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The Effect of Low-Growing Rootstocks on the Adaptability and Productivity of Sour Cherry Varieties (*Prunus cerasus* L.) in Arid Conditions

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Abstract: Sour cherry (*Prunus cerasus* L.), having a rich composition of biologically active connections and antioxidants, is gaining increasing popularity among agricultural producers. Increasing the production of sour cherry fruits requires the introduction of modern technology, one of the elements of which is low-growing rootstocks. For many cultures, the use of low-growing rootstocks has been widely studied, but there is very little information on their use in cherry plantations. We studied new varieties and rootstocks of cherries in the conditions of the dry steppe zone, where this issue had not been studied before. Sour cherry (*Prunus cerasus* L.) varieties—Toy, Memory of Zhukova, and Loznovskaya—are the most adapted to the conditions in which the experiments were conducted. Russian breeding forms (Krymsk, Krasnodar region), which were taken as rootstocks, are widely used for sweet cherries (*Prunus avium* L.), but are practically never used for sour cherries (*Prunus cerasus* L.). The influence of rootstocks on such parameters as drought resistance, heat resistance, winter hardiness, and productivity was studied in variety–rootstock combinations. The study showed that they had the greatest drought resistance, and accordingly affected the grafted variety with rootstock, in the pedigree of which there are wild species. These rootstocks were of the VSL and RVL series. The study of the productivity of variety–rootstock combinations showed that in the grafted varieties the most rapid entry into the fruiting season and the greatest increase in the yield was facilitated by the rootstock forms of VSL-1 and VSL-2 (K5) which made it possible to obtain a yield of 5.8–8.1 kg/tree, depending on the variety grafted onto them. However, it is necessary to continue the research that has been started in order to fully determine the possible qualitative and quantitative parameters of the studied variety–rootstock combinations and to identify the most promising ones for further introduction into industrial production. This work was carried out within the framework of the topic of the state task of the Scientific Research Center of Agroecology of the Russian Academy of Sciences No. 0713-2019-0009: "Theoretical foundations, creation of new competitive biotypes of agricultural crops with high productivity, quality, sustainability and varietal technologies based on the latest methods and technological solutions in a changing climate, including seed breeding and nursery breeding".

Keywords: cherry; drought resistance; winter hardiness; clonal rootstocks; variety; yield

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1. Introduction

Recently, more and more emphasis has been placed on healthy eating. Important components of a balanced diet, as well as a source of vitamins, minerals, antioxidants, etc., are fresh vegetables and fruits. Among stone fruit crops of the temperate zone, one of the highest levels of antioxidants is found in ordinary or sour cherries (*Prunus cerasus* L.), which are also a source of biologically active and nutritious compounds. Their use can reduce the risk of occurrence and help in the prevention of diseases such as osteoarthritis, diabetes, cancer, cardiovascular disease, and Alzheimer's diseases, as well as help to reduce high blood pressure, gout, and insomnia [1,2].

In many countries of the world sour cherry (*Prunus cerasus* L.), along with cherries (*Prunus avium* L.), is an important economic crop, the largest producers of which are Turkey, USA, China, Iran, and Chile [3,4]. In Russia, in the past, sour cherry was one of the most widespread and, at the same time, least demanding stone crops, and it was grown mainly for processing [5]. In the 1990s, with the development of horticultural innovation and the emergence of new requirements for elements of technology, existing plantings ceased to meet the needs of the market and the area under cherry plantations began to decline sharply. Currently, despite the revival of domestic fruit growing, Russia is forced to import fruit products in the amount of more than 5 million tons, among which a large percentage (66.2%) are citrus and exotic fruits, the remaining 33.8% are traditional fruits of this country (apples, pears, plums, cherries, etc.). At the same time, the share of cherry fruits imported to Russia in 2020 was 0.2% [6,7].

The basis of modern world and domestic fruit growing is intensification, which includes the selection of modern variety–rootstock combinations and the introduction of various elements of cultivation technology [8–12]. Thanks to intensive technologies, the output of marketable products per unit area has increased, the time of entry into fruiting has reduced, and production costs are also reduced [4,13]. The expansion of the assortment of rootstock forms and varieties makes it possible to make modern cherry fruit production more attractive for agricultural producers around the world [14–18]. In Russia, with widely developed household gardening, new varieties and technologies will also be in demand among the population.

In recent years, thanks to the emergence of new modern varieties and rootstocks, the areas under cherry plantations in Russia have begun to expand, which in the near future will eliminate the need to import of fruits [19].

New, modern varieties and rootstocks are more competitive in terms of basic qualitative and quantitative characteristics, such as growth strength, resistance to biotic and abiotic factors, plant productivity, and product quality [20–26]. At the same time, among the variety of factors that have a positive effect on increasing the biopotential of agrocenosis and the final result of production, the variety–rootstock combination is one of the key ones, increasing it by more than 25% [27,28]. The degree of stability of different varieties and rootstocks may have significant differences depending on the place of growth. Global climate change has also recently influenced sustainability and productivity factors [29–36]. Therefore, it is especially important to conduct a study taking into account the conditions of the place of growth, including new forms of varieties and rootstocks.

The purpose of our research at the initial stage was to study rootstock forms and their effect on winter hardiness, drought resistance, early fruitfulness, and productivity of sour cherry varieties in arid conditions of the Volgograd region of Russia.

