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Evaluation of introduced sweet cherry cultivars under arid conditions of Southern Russia

CORRESPONDENCE:
Margarita Y. Azarova
E-mail: azarova778@gmail.com

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Elena V. Pismennaya[1], Margarita Yu. Azarova[1], Akash Jamil[2]

[1] Stavropol State Agrarian University, Stavropol, Russia

[2] Cholistan University of Veterinary and Animal Sciences (CUVAS), Bahawalpur, Pakistan

ABSTRACT

INTRODUCTION. The expansion of commercial sweet cherry cultivation in the arid regions of southern Russia is constrained by the lack of cultivars that combine adaptability to local soil and climatic conditions, regular bearing, and high fruit quality.

AIM. To identify the most promising introduced sweet cherry cultivars in terms of productivity and fruit quality when grown on Gisela 6 rootstock in the arid zone of Stavropol Krai.

MATERIALS AND METHODS. The research was conducted from 2023 to 2025 on the cultivars Sweet Early, Ferrovia, Samba, Skeena, Kordia, and Regina in an orchard established in 2021 with a planting spacing of 3.5 × 1.5 m. Yield, alternate bearing index, fruit morphometric parameters, and biochemical composition were assessed. Statistical processing was performed using Statistica v23 with cluster analysis.

RESULTS. All studied cultivars produced fruit annually; however, they exhibited significant differences in the level and stability of productivity. In 2023, the maximum yield was recorded for Kordia and Skeena (2.10 t/ha each); in 2024, for Sweet Early (4.52 t/ha); and in 2025, for Skeena (0.68 t/ha). Average fruit weight ranged from 9.1 to 11.1 g, average flesh weight from 8.2 to 10.3 g, and total sugar content from 16.7% to 23.0%. The smallest inter-cultivar distance for the trait complex was found between Samba and Kordia.

CONCLUSION. Under the conditions of the arid zone of Stavropol Krai, the cultivars Skeena, Kordia, Regina, and Samba, which were distinguished by a complex of economically valuable traits, are of greatest practical interest. The obtained results can be used to improve the sweet cherry cultivar assortment for intensive plantings in the region.

KEYWORDS: Sweet cherry, cultivar, arid zone, Stavropol Krai, yield, fruit quality, biochemical composition, cluster analysis

Исследовательская статья

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Оценка интродуцированных сортов черешни в засушливых условиях Юга России

Е.В. Письменная[1], М.Ю. Азарова[1], А. Джамиль[2]

[1] Ставропольский государственный аграрный университет, Ставрополь, Россия

[2] Чолистанский университет ветеринарных и зоотехнических наук, Бахавалпур, Пакистан

КОРРЕСПОНДЕНЦИЯ:
Маргарита Юрьевна Азарова
E-mail: azarova778@gmail.com

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КОНФЛИКТ ИНТЕРЕСОВ:
авторы сообщают об отсутствии конфликта интересов.

АННОТАЦИЯ

ВВЕДЕНИЕ. Расширение промышленного возделывания черешни в засушливых районах юга России ограничивается недостатком сортов, сочетающих адаптивность к местным почвенно-климатическим условиям, регулярное плодоношение и высокое качество плодов.

ЦЕЛЬ. Выявить наиболее перспективные интродуцированные сорта черешни по продуктивности и качеству плодов при выращивании на подвое Gisela 6 в засушливой зоне Ставропольского края.

МАТЕРИАЛЫ И МЕТОДЫ. Исследования проведены в 2023–2025 гг. на сортах Sweet Early, Ferrovia, Samba, Skeena, Kordia и Regina в саду 2021 года закладки, созданном по схеме 3,5 × 1,5 м. Оценивали урожайность, индекс периодичности плодоношения, морфометрические показатели плодов и их биохимический состав. Статистическую обработку выполняли в программе Statistica v23 с применением кластерного анализа.

