Influence of rootstock on the quality of sweet cherry fruits in the conditions of the Lower Volga region

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Abstract. Sweet cherry is a thermophilic and whimsical crop that reacts painfully to unfavorable meteorological conditions, such as frost, drought or high humidity in the air and soil. At the same time, this crop requires a uniform supply of heat and moisture during the growing season. In the climatic conditions of the Volgograd region, stressful situations often arise that can partially or completely reduce the yield of fruit crops, especially those introduced to our region from other regions. To reduce the risk of losing the yield of fruit plantations, including sweet cherry, it is necessary to pay special attention to the choice of the variety, as well as the rootstock on which this variety is grafted. The publication presents the results of studying the influence of rootstocks on the qualitative and quantitative indicators of sweet cherry fruits, such as taste, weight, uniformity, color, and productivity. According to the results of the study in the field (in the garden), varietal-rootstock combinations were identified that have one-dimensional, crack-resistant, large fruits, while maintaining high and stable productivity. According to the results of research, it was found that the rootstock affects not only the strength of growth and the shape of the crown, but also the quality of the fruit. The most dependent of the studied varieties on the type of rootstock is Euphoria, the lowest weight of berries was observed on the rootstock VSL-1. At the same time, this rootstock has a higher percentage of resistance to cracking of the fruit. Based on the conducted research, it can be concluded that with the help of rootstock, it becomes possible to influence the quality indicators of fruits.

1. Introduction
When laying modern garden plantings, more and more new rootstocks are used, the diversity of which, especially in stone crops, is currently little inferior to the variety of varieties and hybrids [1-2]. It is obvious that the variety grafted on the rootstock retains all its varietal characteristics, regardless of the selected rootstock. It is obvious that the variety grafted on the rootstock retains all its varietal characteristics, regardless of the selected rootstock. At the same time, the rootstock can influence the growth processes of the grafted variety, determining the characteristics of growth, development, as well as the level of winter hardiness and drought resistance [2]. This, in turn, affects the activity of plant metabolism, the accumulation of biomass, and, accordingly, the intensity of photosynthesis [3-4].

The influence of rootstock on the growth of trees is a well-known fact, but scientists cannot come to a consensus about the impact on the quality of fruits. Qualitative characteristics of the fruit are
meant appearance, one-dimensionality, weight, taste, cracking, etc. Sweet cherry as the earliest fruit crop is particularly acutely affected by external factors [5-8]. Therefore, when laying out plots, it is necessary to carefully approach the choice of rootstock.

The purpose of these studies was to study the influence of rootstock on the quality of fruits and to identify the best varietal-rootstock combinations of sweet cherry. The analysis of data on yield and quality of fruits allows us to identify the most productive combinations for further use in intensive plantings.

2. Materials and methods

Studies on the influence of rootstock on the quality of fruits were conducted in the laboratory of breeding, seed production and nursery production of the Federal Research Center of Agroecology of the Russian Academy of Sciences in the Dubovsky district of the Volgograd region for several years. The objects of research were varieties of sweet cherries selected by the Crimean OSS - Alexandria, Amulet and Euphoria on different rootstocks in the 2013 planting year. The scheme of planting trees is 5x2 m; the plot is irrigated; irrigation was carried out by means of cable lines [9].

All observations and records were carried out according to the generally accepted method [10]. The number of registered trees of each variety-rootstock combination was from 6 to 10 plants. The qualitative characteristics of the fruits were evaluated according to the generally accepted method [10].

The appearance and taste of the fruit were evaluated on the basis of visual inspection and tasting evaluation. The characteristic taste consists of a certain combination of sugars and acids in the fruit and is evaluated on a five-point scale: 1 - fruit is not suitable for fresh consumption (very bad taste); 2 - fruit is not suitable for fresh consumption (bad taste); 3 – average taste (satisfactory); 4 - table (good taste); 5 – dessert (excellent taste) [10].