2. Materials and Methods

2.1. Plant Resources

For study, the following rootstocks were planted directly to a permanent place in the garden in the spring of 2018: seedlings of Magaleb cherry (*Prunus mahaleb*), as a control; VSL-1, VSL-2, RVL-2, RVL-9, and LC-52-interspecific hybrids obtained from the Crimean experimental breeding station branch of the All-Russian Scientific Research Institute of Plant Growing. All rootstocks fared well, and in July 2018 were grafted with the following cherry (*Prunus cerasus* L.) varieties by oculation: Loznovskaya and Memory of Zhukova—intraspecific hybrids of selection of the Federal Scientific Center for Agroecology, Complex Land Reclamation and Protective Afforestation of the Russian Academy of Sciences (Federal Scientific Center for Agroecology of the Russian Academy of Sciences), Russia, and the Toy variety—interspecific hybrid breeding of the M.F. Sidorenko Institute of Irrigated Horticulture of the UAAS, Ukraine (genetic material is in the collection plantings of the

Federal Research Center of Agroecology of the Russian Academy of Sciences, Volgograd Region, Russia).

Magaleb (seedlings of Magaleb cherry (*Prunus mahaleb*)) is a medium-sized rootstock. Varieties grafted on this rootstock enter fruiting for 4–5 years and trees reach a height of 2–2.5 m [37].

Rootstock VSL-1 (*Prunus fruticosa* × *Prunus serrulata var. lannesiana*) is stunted and reduces growth by 50–60%. Trees reach a height of 2–2.5 m and varieties grafted on this rootstock enter fruiting for 3 years after planting in the garden [38].

Rootstock VSL-2 (Krymsk® 5 (K5) (*Prunus fruticosa* × *Prunus serrulata var. lannesiana*)) is medium-sized and reduces growth by 30–50%. Trees reach a height of 3–3.5 m. It is an indicator of the presence of the virus in the grafted varieties that makes it possible to obtain virus-free planting material [38].

Rootstock LC-52 (Krymsk® 6 (K6) (*Prunus cerasus* × (*Prunus cerasus* × *Prunus maackii*))) is a medium-sized rootstock. It reduces cherry growth by 30%, trees reach a height of 3–3.5 m, and varieties enter fruiting for 3–4 years after planting in the garden [38].

Rootstock RVL-2 (*Prunus cerasus* × *Prunus maackii)* × *Prunus serrulata var. lannesiana*) is a medium-sized rootstock. It reduces the growth of cherry and sweet cherries by 25–30%. It shows intensive growth of trees in the first years on fertile soils, but after entering fruiting for 3–4 years, it sharply decreases in growth and forms high, annual yields [38].

Rootstock RVL-9 (*Prunus cerasus* × *Prunus maackii)* × *Prunus serrulata var. lannesiana*) is a medium-sized rootstock. It reduces cherry growth by 30% and trees reach a height of 3–3.5 m [38].

The Loznovskaya cherry variety (*Prunus cerasus* × *Prunus cerasus*) produces 7 g fruit of dark red color. The taste is sour-sweet. The variety is self-fertile and there is an early ripening period. Winter hardiness and drought resistance are very high. They are relatively resistant to diseases [39].

The Memory of Zhukova cherry variety (*Prunus cerasus* × *free pollination*) produces medium-sized fruit of 5.5 g. The taste is sweet and sour. The variety is self-fertile and the color of the berries and pulp is dark red. There is an average maturation period. Winter hardiness and drought resistance are very high and they are resistant to diseases [39].

Cherry variety Toy (*Prunus cerasus* × *Prunus avium*) produces large fruits of 7–8 g. The pulp is red, juicy, dense, and tender. The taste is sour-sweet and the plants are self-fertile. The best pollinator varieties are cherry Minx, Samsonovka, and sweet cherries, Valery Chkalov and large-fruited. This variety has an average maturation period, winter hardiness of wood is average and the buds are low. Drought resistance is high and they are relatively resistant to diseases and pests [40].

Combinations of all studied varieties with Magaleb cherry (*Prunus mahaleb*) are well known and compatible, which allows for an objective assessment of their qualitative and quantitative characteristics [39]. As for the rest of the rootstocks, under these conditions, sour cherry varieties were being studied for the first time. The compatibility of these combinations has not been sufficiently studied, but judging by the initial growth of grafted plants in the nursery and further in the garden, it should be quite high.

All the trees in the garden were arranged according to the scheme of 5 m between rows and 2 m between trees in a row (1000 trees per 1 ha) [11,21,28]. The scheme of the experiment included six rootstocks, three varieties, and four replications and all plants were located randomly. In total, the test consisted of 72 trees (eighteen variety–rootstock combinations and four repetitions of each combination).

2.2. Location of the Experimental Site and Conditions

The experimental site was located on the territory of the Laboratory of breeding, seed production and nursery; Breeding of the Federal Research Center of Agroecology of the Russian Academy of Sciences, Russia, in the dry-steppe zone of the Volgograd region, on the right bank of the Volga River (49.071880, 44.798608). The soil was of a slightly alkaline light chestnut subtype, with light mechanical composition and low humus content of −1.73% and pH of 7.2–7.5.

The average sum of positive temperatures for the growing season (April–October) ranged from 2850° to 3050° [41,42]. The years of research differed significantly in the temperature regime and the amount of precipitation during the growing season, from April to September (Table 1).

Table 1. Meteorological conditions during the years of research (average for 2019–2021).

