 25.04 | 9.06 | 8.07 | 23.09 | 155 |
| 10–08–14–3 | Misgiuli Kara | Spartanets Magaracha | 21.04 | 6.06 | 5.07 | 23.09 | 157 |
| 10–08–11-4 | Misgiuli Kara | Spartanets Magaracha | 21.04 | 6.06 | 5.07 | 23.09 | 157 |
| Kefesiya (c) | | | 24.04 | 7.06 | 8.07 | 18.09 | 146 |
| $\bar{x}$ | | | 23.04 | 7.06 | 6.08 | 16.09 | 148 |
| σ | | | 2.30 | 1.80 | 1.89 | 6.31 | 6.09 |
| V, % | | | 10.0 | 24.5 | 30.5 | 39.4 | 4.1 |

**Table 13.**
*Phenology of hybrids of native grape varieties of the Crimea.*

The established biological variability of this trait, according to the existing gradation of the OIV scale, made it possible to distribute the studied genotypes by terms of ripening. Forms 'Magarach No.5–08–8-4', 'Magarach No.10–08–8-2', 'Magarach No.10–08–8-3', 'Magarach No.10–08–4-4', 'Magarach No.4–08–3-3', 'Magarach No.9–08–6-4' refer to varieties of average term of ripeness - 4 points – September, 01–15, and forms 'Magarach No.10–08–17-2', 'Magarach No.11–08–9-2', 'Magarach No.10–08–14–3', 'Magarach No.10–08–11-4' and control variety 'Kefesiya' – to varieties of average-late term of ripeness - 5 points – September, 16–30. To determine the biological productivity of the studied promising forms, it is necessary to consider their bearing potential (**Table 14**).

Among the studied genotypes the least development of shoots was observed in forms 'Magarach No. 10-08-8-2', 'Magarach No. 9-08-6-4', 'Magarach No. 10-08-11-3'. In other forms this trait did not have significant differences compared to the control and was in the range 62.5–86.4%.

Fruit-bearing coefficient is one of the main parameters determining the potential productivity of genotypes. Among the forms under study, a very low fruit-bearing coefficient was noted in the genotypes 'Magarach No.10–08–8-2', 'Magarach No.9–08–6-4' and 'Magarach No.4–08–4-3'. Elite form 'Magarach No.10–08–17-2' had fruit-bearing coefficient (1.1) much higher than the control (0.66). Productiveness of the shoot in the wet raw bunch weight (g/shoot) should be considered as a resulting parameter of crop efficiency of variety. The inheritance of the forms under study with distinct direction of the trait value downwards was observed taking into account the varietal peculiarity of Crimean native wine grape cultivars and initial low productivity. Four studied forms were characterized by shoot productivity at the level of the control variety 'Kefesiya'.

The adjusted varietal specificity of the potential productivity of ten promising forms allowed to select four hybrid forms to the elite – 'Magarach No.5–08–8-4', 'Magarach No.10–08–4-4', 'Magarach No.10–08–8-3', 'Magarach No.10–08–14–3'.

Qualitative characteristics of promising forms were studied together with the determination of the productive period and fruit-bearing potential (**Table 15**). On average, among the studied forms the juice output was 58.2%. According to

| Hybrid form, Magarach No. | Shoot formation per bush, % | | Coefficient | | Productivity of the shoot, g/shoot |
|---|---|---|---|---|---|
| | developed | fruit-bearing | C1 | C2 | |
| 10–08–8-2 | 50.0 | 22.2 | 0.22 | 1.00 | 42.2 |
| 9–08–6-4 | 46.2 | 33.3 | 0.34 | 1.00 | 57.7 |
| 10–08–11-3 | 48.1 | 38.5 | 0.60 | 1.20 | 62.2 |
| 4–08–4-3 | 63.2 | 29.2 | 0.31 | 1.10 | 67.2 |
| 10–08–17-2 | 66.1 | 56.4 | 1.10 | 1.90 | 69.8 |
| 11–08–9-2 | 86.4 | 31.6 | 0.66 | 1.00 | 70.3 |
| 10–08–14–3 | 62.5 | 46.7 | 0.57 | 1.00 | 75.3 |
| 10–08–4-4 | 70.3 | 50.0 | 0.58 | 1.15 | 84.7 |
| 5–08–8-4 | 66.7 | 37.5 | 0.50 | 1.33 | 85.0 |
| 10–08–8-3 | 75.7 | 44.9 | 0.50 | 1.17 | 86.4 |
| Kefesiya (c) | 72.4 | 55.1 | 0.66 | 1.02 | 88.4 |
| LSD05 | 15.9 | 11.1 | 0.17 | 0.03 | 17.2 |

**Table 14.**
*Crop productivity of hybrids of native grape varieties of the Crimea.*

| Elite form, Magarach No. | Stem weight, % | Seeds weight, % | Skin and pulp weight, % | Juice output, % | Parameter of structure |
|---|---|---|---|---|---|
| 5–08–8-4 | 3.5 | 8.0 | 37.1 | 51.4 | 18.6 |
| 10–08–4-4 | 2.7 | 8.9 | 29.0 | 59.4 | 43.0 |
| 10–08–8-3 | 3.9 | 5.9 | 29.8 | 60.2 | 25.0 |
| 10–08–14–3 | 1.5 | 11.1 | 34.5 | 52.9 | 67.5 |
| Kefesiya (c) | 2.1 | 5.2 | 32.4 | 62.4 | 46.7 |
| $\bar{x}$ | 3.0 | 7.3 | 30.2 | 58.2 | 37.2 |
| σ | 1.1 | 2.5 | 6.6 | 8.1 | 18.7 |
| V,% | 35.6 | 33.9 | 21.8 | 14.0 | 50.3 |