The resistance to fruit cracking was determined by collecting 100 fruits of each variety and visually determining the percentage of cracked berries. The size and one-dimensionality of the fruits were determined on a five-point scale: 1 - very small fruits; 2 - small, not aligned in size and shape; 3 - medium-sized fruits, dull, not aligned in size and shape; 4 - mostly large fruits of medium one-dimensionality; 5 - large and aligned fruits.

The average weight of one fruit was determined by weighing the sample (100 fruits) and dividing the resulting weight by their number. Fruit size was determined on a 5-point scale, where 5 - very large (>8.3 g); 4 - large (6.3-8.2 g); 3 – medium (4.6-6.2 g); 2 – small (3.3-4.5 g); 1 - very small (< 3.2 g). Crop accounting was determined in kilograms, by weighing the fruits during the removable maturity period or counting all the fruits on the accounting branches (2-3 weeks before the removable maturity).

When determining the yield of the studied varieties, it is necessary to take into account not only the average yield per tree, but also the regularity of fruiting. To establish this indicator, a certain number of years of observations of fruit-bearing trees with normal (at least 3-5 points) and excellent (4-5 points) degree of fruiting is taken into account. On the basis of these data, the following varieties are characterized: high-yielding, yielding, medium-yielding and low-yielding [10].

3. Results and discussions

The quality of the fruit is a varietal feature, however, depending on the prevailing weather conditions, this feature may vary slightly. Therefore, for an objective assessment of quality indicators, several years of observations are required. The minimum period for conducting these studies is three years. The study of the quality of the fruit is carried out during the full ripening period. Sweet cherry is the earliest crop, the ripening period of which falls to May-July, so the quality of the fruit is most influenced by the temperature regime and the amount of precipitation that falls to these months [11-14]. For four years of observations, the meteorological conditions were favorable for the growth and fruiting of sweet cherries (Table 1) [15].

Most of the variety-rootstock combinations showed high resistance of the fruit to cracking (Debiskaeva S. Yu., 2010). The most susceptible to cracking were the fruits of the Euphoria variety,
damage was observed on almost all cultivar-rootstock combinations with this variety for the entire time of observations. Minimal (less than 1%) damage was caused to the fruits of the Amulet variety on the rootstocks A-47-9 and A-30. The variety Alexandria did not show signs of fruit cracking in any of the studied variety-rootstock combinations (Table 2).

Table 1. Meteorological conditions of the sweet cherry fruit ripening period, 2017-2020

| Year  | Average monthly temperature, °C | Precipitation, mm | Relative humidity of the air, % |
|-------|---------------------------------|-------------------|--------------------------------|
|       | May    | June   | July   | May    | June   | July   | May    | June   | July   |
| Average rate | 18.0   | 22.8   | 25.6   | 43.4   | 40.1   | 26.6   | 41     | 42     | 40     |
| 2017  | 16.5   | 21.4   | 25.6   | 28.6   | 43.8   | 1.3    | 52     | 44     | 33     |
| 2018  | 21.1   | 24.9   | 27.3   | 12.7   | 7.2    | 79.2   | 36     | 32     | 51     |
| 2019  | 19.9   | 26.9   | 23.5   | 50.4   | 13.9   | 59.8   | 60     | 35     | 58     |
| 2020  | 15.7   | 25.5   | 28.8   | 53.5   | 18.6   | 0.6    | 68     | 41     | 34     |