РЕЗУЛЬТАТЫ. Все изученные сорта плодоносили ежегодно, однако заметно различались по уровню и устойчивости продуктивности. В 2023 году максимальная урожайность отмечена у сортов Kordia и Skeena — по 2,10 т/га, в 2024 году — у Sweet Early 4,52 т/га, в 2025 году — у Skeena 0,68 т/га. Средняя масса плодов варьировала от 9,1 до 11,1 г, средняя масса мякоти — от 8,2 до 10,3 г, содержание общих сахаров — от 16,7 до 23,0 %. Наименьшая межсортовая дистанция по комплексу признаков установлена между Samba и Kordia.

ЗАКЛЮЧЕНИЕ. В условиях засушливой зоны Ставропольского края наибольший практический интерес представляют сорта Skeena, Kordia, Regina и Samba, выделившиеся по комплексу хозяйственно ценных признаков. Полученные результаты могут быть использованы при совершенствовании сортимента черешни для интенсивных насаждений региона.

КЛЮЧЕВЫЕ СЛОВА: черешня, сорт, засушливая зона, Ставропольский край, урожайность, качество плодов, биохимический состав, кластерный анализ

INTRODUCTION

Sweet cherry (*Prunus avium* L.) is one of the most valuable fruit crops in warm-climate regions due to its early market arrival, high fruit palatability, and stable consumer demand [1; 2]. For commercial horticulture in southern Russia, this crop is of particular interest as an object for assortment diversification and enhancing the economic efficiency of intensive plantings [3; 4]. However, successful sweet cherry cultivation under arid conditions is determined not only by the biological characteristics of the species but also by the degree of cultivar adaptation to the specific growing environment [5; 6]. Under conditions of moisture deficit, high summer temperatures, and unstable winter-spring factors, cultivars may significantly differ in precocity, yield stability, fruit size, and biochemical fruit characteristics [7; 8]. Therefore, the introduction of new cultivars must be accompanied by their comprehensive evaluation directly in the target growing region [9].

Modern intensive orchard systems impose higher demands on cultivars compared to traditional plantings [10; 11]. For commercial use, cultivars combining satisfactory yield, relatively regular bearing, large fruit, and favorable chemical composition parameters are of greatest value [12]. These parameters are particularly important when using semi-dwarf rootstocks, which are becoming increasingly widespread in intensive sweet cherry plantings [13; 14].

For the arid zone of Stavropol Krai, identifying sweet cherry cultivars best adapted to local growing conditions is of particular importance [15]. The region requires cultivars capable of producing a marketable yield under arid climate conditions while simultaneously ensuring fruit quality that meets current market requirements. One approach to replenishing the regional commercial cultivar assortment is the introduction of foreign sweet cherry cultivars. However, cultivars differ in their adaptability to environmental stress factors, so their economic value must be assessed directly under specific agro-ecological growing conditions [16; 17]. The necessity of this approach justifies a comparative study of introduced sweet cherry cultivars under commercial orchard conditions in the arid zone of Stavropol Krai. In this regard, the objective of this study was to identify the most promising introduced sweet cherry cultivars in terms of productivity, bearing regularity, fruit size, and biochemical fruit parameters in the arid zone of Stavropol Krai.

MATERIALS AND METHODS

Study Conditions and Research Objects

The research was conducted from 2023 to 2025 in the second soil-climatic zone of Stavropol Krai, Russia (geographical coordinates: 45°49'33" N, 42°31'21" E). The agricultural enterprise was Krasochnoye LLC.

The research objects comprised six introduced sweet cherry cultivars with different ripening periods: Sweet Early, Ferrovia, Samba, Skeena, Kordia, and Regina, all grafted onto Gisela 6 rootstock. The cultivar Skeena was developed from a cross of 2N-60-7 × 2N-38-32 (British Columbia); Sweet Early from a cross of Burlat × Sunburst (registered with the Community Plant Variety Office of the European Union); Ferrovia is not patented; Samba from a cross of 2 S 84-10 × Stella 16 A-7 (Canada); Kordia is not patented (bred by J. Blazek, Czech Republic); and Regina from a cross of Schneiders Späte Knorpelkirsche × Rube (Hanover, Germany).

The sweet cherry orchard was established in 2021 with a planting spacing of 3.5 × 1.5 m. The tree training system was a slender spindle. The total number of record trees was 60, including 10 trees per cultivar, with three replications.

The soil cover of the experimental plot consisted of southern, carbonate, medium-thick, weakly humus-rich chernozems in combination with surface meadow-chernozem carbonate soils (up to 10%) (Table 1).