Months	2019			2020			2021		
	Average Air Temperature, °C	**Precipitation, mm**	**Relative Humidity of the Air, %**	**Average Air Temperature, °C**	**Precipitation, mm**	**Relative Humidity of the Air, %**	**Average air Temperature, °C**	**Precipitation, mm**	**Relative Humidity of the Air, %**
April	11.7	21.8	65	8.9	2.2	45	11.8	29.2	55
May	19.9	50.4	60	15.7	53.4	59	20.3	31.2	45
June	26.9	13.9	35	25.5	18.6	32	16.8	21.7	53
July	23.5	59.8	58	28.8	0.6	27	29.6	13.8	29
August	20.7	3.8	63	23.5	13.6	35	28.6	8.2	31
September	16.4	19.5	50	19.2	1.8	39	16.0	19.1	52
During the growing season		169.2			110.3			123.2	

Over the years of research, with an average annual norm of 190.4 mm, there was a shortage of precipitation: 169.2 mm in 2019, 90.2 mm in 2020, and 123.2 mm in 2021. At the same time, uneven precipitation was noted both by year and by month. The average monthly temperatures during the research period varied from 8.9 to 28.8 °C, which was, on average, 1 °C higher than the average long-term norm. By year, the maximum temperature values were recorded in August 2019—37.30 °C, July 2020—35.70 °C, and July 2021—36.0 °C. The humidity of the air varied from 25% in 2019 to 65% in 2021, which was, on average, 1–7% lower than the average long-term indicators. In the summer, dry winds and air droughts are often observed in the districts of the Volgograd region, which led to significant dryness of the air and drying of the upper soil horizons. The hydrothermal coefficient (HTC) also had a significant difference—in 2019 it was 0.7, in 2020 it was 0.3, and in 2021 it was 0.4. This had an extremely negative impact on the drought resistance of cherry cultivar–rootstock combinations, but at the same time allowed us to identify the best in this indicator.

2.3. Maintaining the Prototype, Records, and Observations

Due to the arid conditions of the experimental plot, the plantings were irrigated weekly with drip irrigation at a rate of 160 to 200 m^3/ha, depending on the prevailing conditions, with drip garden lines with emitters of 2 L/hour at a distance of 60 cm (NETAFIM, Israel). The trees were formed according to the free-growing spindle system. The care of plants was carried out according to the generally accepted technologies for the care of stone plantings in the south of Russia [43]. In the trunk strip, within 1 m, weeds were destroyed by 1% glyphosate introduced in early May, early June, and mid-July. The soil in the aisles during the growing season was kept under black steam and treated for weeds with a disc harrow (BDM-3, Russia) as the weeds grew.

Drought resistance and heat resistance were carried out by laboratory method. To determine drought resistance and heat resistance, the water content of the leaf, the water scarcity, and the water-holding capacity of the leaves were determined. Leaves for laboratory experiments were collected in the morning from 6 to 7 am.

The hydration of the leaf was determined by the Matskov method. To determine the total amount of water, 5–10 leaves were placed in metal buckets (twofold repetition) and dried in a thermostat (SHS-80-01 SPU, Russia) at 105 °C to a constant mass. The total amount of water (B) as a percentage of the raw weight of the sample was determined by the formula:

$$B = \frac{(b-c)}{(b-a)} * 100\% \tag{1}$$

where a is the weight of an empty weighing bottle (g), b is the weight of a weighing bottle with a wet sample (g), and c is the weight of a weighing bottle with a dry sample (g).

Water deficiency was determined by whole leaves. Whole leaves (3–5 pieces each) with updated sections of petioles were weighed (VLTE-310 scales, “Gosmeter” Research and Production Enterprise, St. Petersburg, Russia) and placed with petioles in a flask with water for saturation. The repetition was twofold. The flasks were placed in a crystallizer with water and covered with the same crystallizer to create an air chamber. After 24 h saturation, the leaf petioles were dried with filter paper and the leaves were weighed. The water deficit (WD) in the leaves (as a percentage of the total water content in the state of full saturation) was calculated by the formula:

$$\mathrm{W} = \frac{C-A}{C-B} * 100\% \tag{2}$$

where A is the raw weight, B is the mass of the dry weight, and C is the mass of leaves after full saturation with water.

To determine the water-holding capacity of the leaves, 3–10 pieces (depending on the size) were weighed in twofold repetition (VLTE-310 scales, “Gosmeter” Scientific and Production Enterprise, Russia), and then placed on grids in a thermostat (SHS-80-01 SPU, Russia) with a constant temperature (23 °C) and humidity of the air. After 2, 4, and 6 h, repeated weighings were carried out to determine water loss. The higher the water-retention capacity, the less the loss of water (LW) by the leaves over a certain time, which was determined by the shape:

$$\mathrm{LW} = \frac{B}{A} * 100 \tag{3}$$

where A is the water content before the start of the experiment (g) and B is the loss of water over a certain period of time (g).

This technique was described earlier in more detail [44,45].

Determination of potential frost resistance was carried out by laboratory method. For the study, branches were cut at a height of 1.5–2 m, from different sides of trees, and at least 100 flower buds were used. The cut branches, tied in bundles and provided with labels, were placed in a refrigerating chamber (KHTV-022, Russia). The temperature was reduced at a rate of 2–4 °C per hour. Freezing at a temperature set by *experiment option* (see Frost resistance experience options below) was carried out for 8–12 h. After that, the samples were subjected to slow thawing. The thawed branches had their lower parts cut off by 1.5–2 cm and placed in vessels with water for 48 h at a temperature of 18–20 °C. During this period, the frozen bud tissues turned brown and, when examined, easily differed from the living ones. The damage was assessed and accounted for by looking at the buds on a longitudinal section made with a razor blade. This technique was described earlier in more detail [44–46].

