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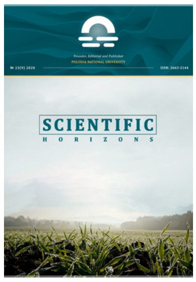

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Analysis of modern technologies for growing cherry varieties in temperate climates

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Abstract. The research relevance is predefined by the need to optimise fruit crop cultivation systems considering weather conditions. The research aims to test the grafting technology of intensive sweet cherry plantations on small and medium-sized rootstocks. The leading method in achieving the research goal was a field experiment. The main results of this study are as follows: the leading technologies for increasing the yield of sweet cherry varieties depending on the impact of environmental stress factors are presented; the use of clone rootstock

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technology in sweet cherry plantations in temperate climates is substantiated. According to a set of indicators of productivity formation, the yield of plantations of different designs was predicted. Namely, the scheme of variety-rootstock combinations of intercalary placement, its length, and parameters of the growth complex for plants were revealed; indicators of physiological activity, growth, productivity, fruit quality, and economic efficiency in intensive sweet cherry plantations were determined. It has been established that the application of this technology will increase yields and improve the quality parameters of sweet cherry fruits by developing varieties with compact crowns, which will allow to compact the plantations. It has been analysed that climatic conditions are the main factor in the process of harvest formation. A list of stress factors of temperate climate that affect the yield of sweet cherries has been identified. It is proved that the introduction of clonal rootstock technology is the most effective for growing intensive plantations of sweet cherries in a temperate climate. Practically, the research aims to determine and test a set of elements of physiological indicators of the potential yield of sweet cherry plantations of different designs, to introduce them into production and use them in further breeding

Keywords: fruit trees; stone fruit plant; horticulture; yield; innovative methods of reproduction; optimal breeding conditions

INTRODUCTION

Due to its agrobiological potential, Ukraine is a leader in global sweet cherry production. Adaptive horticulture is the leading principle of modern fruit production, which considers the maximum of optimally dosed factors of horticultural productivity. Currently, there are many technologies for growing sweet cherries in temperate climates. However, the disadvantage of most of the technologies traditionally used in Ukraine for growing sweet cherries was the late entry of trees into commercial fruiting and the complicated process of processing large trees in the orchard. High yields of sweet cherries are influenced by agronomic, management and natural and climatic factors. In such conditions, the optimal technology for ensuring sweet cherry yields is the use of small and medium-sized rootstocks in intensive plantations of sweet cherries. Therefore, the study of the effectiveness of rootstock technology implementation has been the most relevant topic in scientific institutions in recent years. The development of modern technologies for growing fruit trees was carried out by O.A. Kishchak and Yu.P. Kishchak (2021), T. Malyuk *et al.* (2021), B. Gulko (2020), J. Blažek *et al.* (2022), P. Drogoudi *et al.* (2020) and A. Küden *et al.* (2022).

In recent years of independent Ukraine, agricultural specialists tested numerous different rootstocks and layouts of sweet cherry trees. However, the optimal design of intensive plantations does not yet exist. The design of such plantations is determined by the variety, rootstock, and crown shape, and all these factors must be considered, as the determination of one affects the performance of the other. The study of increasing the yield of sweet cherries by rootstock of weak and medium-sized trees was carried out by J. Lanauskas *et al.* (2023). The design of plantations using this technology must meet certain standards: a straight trunk and a developed root system, the trunk and root must be healthy, the latter without significant distortions of the root collar, rootstocks must be of the same age and undamaged, with homogeneous species composition and quality.

Organic technology, which is applied without the use of synthetic chemical pesticides and mineral fertilisers, is one of the innovative technologies in modern horticulture, which was introduced by T. Herasko (2021). Based on this technology, sweet cherries are grown by calculating the balance of water regime, photosynthetic pigments, leaf area and biochemical composition of the fruit. The fruits of such cherries can be consumed without fear for the health of children and adults; however, organic cherries are not grown on an industrial scale because, from a practical point of view, they are not very efficient.

Given the current economic conditions and the development of gardening enterprises in Ukraine, production volumes are characterised by the yield of fruit crops. According to research by O. Kishchak *et al.* (2020), 50% of fertile lands have shifted climatic zones and desertification is observed in some central regions of Ukraine, which will subsequently lead to significant changes in fruit tree yields. Unseasonal frosts or too warm winters and other negative natural factors affect gross harvest rates. Therefore, the technology of sweet cherry cultivation, which considers environmental compliance or discomfort with certain weather factors, is one of the important issues for researchers.