**Table 15.**
*Mechanical composition of the bunch of elite form.*

the gradation of the OIV scale, the studied genotypes 'Magarach No.5–08–8-4', 'Magarach No. 10-08-14-3' belong to the group of varieties with the low output of juice, and the elite forms 'Magarach No. 10-08-4-4', 'Magarach No. 10-08-8-3' and the control variety 'Kefesiya' - to the group of varieties with an average juice output. Form 'Magarach No. 10–08–8-3' in terms of the average weight of the bunch was quite different from initial form 'Kefesiya'. Such a variety was explained by the different type of flower: female in the variety 'Kefesiya' and androgenous in the studied elite form 'Magarach No. 10-08-8-3'. The output yield was recalculated per 1 ha depending on the average yield per bush in elite forms. Records determining the cropping potential of the studied genotypes were obtained. Form 'Magarach No. 10–08–14–3' was characterized by a very low productivity (21.9 center/ha), form 'Magarach No. 5-08-8-4' (45.2 center /ha) did not significantly differ from the control (48.0 center /ha). There was no difference between productivity of elite forms 'Magarach No.10–08–4-4' (53.2 center /ha) and 'Magarach No.10–08–8-3' (55.7 center /ha), but essential increase in crop yield of these genotypes compared to the control variety 'Kefesiya' was revealed.

We have obtained data that determine the potential juice yield per hectare. It allowed us to recommend the elite form for production tests. The highest value of the parameter of juice output per hectare (336.4) among the studied genotypes was noted in form 'Magarach No. 10-08-8-3' ('Kefesiya' x 'Ifigenia') (**Table 16**).

As a general matter, the obtained data of the productive period, potential crop efficiency, mechanical composition and yielding capacity of the studied gene

| Elite form, Magarach No. | Bunch weight, g | Yield, kg/bush | Crop productivity, center /ha | Juice output, dL/ha |
|---|---|---|---|---|
| 5–08–8-4 | 170 | 1.356 | 45.2 | 232.3 |
| 10–08–4-4 | 146 | 1.595 | 53.2 | 315.8 |
| 10–08–8-3 | 173 | 1.670 | 55.7 | 336.4 |
| 10–08–14–3 | 108 | 0.659 | 21.9 | 116.2 |
| Kefesiya (c) | 162 | 1.414 | 48.0 | 299.5 |
| LSD05 | 9.1 | 0.07 | 3.7 | 17.2 |

**Table 16.**
*Crop productivity of elite forms.*

pool, was united to choose and highlight two elite forms 'Magarach No. 10-08-4-4' ('Misgiuli Kara' x 'Ifigenia') and 'Magarach No. 10-08-8-3' ('Kefesiya' x 'Ifigenia').

## 8. Conclusions

In the process of studying the biology of local grape varieties of the Crimean region investigated the possibility of their use in breeding to obtain more adaptive grape varieties that can be competitive in the viticulture and winemaking market. The grape plant in more than 2000 years of culture has shown in itself an exceptionally high adaptive capacity to stress factors. Nevertheless, thanks to introgression of genes of resistance to drought, low temperatures, and pathogens, we are able to manage the genetic diversity of the crop and create a wide range of new grape varieties.

Thus, we can state: according to the main economic parameters, the most profitable for cultivation without irrigation in the eastern South Coast zone of viticulture of Crimea among the native grape varieties are 'Gevat Kara', 'Kokur Belyi' and 'Kapselski Belyi'. A group of varieties including 'Kefesiya', 'Kok Pandas' and 'Tashly', was selected in the analysis and demonstrates high hybridization efficiency in intraspecific crossing and in crossing with complex interspecific hybrids. Hybridological analysis of the progeny in F1 showed that the average index of resistance to oidium depends on the genetic characteristics of the parent components. Hybridological analysis showed that the most resistant progeny developed in the crossing of 'Khersonesskii' × 'JS 26–205' (6.8 points). It is established that a high degree of genotypically determined inheritance of the trait of resistance to oidium is observed in crossings with the participation of female forms of interspecific origin – 'Magarach No. 31-77-10', 'Muscat Jim' and male forms– 'Spartanets Magaracha' and 'Tsitronnyi Magaracha'. The forms selected to the elite in each population have different frost resistance. Such difference is observed in the population of 'Sary Pandas' x 'Tsitronnyi Magaracha' in the form 'Magarach No. 7-08-7-3': frost resistance is minus 22 °C, and in the form 'Magarach No. 7-08-15-3' it reaches minus 24°C. Almost all elite forms, in contrast to the initial Crimean native varieties in populations, are characterized by frost resistance higher by 2°C. Four genotypes 5–08–8-4 ('Misket' x 'JS 26205'), 10–08–4-4 ('Misgiuli Kara' x 'Ifigenia'), 10–08–8-3 ('Kefesiya' x 'Ifigenia') and 10–08–14–3 ('Misgiuli Kara' x 'Spartanets Magaracha') were selected from the group of native grape varieties - donors of traits and obtaining hybrids of the first generation, which are improved analogues of the native grape varieties of Crimea.

## Conflict of interest

The authors declare no conflict of interest.

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