Frost resistance experience options:

Option 1—resistance to early frosts. Hardening of cuttings at −5 °C (120 h) and −10 °C (120 h), then reducing the temperature by 5 °C per hour to −20 °C. Further freezing for 8 h. After 8 h of freezing, thawing and storage of samples in a chamber for thawing at 2 °C or storage at −2 °C;

Option 2—the maximum level of frost resistance. Freezing temperature −35°. Reducing the temperature by 5 °C per hour to −35 °C. Further freezing for 8 h with further thawing and storage of samples in the chamber for thawing at 2 °C or storage at −2 °C;

Option 3—maintaining stability during thaw periods. To detect the reaction of soils to thaws after quenching at −5 °C and −10 °C, storage of cut branches in a cabinet with a temperature of +2 °C for 72 h, and then freezing at −20 °C for 8 h.

Option 4—the ability to restore stability when re-quenching after thaws. Quenching was carried out for 120 h at a temperature of −5 °C and −10 °C, then 72 h thaw at a temperature of +2 °C, then quenching again at a temperature of −5 °C and −10 °C for 72 h, then freezing at −25 °C for 8 h.

Productivity and quality were determined by the weight method [47]. When determining the harvest, a sample of 100 fruits was taken (without defects or rot, the most typical for a tree), the total weight of fruits from the tree was recorded, the average weight of the fruit was calculated and the number of fruits per tree was estimated.

The productivity of the variety−rootstock combination was calculated relative to biometric parameters: projection area (S), volume (V) of the crop, cross-sectional area of the stem (S), for the calculation of which, the following formulae were used:

$$\text{S crown} = d^2 \times \pi/4 \tag{4}$$

$$\text{V crown} = \pi r^2 \times h/3 \tag{5}$$

$$\text{S stem} = \pi d^2{}_1/4 \tag{6}$$

where d is the diameter of the crown, i.e., the average value of two indicators of the diameter of the crown (along and across the row); r is the radius of the crown, i.e., 1/4 of the sum of two indicators of the diameter of the crown (along and across the row), h is the height of the tree; and d1 is the diameter of the stem.

2.4. Statistical Analysis

Statistical analysis was carried out according to B.A. Dospekhov [30]. Calculations were performed using the Microsoft Excel 2010 software package and the STATISTICA program. The significance of the difference between the analyzed indicators (HCP05) was determined with a reliable probability of 95%, the arithmetic mean (M) and standard deviation (±SD) were calculated. The coefficient of paired correlation (r) between the features was calculated with a reliable probability of 95%.

3. Results

Analysis of moisture loss by varieties in different years of observation showed that the differences in average indicators were not significant; the smallest were observed in the Toy variety, the largest in the Loznovskaya variety (Table 2).

Within the framework of the variety−rootstock combination, depending on the rootstock, differences in water losses by leaves were also observed. The greatest losses of water by leaves were observed in almost all varieties on the rootstock of Magaleb.

Table 2. Water-holding capacity of cherry leaves on various rootstocks at critical summer temperatures (39.20–40.20 °C), average for three years (2019–2021).

Variety	Rootstock	Water Scarcity, %	Weight before Drying, g	Loss of Water by Leaves after 6 h of Withering, %			
				2019 Year	2020 Year	2021 Year	Average for 3 Years
Toy	Magaleb, st	22.00	3.80	12.70	13.30	12.60	12.90
	VSL-1	14.30	6.04	13.40	14.90	14.00	14.10
	RVL-2	13.30	4.28	11.30	12.90	12.80	12.30
	VSL-2 (K5)	14.60	3.73	10.80	11.90	12.30	11.70
	RVL -9	17.80	4.92	11.90	12.10	13.80	12.60
	LC-52 (K6)	17.70	5.90	14.20	15.10	14.90	14.70
	Average	**16.90**	**4.90**	**13.00**	**13.70**	**15.20**	**13.90**

Table 2. *Cont.*

Variety	Rootstock	Water Scarcity, %	Weight before Drying, g	Loss of Water by Leaves after 6 h of Withering, %			
				2019 Year	2020 Year	2021 Year	Average for 3 Years
Memory of Zhukova	Magaleb, st	10.40	3.09	17.30	15.80	33.00	22.00
	VSL-1	12.10	3.20	11.50	11.70	23.10	15.40
	VSL-2 (K5)	20.80	3.09	12.10	14.60	4.50	10.40
	RVL-2	15.30	2.46	12.20	15.10	11.40	12.90
	RVL-9	11.40	3.32	16.80	14.00	20.20	17.00
	LC-52 (K6)	13.80	4.49	15.50	16.20	23.40	18.40
	Average	**14.10**	**3.26**	**13.90**	**14.30**	**18.50**	**14.10**
Loznovskaya	Magaleb, st	11.30	4.76	18.50	20.30	25.00	21.30
	RVL-9	11.10	5.99	15.20	18.80	15.90	16.60
	RVL-2	10.10	5.34	13.70	14.50	16.70	15.00
	VSL-2 (K5)	12.10	1.66	12.80	12.20	24.10	16.40
	VSL-1	11.30	6.58	11.70	13.20	12.90	12.60
	LC-52 (K6)	11.90	4.90	12.70	14.90	13.50	13.70
	Average	**12.10**	**5.07**	**14.10**	**15.70**	**17.70**	**15.80**
HCP_{05}	-	**0.70**	**-**	**0.70**	**0.70**	**0.80**	**0.70**

In the Toy variety, the differences in moisture loss depending on the rootstock were insignificant, while the least moisture loss by leaves was observed on the rootstock VSL-2 (K5) (Table 3).