Table 2. Cracking of sweet cherry fruits in the garden

| Variety | Rootstock | Cracked fruits, % of the total number of fruits | Type of cracking       |
|---------|-----------|-----------------------------------------------|------------------------|
| Amulet  | A-30      | - 0 0 0 1                                      | Cracks on the top      |
|         | 10-62-01  | - 0 0 0 0                                     | No cracks              |
|         | RVL-10    | - 0 0 0 0                                     | No cracks              |
|         | A-47-9    | - 0 0 0 1                                     | Cracks on the top      |
|         | A-12      | - 0 0 0 0                                     | No cracks              |
|         | VSL-1     | - 0 0 0 0                                     | No cracks              |
| Alexandria | 10-62-01  | - 0 0 0 0                                     | No cracks              |
|         | A-30      | - 0 0 0 0                                     | No cracks              |
|         | Antipka   | - 0 0 0 0                                     | No cracks              |
|         | A-20      | - 0 0 0 0                                     | No cracks              |
| Euphoria | A-47-9    | - 3 5 10                                      | Cracks on the top, side|
|         | 10-62-01  | - 1 3 8                                       | Cracks on the top, side|
|         | A-30      | - 2 5 11                                      | Cracks on the top, side|
|         | VSL-1     | - 1 3 5                                       | Cracks on the top, side|

In the Amulet variety, only apical cracking of the fruit was observed, while in the Euphoria variety, cracks were of two types: apical and lateral. The highest percentage of fruit cracking was observed in 2020, which is due to the influence of a combination of various factors, such as high humidity (more than 68%), low temperatures and precipitation during the ripening period.

Another important indicator that characterizes the quality of fruits is their taste and weight. In terms of taste, the fruits of almost all varietal-rootstock combinations, with the exception of Amulet/RVL-10, had a sweet dessert taste and, accordingly, were awarded the highest score (Table 3).

The average weight of one fruit, for four years of observations, varied within one variety, depending on the rootstock: in Amulet - from 9 to 11.6 g, in Alexandria - from 8.1 to 9.6 g, in Euphoria - from 6.7 to 10.7 g (Table 3). The greatest difference in fruit weight depending on the rootstock on which the variety is grafted was observed in varietal–rootstock combinations with the Euphoria variety, the difference was more than 40%. In this variety, the lowest weight was recorded on the rootstock of VSL-1 6.2 g in 2020, for the rest of the rootstocks, the difference in fruit weight was insignificant and ranged from 5 to 9%. In terms of size, the fruits of almost all the studied
varietal-rootstock combinations can be attributed to large-fruited, with the exception of the fruits of the Euphoria/VSL-1 combination.

Table 3. Pomological indicators of fruits of varietal-rootstock combinations of sweet cherries, 2017-2020.

| Varieties | Fruit weight, g | Taste, in points | One-dimensionality, in points | Yield, kg / tree |
|-----------|-----------------|------------------|-----------------------------|------------------|
|           | 2017  | 2018  | 2019  | 2020  | Av. | 2017 | 2018 | 2019 | 2020 | Aver. |
| Amulet    | A-30  | 12.3  | 11.7  | 11.1  | 11.6 | 5    | 0.1  | 1.7  | 13.5 | 17.2 | 8.2  |
|           | 10-62-01 | - 10.1 | 9.8 | 9.9 | 9.9 | 5 | 4 | - | 1.0 | 11.4 | 13.9 | 8.8 |
|           | RVL-10 | - 9.3 | 9.5 | 9.6 | 9.5 | 4 | 4 | - | 0.5 | 9.7 | 12.9 | 7.7 |
|           | A-47-9 | - 11.1 | 10.5 | 10.3 | 10.6 | 5 | 5 | - | 0.9 | 12.3 | 15.9 | 9.7 |
|           | A-47-9 | - 11.1 | 10.5 | 10.3 | 10.6 | 5 | 5 | - | 0.9 | 12.3 | 15.9 | 9.7 |
|           | A-12  | 11.9 | 10.7 | 9.2 | 10.1 | 10.5 | 5 | 5 | 0.2 | 2.1 | 13.5 | 17.9 | 8.5 |
|           | VSL-1  | - 9.1 | 8.9 | 8.9 | 9.0 | 5 | 5 | - | 1.4 | 12.4 | 15.8 | 9.9 |
|           | 10-62-01 | - 8.5 | 8.0 | 7.8 | 8.1 | 5 | 5 | - | 0.4 | 8.6 | 10.9 | 6.6 |
|           | A-30  | - 9.5 | 9.2 | 9.3 | 9.3 | 5 | 4 | - | 0.8 | 12.1 | 15.7 | 9.5 |
| Alexandria | Antipka | 10.5 | 9.5 | 9.3 | 9.3 | 9.6 | 5 | 4 | 0.2 | 1.5 | 13.7 | 16.7 | 8.0 |
|           | A-20  | - 9.2 | 8.8 | 8.9 | 8.9 | 5 | 5 | - | 0.6 | 9.3 | 11.8 | 7.2 |
|           | A-47-9 | 13.1 | 10.1 | 9.8 | 9.7 | 10.7 | 5 | 5 | 0.2 | 1.3 | 14.1 | 15.6 | 7.8 |
|           | 10-62-01 | - 9.0 | 9.1 | 8.9 | 9.0 | 5 | 5 | - | 1.1 | 14.3 | 16.1 | 10.5 |
| Euphoria  | A-30  | 12.9 | 9.5 | 9.2 | 9.3 | 10.2 | 5 | 5 | 0.3 | 2.5 | 15.2 | 17.2 | 8.8 |
|           | VSL-1  | - 6.3 | 6.5 | 6.2 | 6.3 | 5 | 5 | - | 0.9 | 7.7 | 13.1 | 7.2 |