Table 1
Agrochemical analysis of the experimental plots (2023–2025)

Soil sampling depth, cm	pH (water extraction method*	Available phosphorus, mg/kg soil (Machigin method as modified by CINAO**	Available potassium, mg/kg soil (Machigin method as modified by CINAO***	Organic matter, % (I.V. Tyurin method, CINAO***
0–20	8.1–8.4	21–23	393–470	2.57–2.67
20–40	8.2–8.4	10–16	248–318	2.20–2.38
40–65	8.4–8.5	<9	235–258	1.76–1.82

Notes: *GOST 26423–85. Soils. Methods Gog determination ot'spceific electric conductivity, pH and solid residue of water extract. 2011;8. (In Russ.) https://files.stroyinf.ru/Data/201/20148.pdf

**GOST 26205–91. Soils. Determination of mobile compounds of phosphorus and potassium by Machigin method modified by CINAO. 2023;10. (In Russ.) https://internet-law.ru/gosts/gost/10373/

***GOST 26213–91. Soils. Methods for determination of organic matter. 1993;8. (In Russ.) https://okhotin-grunt.ru/gost/%D0%93%D0%9E%D0%A1%D0%A2_26213-91.pdf

Weather Conditions

The climate of the intensive orchard area is arid. The hydrothermal coefficient ranges from 0.5 to 0.9. The average sum of active temperatures during the agricultural year (2023–2025) was 2630°C, total precipitation was 193.9 mm, maximum summer temperatures reached +30.1°C (July–August), and the minimum temperature was –8.9°C (January).

Methods

Yield was determined according to the program and methodology for cultivar evaluation of fruit, berry, and nut crops [18; 19; 20]. Biochemical and technological analysis of fruits was performed following the "Methodological Guidelines for the Determination of Chemical Substances for Assessing the Quality of Vegetable and Fruit Crop Yields" [1]. Statistical processing was carried out using Statistica v23 (x64) software for cluster analysis. The squared Euclidean distance, calculated based on the following parameters, was used as the similarity measure: yield, alternate bearing index, average fruit weight, fruit diameter, soluble solids content, titratable acidity, and sugar-acid ratio.

RESULTS

Yield and Fruiting Periodicity

All studied sweet cherry cultivars came into bearing and produced a harvest annually during the observation period, but significantly differed in the level and stability of yield. In 2023, the highest yield was recorded for the cultivars Kordia and Skeena, with 2.10 t/ha each, while the lowest was for Sweet Early at 0.34 t/ha (Table 2).

In 2024, according to Table 2, the highest yield was observed for Sweet Early (4.52 t/ha), while the lowest was for Regina (0.90 t/ha). In 2025, Skeena was the most productive cultivar, with a yield of 0.68 t/ha, whereas the minimum value was again recorded for Sweet Early (0.14 t/ha).

The alternate bearing index also significantly differed among cultivars. The lowest index was found for Skeena (43.8%), and a slightly higher value was recorded for Regina (52.0%), indicating relatively lower irregularity of bearing under the experimental conditions. The highest index values were observed for Sweet Early (93.9%) and Ferrovia (89.3%), suggesting more pronounced year-to-year yield fluctuations.

Fruit Morphometric Parameters

According to the study data, all cultivars were classified as large-fruited. Average fruit weight ranged from 9.1 g (Sweet Early) to 11.1 g (Regina), while flesh weight ranged from 8.2 to 10.3 g (Table 3).

Table 2
Alternate bearing index of introduced sweet cherry cultivars under the arid zone conditions of Stavropol Krai

Cultivar	Yield, t/ha			Alternate bearing index, %	Group
	2023	2024	2025		
Early ripening					
Sweet Early	0,34	4,52	0,14	93,9	4
Medium ripening					
Ferrovia	0,61	3,00	0,17	89,3	4
Samba	1,05	2,92	0,31	80,8	3
Medium-late ripening					
Skeena	2,10	1,74	0,68	43,8	2
Late ripening					
Kordia	2,10	2,61	0,44	71,1	3
Regina	1,30	0,90	0,41	52,0	2

Notes: Based on the index value, cultivars were classified into groups: Group 1 (21–40%) — relatively regular bearing; Group 2 (41–60%) — moderate periodicity; Group 3 (61–80%) — strong periodicity; Group 4 (81–100%) — very strong periodicity.