O. Alekseeva and P. Bondarenko (2021) proves that the process of intensive cultivation of sweet cherries using weak rootstocks should consider the physiological structure of generative formations, their density and number, the number of fruit buds on these formations, the number of flowers on these buds. It is also indicated that the length of the generative insert should be no more than 30 cm, as it is under these conditions that the greatest productivity potential can be predicted.

Considering the above-mentioned, the research aims to study the effectiveness of clone grafting for intensive gardening in the central region of Ukraine.

MATERIALS AND METHODS

The field study was conducted at the farm in the village of Chaplyka, Pavlohradskyi district, Dnipro region. The climate of the study area is temperate continental, with an average winter temperature of -5...-6°C, summer temperature of +22...+23°C, with an average annual precipitation of 400 to 490 mm, and northeast and east winds. The soil of the study area is simple black soil with a high percentage of fertility (Drobitko *et al.*, 2022).

Two sweet cherry varieties were used in the study: Valeriy Chkalov (early ripening) and Krupnoplidna (late ripening) in a young plantation (3-6 vegetations). The first variety forms vigorous trees with large fruits. The second is a medium-sized tree with large fruits. Both varieties have high commercial characteristics. Seedlings of Magaleb cherry (Antipka) and Gisela 5 were used as rootstocks. The rootstocks of Magaleb cherry seedlings make the trees vigorous and resistant to drought and frost. The advantage of this rootstock is a reduction in fruit ripening and an acceleration of productivity after planting. This type of rootstock is widely used in the formation of orchards because of its ease of propagation, ease of budding and good growth of grafting components. Gisela 5 is a rootstock that reduces the vigour of tree growth, this type of rootstock is most popular in Europe. Although the use of Polish, Hungarian and American rootstock technologies in Ukraine does not allow for high yields in temperate climates, Ukrainian researchers are conducting studies to adapt these technologies to the Ukrainian climate. The advantage of this technology is the good growth of components at the grafting site and good angles of skeletal branches, which produce small root shoots. The growth vigour of trees grafted with Gisela 5 is reduced by 50%, and such cherries enter commercial fruiting early with a high level of efficiency. Trees become suitable for high-density and intensive planting. The disadvantages of this rootstock variant are the risk of damage to early flowering by spring frosts, the tree ages quickly due to high productivity, and the tree needs additional support due to the reduced root system and spindle-shaped crown.

The experimental study lasted for 1 year and had two variants: studying the effect of inserts of Magaleb cherry seedlings (Antipka) on the yield of cherry trees of the Krupnoplidna variety and studying the effect of Gisela 5 clone rootstocks on the yield of sweet cherries of the Valery Chkalov variety. The experimental plots had an area of 200 m^2 (5 m × 3 m and 5 m × 4 m, respectively), with 10 trees on each plot.

Each of the trees was selected through phenological observations, and the main indicators of yield prediction were also noted through these observations. These indicators include stem circumference, crown parameters, number and length of shoots, degree of flowering and useful ovary, the density of generative formations, average fruit weight and diameter. Leaf surface area was also taken into account as one of the parameters of the predicted yield, and the content of pigments chlorophyll *a* and carotenoids *b* was determined using a UNICO 2800 UV/VIS spectrometer. The length of the intercalary in all variants was 20 cm. The agronomic conditions of the research in all variants were identical. Statistical processing of the data obtained was carried out using Agrostat New and Minitab 16 computer programs.

RESULTS

To create intensive sweet cherry plantations in temperate climates, special attention should be paid to a comprehensive study of the main parameters of tree growth. Specifically, budding height and planting depth, quality of varieties, rootstocks, the density of varieties, types of crown formation, degree of pruning, and water and nutrient conditions. This study traced the interconnection of the elements of plantation design: variety and rootstock combinations, layout, and tree crown shape. Table 1 shows one of these parameters, namely, biometric parameters of tree crowns and boles depending on variety-rootstock combinations.

Table 1. *Biometric indices of crown and bole formation in sweet cherries Krupnoplidna on Antipka rootstock and Valery Chkalov on Gisela 5 rootstock*

Rootstock variants	Variety of sweet cherry	Plot size	The cross-sectional area of the bole, m^2	Crown projection area		Crown area	
				Actual, m^2	The utilisation of the feeding area, %	Actual, m^3	The utilisation of growth space, %
Antipka	Krupnoplidna	5 m × 3 m	254.3	8.4	63	8.3	52
		5 m × 4 m	326.7	8.8	80	9.8	59
Gisela 5	Valery Chkalov	5 m × 3 m	167.3	9.1	86	9.7	57
		5 m × 4 m	198.5	10.2	73	10.7	69