Table 3. The effect of various rootstocks on the water-holding capacity of leaves, (average for 2019–2021).

Variety	Rootstock	Loss of Water Leaves after 6 h of Tuning, %			
		2019 Year	2020 Year	2021 Year	Average for 3 Years
Toy	Magaleb, st	12.7	13.3	12.6	12.9
	VSL-1	13.4	14.9	14.0	14.1
	RVL-2	11.3	12.9	12.8	12.3
	VSL-2 (K5)	10.8	11.9	12.3	11.7
	RVL-9	11.9	12.1	13.8	12.6
	LC-52 (K6);	14.2	15.1	14.9	14.7
	HCP_{05}	0.62	0.67	0.67	0.65
Memory of Zhukova	Magaleb, st	17.3	15.8	33.0	22.0
	VSL-1	11.5	11.7	23.1	15.4
	VSL-2 (K5)	12.1	14.6	4.5	10.4
	RVL-2	12.2	15.1	11.4	12.9
	RVL-9	16.8	14.0	20.2	17.0
	LC-52 (K6)	15.5	16.2	23.4	18.4
	HCP_{05}	0.71	0.73	0.96	0.8

Table 3. *Cont.*

Variety	Rootstock	Loss of Water Leaves after 6 h of Tuning, %			
		2019 Year	2020 Year	2021 Year	Average for 3 Years
Loznovskaya	Magaleb, st	18.5	20.3	25.0	21.3
	RVL-9	15.2	18.8	15.9	16.6
	RVL-2	13.7	14.5	16.7	15.0
	VSL-2 (K5)	12.8	12.2	24.1	16.4
	VSL-1	11.7	13.2	12.9	12.6
	LC-52 (K6);	12.7	14.9	13.5	13.7
	HCP_{05}	0.71	0.78	0.9	0.8

For the Memory of Zhukova variety, the differences in moisture loss by leaves depending on the rootstock were more significant. The most significant moisture losses, especially in 2021, were observed on the rootstocks of VSL-1, RVL-9, LC-52, and Magaleb, and the minimum on RVL-2 and VSL-2.

In the Loznovskaya variety, the lowest moisture losses by leaves, both in 2021 and in general by year, were observed on the rootstock LC-52 (K6) and VSL-1, the maximum in 2021, on the rootstocks VSL-2 (K5) and Magaleb, and by year, on the rootstocks Magaleb, RVL-9 and VSL-2 (K5).

The study of the winter hardiness of variety—rootstock combinations of cherries by various components (variants: V1, V2, V3, and V4) showed no significant effect of the rootstock on the resistance of the variety to adverse winter factors. In all studied cultivar—rootstock combinations, there was no damage to either vegetative shoots or generative organs (Figure 1).

Despite the fact that the varieties differed in strength and growth pattern, rootstocks had a significant impact on these parameters (Table 4).

Table 4. Biometric indicators of cherry cultivar—rootstock combinations, (2019—2021 years).

Variety	Rootstock	Tree Height, m	Crown Diameter, m	Diameter of the Stem, cm	Crown Projection Area, m^2	Crown Volume, m^3	Cross-Sectional Area of the Stem, cm^2
Loznovskaya	Magaleb, st	2.24	2.54	7.44	5.06	3.78	43.45
	LC-52 (K6)	2.38	2.44	6.62	4.67	3.71	34.4
	VSL-1	2.22	2.14	5.23	3.59	2.66	21.47
	RVL-2	1.76	1.78	5.15	2.49	1.46	20.82
	RVL-9	1.82	2.08	5.74	3.39	2.06	25.86
	VSL-2 (K5)	1.78	2.2	5.23	3.8	2.25	21.47
Memory of Zhukova	Magaleb, st	2.34	2.66	10.24	5.55	4.33	82.31
	LC-52 (K6)	2.3	2.62	8.03	5.39	4.13	50.62
	RVL-2	2.16	1.96	7.93	3.01	2.17	49.36
	RVL-9	2.06	2.08	6.49	3.39	2.33	33.06
	VSL-1	2.16	2.3	5.99	4.15	2.99	28.16
	VSL-2 (K5)	2.16	2.36	8.74	4.37	3.15	59.96

Table 4. *Cont.*

Variety	Rootstock	Tree Height, m	Crown Diameter, m	Diameter of the Stem, cm	Crown Projection Area, m^2	Crown Volume, m^3	Cross-Sectional Area of the Stem, cm^2
Toy	Magaleb, st	2.22	2.34	8.99	4.3	3.18	63.44
	LC-52 (K6)	2.2	2.44	7.82	4.67	3.43	48.00
	VSL-1	1.84	2.12	5.80	3.53	2.16	26.41
	RVL-2	1.74	1.94	6.51	2.95	1.71	33.27
	RVL-9	1.66	1.9	6.86	2.83	1.57	36.94
	VSL-2 (K5)	1.98	2.18	6.40	3.73	2.46	32.15
HCP_{05}		0.10	0.11	0.35	0.20	0.14	1.98