[1] Guidelines for chemical-technological variety testing of vegetable, fruit and berry crops for the canning industry. 1993;107. (In Russ.)

Pit weight varied within a relatively narrow range (0.8 to 0.9 g); however, the pit proportion in the total fruit weight differed among cultivars. The highest value of this parameter was found for Sweet Early (9.9%), while the lowest was for Regina (7.2%); a similar result was obtained for Skeena (7.3%).

Fruit Biochemical Parameters

Substantial inter-cultivar variability was revealed in the biochemical composition of the fruits (Table 4).

Total sugar content ranged from 16.7% (Skeena) to 23.0% (Kordia); high values were also recorded for Regina (22.8%) and Samba (22.1%). Titratable acidity varied from 0.48% (Ferrovia) to 0.79% (Skeena), whereas the sugar-acid ratio ranged from 21.1 (Skeena) to 44.7 (Regina). These parameters indicate differences among cultivars not only in the level of sugar accumulation but also in the sugar-to-acid balance, which is important for taste evaluation and technological suitability of the fruits. Skeena exhibited a sweet taste, while the remaining cultivars exhibited a very sweet taste.

Cluster Analysis of Sweet Cherry Cultivars

The dendrogram and proximity matrix revealed a pronounced differentiation of the cultivars based on the set of studied traits. The proximity matrix was calculated using squared Euclidean distance, which made it possible to determine the structure of the obtained data by grouping the most similar cultivars into clusters according to increasing distance. The smallest measure of dissimilarity was found between the cultivars Samba and Kordia (1.279), followed by the pairs Ferrovia and Kordia (5.713), as well as Sweet Early and Ferrovia (7.457) (Figure 1, Table 5).

Table 3
Qualitative parameters of sweet cherry cultivars under the arid zone conditions of Stavropol Krai, 2023–2025

Cultivar	Fruit weight, g	Flesh weight, g	Pit weight, g	Pit weight / fruit weight, %
Early ripening				
Sweet Early	9.1	8.2	0.9	9.9
Medium ripening				
Ferrovia	10.2	9.3	0.9	8.8
Samba	10.3	9.4	0.9	8.7
Medium-late ripening				
Skeena	11.0	10.2	0.8	7.3
Late ripening				
Kordia	10.2	9.3	0.9	8.8
Regina	11.1	10.3	0.8	7.2

Table 4
Biochemical analysis of sweet cherry fruits under the arid zone conditions of Stavropol Krai, 2023–2025

Cultivar	Total sugars, %	Titratable acidity, %	Sugar:acid ratio
Early ripening			
Sweet Early	18.3	0.49	37.3
Medium ripening			
Ferrovia	18.9	0.48	39.4
Samba	22.1	0.51	43.3
Medium-late ripening			
Skeena	16.7	0.79	21.1
Late ripening			
Kordia	23.0	0.53	43.4
Regina	22.8	0.51	44.7