Source: *compiled by the authors*

In this study, when planting trees, the stem height indicator was used at the level of 50-70 cm, which is a standard value for industrial plantations. The Krupnoplidnaya variety outperformed the Valery Chkalov variety in terms of the cross-sectional area of the stem by almost 26%, and in terms of stem growth by 1.5 times, indicating that the Krupnoplidnaya sweet cherry variety was characterised by more intensive growth during the study period. It was proved that the assessment of tree growth vigour due to the development of living space in terms of the projection area and crown volume was 8-11% higher in 5 m × 4 m plots than in 5 m × 3 m plots. This suggests that the density of tree planting affects stem growth by increasing the feeding area of trees. The optimal tree height was 3.3-3.5 m, which was sufficient to ensure optimal radiation exposure of the plantations, and the row spacing was 5 m, which meets the established standards for orchard spacing. According to the indicators in Table 1, the allocated nutrition area for the 5 m × 3 m tree layout is 10.5 m, and for the 5 m × 4 m layout it is 14 m, i.e., the second variant of the layout is 19% more efficient on average in terms of space utilisation.

The vegetative growth of trees in a year can be assessed by the total annual growth of trees. This figure includes the number of annual growths on a tree, the average length of one growth, and the total length of annual growth of trees. Given that sweet cherries have a shoot-forming and shoot-regenerating ability of the buds, the number of annual growths is less than that of other stone fruit trees.

Therefore, for the cultivation of competitive intensive plantations, the annual growth rate of a tree is important. For stable, high-quality fruiting, which is ensured by the uniformity of fruit distribution throughout the crown, it is necessary to replace overgrown wood regularly.

Table 2 shows how the growth vigour changes depending on the influence of clonal rootstocks.

Table 2. *Annual growth of sweet cherry trees depending on variety and rootstock combinations*

Rootstock variants	Variety of sweet cherry	Plot size	The number of growths per tree, pcs	The average length of one growth, cm	Total annual growth	
					of 1 tree, m	1 ha, thousand meters
Antipka	Krupnoplidna	5 m × 3 m	163.6	39.6	64.8	43.2
		5 m × 4 m	191.4	45.6	87.3	43.6
Gisela 5	Valery Chkalov	5 m × 3 m	137.4	43.6	59.9	40.0
		5 m × 4 m	173.2	43.8	76.3	38.1

Source: *compiled by the authors*

Thus, according to the data in Table 2, it is proved that the insertion of mahaleb cherry seedlings (Antipka) on one tree of the Krupnoplidna variety formed an average of 166.7 growths per vegetation period, which is 19% more than the insertion of Gisela 5 clone rootstocks on trees of the Valery Chkalov variety. Comparing the arrangement of trees in the 5 m × 3 m and 5 m × 4 m plots, we can say that the formation of denser tree crowns, less prone to bareness, was observed in the 5 m × 4 m plot.

For effective fruiting, the average length of one growth should be more than 30 cm, a decrease in this indicator indicates insufficient vegetative growth and trees require pruning, and an indicator of more than 60 cm for tree growth is excessive, which leads to a decrease in the amount of fouling wood. In this study, the average length of one growth is 37.5-45.6 cm, which indicates a balance of growth and fruiting processes in the plantations. The growth vigour of sweet cherry trees depended to a small extent on the design of the plantations. Namely, trees of the Krupnoplidna variety had a total growth of 42.1-46.0 m/ha, and trees of the Valery Chkalov variety had a total growth of 34.1-40.6 thousand m/ha. In the 5 m×4 m plot, the total annual growth of the trees was 72.8 m, which is 21% more than the total growth in the 5 m×3 m plot, where the compaction of the plantations from 667 trees/ha to 1000 trees/ha reduced the annual growth by 24%.

The next indicator used to predict yields is photosynthetic activity. For trees grafted onto intercalators, the energy they accumulate during photosynthesis is used to form organs and crops. The process of photosynthesis fully depends on the area of the leaf plate on the shoots. It was found that this indicator on the leaves of bouquet branches was at the level of 43.7-45.5 cm^2 and did not depend on the variant of rootstocks. During the phenological observation, it was noted that sweet cherries of the Krupnoplidna variety had slightly larger leaves (70 cm^2) than trees of the Valery Chkalov variety (41 cm^2). All the above factors affect the size of the leaf surface, namely, its increase. Thus, the leaf surface area of Krupnoplidna sweet cherry increased by 23% after inoculation with Antipka, and that of Valery Chkalov by 21%. This increase in the number of leaves was due to an increase in the number of growths on the tree and the total annual growth (Table 3).