Figure 1. Yield of varietal-rootstock combinations, average for 2017-2020

Another important qualitative characteristic for industrial fruit growing is the one-dimensionality of fruits collected from a single tree. In most cases, the studied cultivar-rootstock combinations had fruits equalized in shape and color and were rated with the highest score (Table 3). The combinations
Amulet/10-62-01, Amulet were not sufficiently one-dimensional fruits/RVL-10, Alexandria/A-30 and Alexandria/Antipka.

The study of the productivity of varieties on different rootstocks showed that the yield of varieties also varied within the same variety (Fig. 1).

The highest yield by variety was recorded in 2020 in the combinations Amulet/A-12 (17.9 kg/tree), Alexandria/Antipka (16.7 kg/wood) and Euphoria/A-30 (17.2 kg/wood). The lack of harvest in 2017 (single fruits) and low yield in 2018 is associated with the beginning of the entry into the fruiting season of young cherry plantations. In the following years, there was an increase in yield, which indicates the entry of trees into full fruiting.

4. Conclusions

As a result of studying the influence of rootstocks on the qualitative and quantitative indicators of sweet cherry varieties, significant differences in weight, one-dimensionality, resistance to cracking of fruits, as well as yield, within the variety were revealed. Among the studied variety-rootstock combinations, the high resistance of fruits to cracking was shown by the varieties Alexandria and Amulet on all rootstock forms. In the Euphoria variety, the percentage of cracking on various rootstocks, in the harvest years (2019 and 2020), varied from 3 to 11%, which characterizes this variety as medium-resistant. The highest percentage of cracking was observed in the combinations Euphoria/A-30-11% and Euphoria/A-47-10 – 10%, at the same time, the rootstock of VSL-1 allowed to reduce this indicator to 5%.

According to the one-dimensionality of the fruits, there were no significant differences in the variety-rootstock combinations within the variety. At the same time, the rootstock had a significant impact on the fruit weight and yield of the variety-rootstock combination within the variety. Among the studied varieties and rootstocks, the combinations Amulet/A-30, Amulet/A-12, Amulet/A-47-10, and Alexandria had the highest fruit weight and yield/Antipka, Alexandria/A-30 and most combinations of the Euphoria variety.

Thus, the influence of the rootstock on the productivity and quality of the fruits of the variety grafted on it was confirmed. When laying industrial gardens, it is necessary to take into account, along with the conditions of the area of the plot planned for the cultivation of sweet cherry, the choice of the variety itself, agricultural technology, and the selection of a stock that creates the possibility of managing the yield of grafted trees.

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