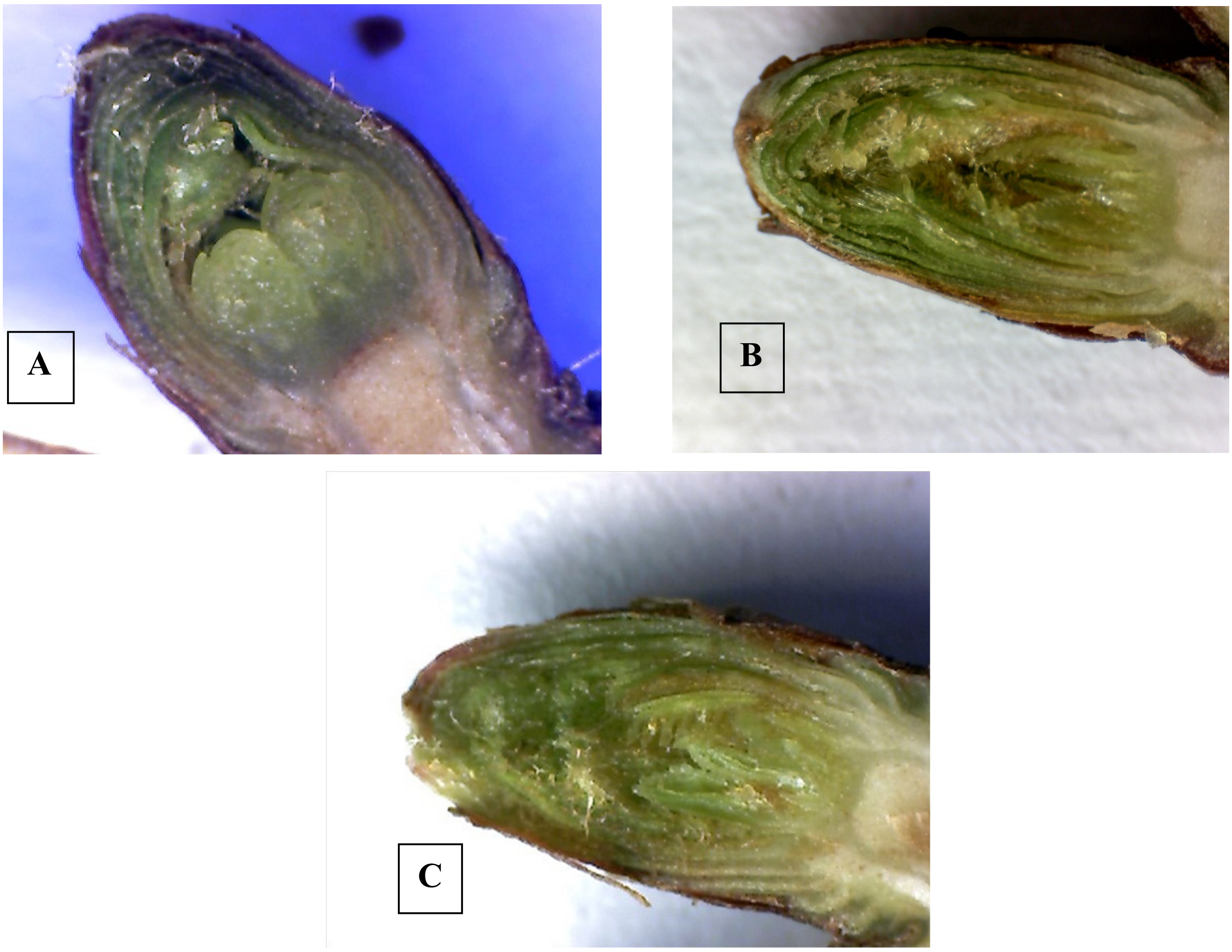

Figure 1. Generative kidneys after freezing in the chamber, varieties: Memory of Zhukova (**A**), Toy (**B**), and Loznovskaya (**C**).

The most significant difference, confirmed statistically, was observed for all varieties on the rootstock of Magaleb and LC-52 (K 6), and this was most clearly seen by the difference in the volume and area of the crown projection. The smallest biometric parameters are marked on the rootstocks of the RVL series (Table 4).

All the studied cherry varieties are perishable, with the beginning of fruiting 3–4 years after planting in the garden with annual seedlings [45,48]. At the same time, individual rootstocks significantly accelerated the entry into fruiting. So, on the rootstocks of the VSL series, all varieties had already tied single fruits in the second year. In the third year, all varieties on all rootstocks (with the exception of seed Magaleb) tied a yield from 1.0 to 8.1 kg/tree (Table 5).

Table 5. Production and quality indicators of variety−rootstock combinations of cherries, 2021 year.

Variety	**Rootstock**	**Yield, 2021**				**Average Fetal Weight, g.**
		kg/Tree	**kg/S Crown Projection**	**kg/V Crown**	**kg/S of the Cross-Section of the Stem**	
Loznovskaya	Magaleb, st	-	-	-	-	-
	LC-52 (K6)	1.5	0.32	0.4	0.043	5.9
	VSL-1	1.5	0.42	0.56	0.07	6.0
	VSL-2 (K5)	2.0	0.53	0.89	0.93	6.1
	RVL-2	1.0	0.40	0.68	0.048	5.7
	RVL-9	1.1	0.32	0.53	0.042	5.4
Memory of Zhukova	Magaleb, st	-	-	-	-	-
	LC-52 (K6)	1.1	0.2	0.27	0.022	5.2
	VSL-1	6.4	1.42	2.14	0.23	5.2
	VSL-2 (K5)	8.1	1.85	2.57	0.14	5.1
	RVL-2	1.02	0.34	0.47	0.021	4.9
	RVL-9	1.0	0.29	0.43	0.03	5.3
Toy	Magaleb, st	-	-	-	-	-
	LC-52 (K6)	2.5	0.53	0.73	0.052	9.7
	VSL-1	5.8	1.65	2.68	0.22	8.9
	VSL-2 (K5)	3.9	1.05	1.58	0.12	8.7
	RVL-2	1.3	0.44	0.76	0.039	8.6
	RVL-9	1.05	0.37	0.67	0.028	8.9
HCP$_{05}$	-	0.44	-	-	-	0.53