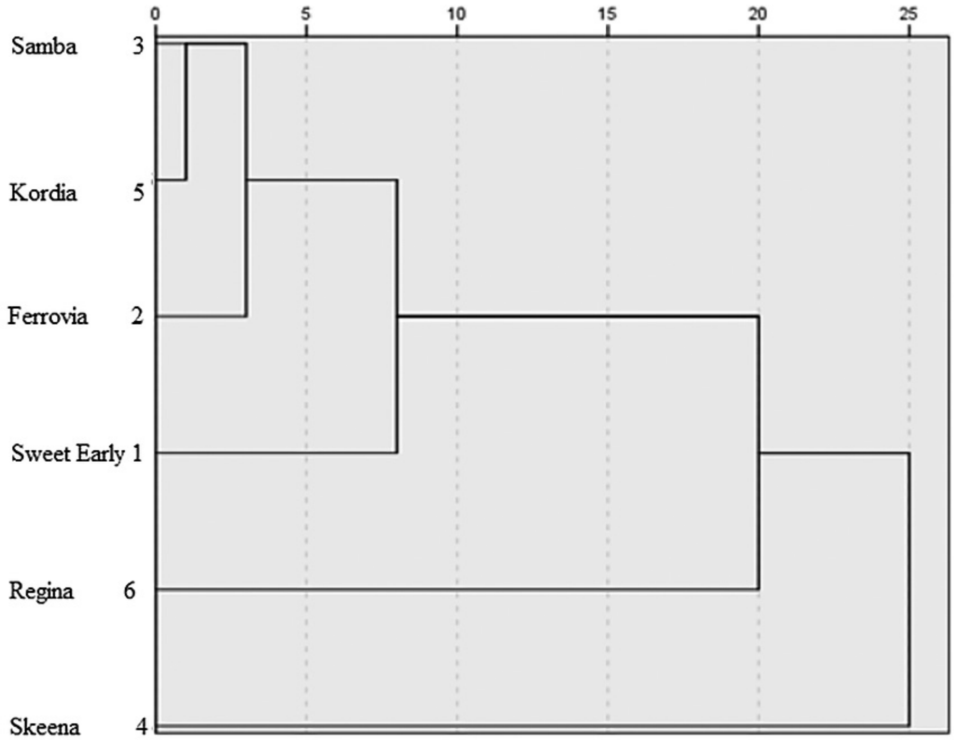

Figure 1
Dendrogram of intergroup relationships of sweet cherry cultivars under the arid zone conditions of Stavropol Krai

Table 5
Proximity matrix. Squared Euclidean distance

Cultivar	Sweet Early	Ferrovia	Samba	Skeena	Kordia	Regina
Sweet Early	—	7.457	10.149	40.574	10.548	40.376
Ferrovia	7.457	—	2.212	26.061	5.713	16.962
Samba	10.149	2.212	—	27.082	1.279	13.836
Skeena	40.574	26.061	27.082	—	27.563	22.383
Kordia	10.548	5.713	1.279	27.563	—	17.804
Regina	40.376	16.962	13.836	22.383	17.804	—

Note: The table was compiled based on the following data: yield (t/ha), alternate bearing index (%), total sugars (%), titratable acidity (%), sugar-acid ratio, fruit weight (g), flesh weight (g), pit weight (g), pit weight/fruit weight (%).

The largest distances were found between Sweet Early and Skeena (40.574), as well as between Sweet Early and Regina (40.376), indicating significant differences in the trait structure of these cultivars. Thus, the results of cluster analysis confirm that the degree of similarity among cultivars under the experimental conditions was determined by a complex of productivity and fruit quality traits, rather than solely by their belonging to a particular ripening group.

DISCUSSION

The obtained results confirm that introduced sweet cherry cultivars differ in their ability to realize their production potential when grown on the same rootstock, including under the arid conditions of Stavropol Krai [21; 22]. These findings are of fundamental importance for commercial horticulture in southern Russia, since a cultivar's suitability for introduction should be determined not by a single high parameter but by a combination of yield, bearing stability, and fruit quality traits [23; 24].

The conducted research revealed a discrepancy between maximum yield in a single year and overall bearing stability. For instance, the cultivar Sweet Early showed the highest yield in 2024, but simultaneously exhibited the highest alternate bearing index, which limits its value as a cultivar with stable productivity under arid zone conditions. In contrast, the cultivar Skeena combined relatively high yield performance with the lowest alternate bearing index, suggesting that it can be considered more stable for commercial production.

The data obtained on fruit marketability are also of great importance [25; 26]. Twenty fruits were sampled from each tree. After harvest, fruit weight, pit weight, flesh weight, and biochemical composition were measured for each individual fruit. It was revealed that Regina and Skeena exhibited the highest average fruit weight, with Regina simultaneously showing the maximum flesh weight and one of the lowest pit proportions relative to total fruit weight. This combination of traits can be considered favorable for fresh consumption, as it is associated with a higher proportion of edible portion and better visual appeal of the product.