The most significant harvest in the third year after planting in the garden was noted in the variety Memory of Zhukova on the rootstock VSL—1–8.1 kg/tree. A significant yield of 5.8 and 3.9 kg/tree, was noted in the Toy variety on the rootstocks of VSL-1 and VSL-2 (K 5), respectively. A smaller yield among the varieties in the third year after planting was noted in the Loznovskaya variety on the rootstock VSL-2 (K5) (2.1 kg/tree). It should also be noted that the rootstock also affects the size of the fruits. In the Loznovskaya variety, this indicator varied, depending on the rootstock—from 5.9 to 6.1 g—with the largest value on the rootstock VSL-2 (K5), in the Memory of Zhukova variety—from 5.2 to 5.3 g—with the largest value on the rootstock RVL-9, in the Toy variety—from 8.7 to 9.7 g—with the largest value on the stock LC-52 (K6) (Table 5).

Statistical analysis (Table 6) showed that the Toy variety differed from other varieties by the highest average value of the fruit weight, which, depending on the rootstock, varied in the range from 8.10 g on the VSL-2 rootstock to 10.20 g on the LC-52 rootstock. In second place was the Loznovskaya variety, with the weight of the fruit ranging from 5.5 g on the rootstock VSL-1 to 5.80 g on the rootstock VSL-2. Zhukova's memory had minimal indicators. The average value ranged from 5.04 to 9.65 depending on the variety and rootstock. The coefficient of variation was 0.02–0.08%. The standard deviation of the coefficient of variation did not exceed 10%, which indicated a slight variability of the values. The accuracy of the experiment was within acceptable values.

Table 6. Statistical indicators of fruit weight of variety—rootstock combinations of cherries (average for 2020–2021).

Variety	Rootstock	Min	Max	Average	Q1	Median	Q3	Coef. Variations	Standard Deviation	Accuracy of Experience, %
Loznovskaya	Magaleb, st	0	0	0	0	0	0	0	0	0
	LC-52 (K6)	5.70	6.30	5.89	5.80	5.90	6.00	0.03	0.04	0.68 ± 0.11
	VSL-1	5.50	6.70	6.07	5.90	6.10	6.20	0.05	0.08	1.3 ± 0.22
	VSL-2 (K5)	5.80	6.40	6.09	5.95	6.00	6.25	0.03	0.05	0.82 ± 0.14
	RVL-2	5.40	6.40	5.90	5.90	6.0	6.20	0.04	0.06	1.02 ± 0.17
	RVL-9	5.50	6.10	5.70	5.50	5.60	5.85	0.04	0.09	1.58 ± 0.17
Memory of Zhukova	Magaleb, st	0	0	0	0	0	0	0	0	0
	LC-52 (K6)	4.90	5.40	5.13	5.00	5.10	5.30	0.03	0.05	0.97 ± 0.17
	VSL-1	4.90	5.30	5.12	5.00	5.10	5.25	0.03	0.04	0.78 ± 0.13
	VSL-2 (K5)	4.60	5.40	5.04	4.95	5.00	5.15	0.04	0.06	1.19 ± 0.20
	RVL-2	4.80	6.00	5.20	4.90	5.20	5.35	0.06	0.09	1.73 ± 0.17
	RVL-9	4.80	6.00	5.20	4.90	5.20	5.35	0.06	0.09	1.73 ± 0.17
Toy	Magaleb, st	0	0	0	0	0	0	0	0	0
	LC-52 (K6)	9.30	10.20	9.65	9.50	9.50	9.75	0.03	0.07	0.73 ± 0.13
	VSL-1	8.50	9.30	8.97	8.85	9.00	9.15	0.03	0.06	0.67 ± 0.11
	VSL-2 (K5)	8.10	9.10	8.65	8.50	8.70	8.85	0.03	0.07	0.80 ± 0.14
	RVL-2	8.40	9.10	8.70	8.55	8.80	8.85	0.02	0.05	0.57 ± 0.17
	RVL-9	8.80	9.40	9.10	8.90	9.10	9.30	0.02	0.06	0.66 ± 0.17

4. Discussion

When determining the water-holding capacity of cherry leaves, variation by variety was manifested, depending on both the conditions of the developing year and the rootstock (Table 2).

Despite the fact that the rootstock of the Magaleb (*Prunus mahaleb*) is drought-resistant [37], in our experiments two varieties on it showed maximum moisture loss by leaves (Table 2). However, the water deficit in these cultivar—rootstock combinations was low. The Toy variety on the Magaleb rootstock (*Prunus mahaleb*) had average moisture loss rates compared to other rootstocks, while the water deficit was one of the highest. It should be noted that the water deficit of the Toy variety on all rootstocks was one of the highest. Apparently, such data are related to the origin of this variety and the presence as one of the parents of sweet cherries *(P. avium*), being more demanding to moistening than sour cherries (*P. cerasus*).