The biochemical parameters complemented the fruit quality assessment across cultivars. Kordia, Regina, and Samba were characterized by high sugar content and high sugar-acid ratio values, indicating favorable taste potential of the fruits. At the same time, Skeena, which stood out for its large fruit size and more regular bearing, exhibited minimal sugar content and maximal acidity. This highlights the need for a more differentiated approach to cultivar evaluation: a single cultivar may be promising in terms of productivity but inferior in certain quality parameters [27; 28].

Additional analytical information was provided by the cluster analysis, which allowed interpretation of the results not by individual traits but by their combination. The proximity of Samba and Kordia indicates similarity in their economic-biological profiles under the experimental conditions, while the considerable distance of Sweet Early from Skeena and Regina reflects differences across the trait complex. Consequently, the grouping of cultivars under arid zone conditions is determined by a multicomponent cultivar response to the natural environment (including soil-climatic and aerodynamic conditions) [29].

Based on the obtained data, Skeena can be considered promising for its combination of more regular bearing and large fruit size, whereas Regina, Kordia, and Samba are of primary interest for fruit quality and biochemical characteristics. This conclusion is consistent with the multi-criteria approach to cultivar evaluation that is adopted in contemporary fruit crop research [30; 31].

CONCLUSION

Under the arid conditions of Stavropol Krai, introduced sweet cherry cultivars on Gisela 6 rootstock differed significantly in yield, bearing periodicity, fruit morphometric parameters, and biochemical composition. Skeena stood out for its bearing periodicity and large fruit size, indicating a relatively more stable and economically valuable response under the experimental conditions. The cultivars Regina, Kordia, and Samba were distinguished by favorable fruit quality parameters, including high sugar content and high sugar-acid ratio values. The obtained results can be used to improve the sweet cherry cultivar assortment for intensive orchards in the arid zone of southern Russia.

Contributions

E. V. Pismennaya: conceptualization; project administration; writing-original draft.

M. Yu. Azarova: investigation; methodology; data curation; writing-review & editing.

A. Jamil: formal analysis; software; validation; writing-review & editing.

Вклад авторов

Е. В. Письменная: разработка концепции, административное руководство исследовательским проектом, написание черновика рукописи.

М. Ю. Азарова: получение финансирования, разработка методологии, курирование данных, написание рукописи — рецензирование и редактирование.

А. Джамиль: формальный анализ, разработка программного обеспечения, валидация результатов, написание рукописи — рецензирование и редактирование.

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About the authors

Elena V. Pismennaya —
Dr. Sci. (Agric.), Prof., Department of Land Management, Cadastre and Landscape Architecture, Stavropol State Agrarian University, Stavropol, Russia

https://orcid.org/0000-0003-2786-1954

pismennaya.elena@bk.ru

Сведения об авторах

Письменная Елена Вячеславовна —
доктор сельскохозяйственных наук, профессор кафедры землеустройства, кадастра и ландшафтной архитектуры, Ставропольский государственный аграрный университет, Ставрополь, Россия

https://orcid.org/0000-0003-2786-1954

SPIN-код: 2770-2383

pismennaya.elena@bk.ru

Margarita Y. Azarova —
Cand. Sci. (Agric.), Senior Lecturer, Department of Agrochemistry and Plant Physiology, Stavropol State Agrarian University, Stavropol, Russia

https://orcid.org/0000-0001-7109-1227

azarova778@gmail.com

Азарова Маргарита Юрьевна —
кандидат сельскохозяйственных наук, старший преподаватель кафедры агрохимии и физиологии растений, Ставропольский государственный аграрный университет, Ставрополь, Россия

https://orcid.org/0000-0001-7109-1227

SPIN-код: 6737-8380

azarova778@gmail.com

Akash Jamil —

PhD in Forestry and Rangeland Management, Prof., Department of Rangeland, Forestry & Wildlife, Cholistan University of Veterinary and Animal Sciences (CUVAS), Bahawalpur, Pakistan

https://orcid.org/0000-0003-0198-9327

Akashjamil2@live.com

Акаш Джамиль —
PhD в области лесного хозяйства и управления пастбищными угодьями, профессор кафедры пастбищного лесоводства и охраны дикой природы, Чолистанский университет ветеринарных и зоотехнических наук, Бахавалпур, Пакистан

https://orcid.org/0000-0003-0198-9327

Akashjamil2@live.com