The lowest values of evaporation, i.e., the greatest water-holding capacity of the leaves, were observed on all varieties and practically for all years of observations on the rootstock VSL-2 (K5), which once again confirms its high drought-resistant properties, including due to its origin [8,17,49]. Along with the stock of VSL-2 (K5), the best indicators for water-holding ability were shown by two varieties, Toy and Memory of Zhukova, on the stock of RVL-9. Despite its origin with a predominance of species that are not so drought-resistant (*Prunus cerasus* × *Prunus maackii)* × *Prunus serrulata var. lannesiana*, this rootstock in our conditions showed relatively high drought resistance. This fact can be explained by the presence of sour cherry *Prunus cerasus* and steppe cherry *Prunus fruticosa* in the parent, since it is believed that *Prunus cerasus* originated from the natural crossing of *Prunus avium* and *Prunus fruticosa* [5,49]. The steppe cherry, being a typical representative of the shrubs of the wild flora of steppe regions, transmits signs of stunting and drought resistance when crossed with other *Prunus* species [50]. According to the results of three-year observations, this rootstock can be considered the most drought-resistant in the acutely arid conditions of the dry steppe zone of the Volgograd region. Similar indicators of water-holding capacity to these varieties on the RVL-9 rootstock were also noted on the Loznovskaya variety (Table 2). On the same variety, high indicators of water-retention capacity were noted on the VSL-1 and LC-52 (K6) rootstocks, while other varieties on these rootstocks have lower indicators of water-retention capacity. This example is another serious confirmation that under certain conditions it is necessary to study the variety and rootstock together, since the differences can be quite significant.

The rootstock is able to control the growth of the grafted variety, accelerate the time of entry into fruiting, and, at the same time, affect productivity [4,9,23]. In the studied conditions, the lowest growth and crown volume of the grafted varieties were provided by the rootstocks RVL-2, VL-9, VL-1, and VSL-2 (K 5). The decrease in biometric parameters relative to the rootstock of the Magaleb ranged from 30 to 40%, depending on the variety—rootstock combination (Table 3), which fully confirms the characteristics of these rootstocks. At the same time, the medium-sized rootstock of LC-52 (K6) in our conditions turned out to be relatively strong, at the level of the Magaleb, which is probably due to its high responsiveness to irrigation.

Earlier entry into fruiting of the variety was provided by all rootstocks, with the exception of the Magaleb. At the same time, the highest yield was obtained on the varieties Toy and Memory Zhukova, grafted on the rootstocks VSL-1 and VSL-2 (K5) (Table 4). These rootstocks, having in their parent forms the wild species *Prunus fruticosa* and the decorative species *Prunus serrulata var. lannesiana*, probably contribute to a faster entry into fruiting and crop growth, which has been noted more than once by both the author of these rootstocks and other researchers [8,18,51]. In our conditions, these rootstocks also contributed to a more accelerated increase in yield. The Loznovskaya variety had an insignificant yield on these rootstocks, from 1.5 to 2.0 kg/tree, which is due to the later entry into fruiting of this variety. The remaining rootstocks provided an insignificant yield of 1.0 to 2.5 kg/tree on all varieties.

At the same time, we can also assume that the studied variety—rootstock combinations may have the above indicators due to not having good enough compatibility. However, the study of these rootstocks on other varieties, both *Prunus avium* cherries and *Prunus cerasus* sour cherries, allows us to speak with some confidence about the good compatibility of these combinations and the direct influence of rootstocks on the characteristics of the varieties grafted on them [4,8,18,38]. Further research, which will undoubtedly be continued, will give a more accurate and complete answer, both on the compatibility of the studied combinations and on their characteristics.

5. Conclusions

The study of cherry cultivar—rootstock combinations in the conditions of the dry-steppe zone of the Volgograd region showed a significant variation of varieties in drought resistance and productivity depending on the rootstock. The studied rootstocks, being derived from different types of cherries, both wild and cultivated, had a different effect on the varieties grafted on them. Thus, in the Toy variety, the variation in moisture loss by leaves, depending on the rootstock, ranged from 11.7% on VSL-2 (K5) to 14.7% on LC-52 (K6). The variety Memory of Zhukova had an even more significant range of moisture loss by leaves, from 10.4% on VSL to 2 to 22% on *Prunus mahaleb*. The Loznovskaya variety also showed a significant variation in the moisture loss of leaves depending on the rootstock, from 12.6% on VSL-1 to 21.3% on *Prunus mahaleb*.

The yield and the size of the fruits also had significant differences depending on the rootstock. The greatest variation was noted in the variety Memory of Zhukova, from 8.1 kg/tree on the rootstock VSL-1 to 1.0 kg/tree on RVL-9. Not as significant, but also a significant difference was observed in the Toy variety, from 5.8 kg/tree on the rootstock VSL-1 to 1.05 kg/tree on RVL-9. The smallest differences in yield were noted in the Loznovskaya variety, from 2.0 kg/tree on VSL-2 (K 5) to 1.0 kg/tree on VL-2. The fruit size also varied depending on the rootstock, in the Loznovskaya variety, from 5.9 to 6.1 g; in the Memory Zhukova variety, from 5.2 to 5.3 g; and in the Toy variety, from 8.7 to 9.7 g. It should be noted that all varieties on the *Prunus mahaleb* rootstock did not bear fruit, because this rootstock marks a later entry of trees into fruiting. Thus, some of the data obtained allow us to draw preliminary conclusions about the combinations of sour cherries that are most suitable for cultivation in arid conditions. At the same time, it is necessary to continue the research that has been initiated in order to fully determine the possible qualitative and quantitative parameters of the studied variety−rootstock combinations and identify the most promising ones for further introduction into industrial production.

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