Table 3. *Leaf area and leaf index depending on the planting design*

Rootstock variants	Variety of sweet cherry	Plot size	Leaf area		Leaf index, m^2 leaf area	
			1 tree, m^2	1 ha, thousand, m^2	per 1 m^2 of crown projection surface area	per 1 m^3 of the crown area
Antipka	Krupnoplidna	5m × 3m	54.3	36.2	6.4	6.6
		5m× 4m	81.4	40.7	9.2	8.3
Gisela 5	Valery Chkalov	5m × 3m	53.5	35.7	5.9	5.5
		5m× 4m	77.2	38.6	7.6	7.2

Source: *compiled by the authors*

Considering the leaf area of a 5 m × 3 m planting density of 667 trees/ha, this figure decreased by 20%, compared to a 5 m × 4 m plot with a density of 500 trees/ha. Leaf index refers to the level of leaf coverage of tree crowns per unit projection area or crown volume. This index is also 15% higher in the 5 m × 4 m layout, which is explained by better crown illumination and a larger feeding area due to improved water and nutrient conditions. Krupnoplidna sweet cherries have a 1.2 times higher leaf index than Valery Chkalov sweet cherries due to the more compressed pyramidal shape of the tree crown. Thus, to improve yields, it is necessary to form a sufficient leaf area.

The main photosynthetic pigments studied in this experiment were chlorophyll *a* and *b*. The content of the former in the leaves ranged from 3.50 to 5.50 mg/g of dry matter, i.e., 57-62% of the total pigment content in the dry matter of the leaves; and the content of the latter was on average 2.8 times lower. The content of carotenoids is 3.0 times lower compared to chlorophyll. Such indicators correspond to the physiological optimum of sweet cherries (Table 4).

Table 4. *Content of photosynthetic pigments in sweet cherry leaves depending on tree crown zones*

Rootstock variants	Variety of sweet cherry	Plot size	Chlorophyll *a*, mg/g		Chlorophyll *b*, mg/g		Carotenoids, mg/g	
			periphery	centre	periphery	centre	periphery	centre
Antipka	Krupnoplidna	5 m × 3 m	4.35	5.50	1.46	1.93	1.54	1.77
		5 m × 4 m	3.72	4.95	1.31	1.80	1.30	1.53
Gisela 5	Valery Chkalov	5 m × 3 m	3.68	4.96	1.19	1.87	1.33	1.54
		5 m × 4 m	4.05	4.26	1.34	1.58	1.29	1.47

Source: *compiled by the authors*

As can be seen from Table 4, the ratio of chlorophyll *a* to chlorophyll *b* averages 3.04, and 2.72 in the central part of the crown. These values are within the physiological norm for sweet cherries. However, there is an increase in the proportion of *b*, which is an indicator of the adaptation of shade leaves to low-light conditions. According to the layout and rootstock variant, the Krupnoplodnaya sweet cherry variety can be distinguished on a 5 m × 3 m plot. It is known that a lack of light leads to a decrease in the thickness of the leaf blade and the number of layers of mesophyll-containing chloroplasts. Therefore, the specific gravity of dry matter of leaves from the crown periphery in this area averaged 75.1 g/m^2 leaf surface, which is 33% higher than that of leaves in the crown centre. Thus, the increase in specific gravity is due to the thickening of the leaf blade, not the proportion of dry matter in the leaves. Thus, this indicator proves that leaves with sufficient light levels outnumber shaded leaves in terms of chlorophyll *a* and *b* content, which allows compensation for the lack of photosynthetic pigments in the central crown zones. This fact once again proves that the content of photosynthetic pigments and their ratio ensures the passage of fruiting processes in sweet cherries.

Up to 80% of the sweet cherry fruit yield is formed in bouquet branches, which are laid on branches of two years and older, and the remaining 20% is formed at the base of annual shoots. The formation of bouquet branches is a long-term process that results in special generative formations. The durability and productivity of these formations depend on the factors discussed above in this study: lighting conditions, photosynthesis rates in leaves, and the age of the generative formation. The analysis of the density of generative formations on the wood of different ages in this study showed that the density of generative formations decreased with increasing age. Thanks to this analysis, it was possible to estimate the yield potential of the plantations. On average, 19.4 bouquet branches per 1 m were formed on two-year-old wood, and 17.4 pcs/m on three-year-old wood, which is 10% less. Starting from the age of four, the number of generative formations decreased by 31% (Table 5).

Table 5. *The density of bouquet branches on the wood of different ages depends on the grafting option and placement scheme*

Rootstock variants	Variety of sweet cherry	Plot size	The density of branches, pcs/m		
			2-year	3-year	4-year
Antipka	Krupnoplidna	5 m×3 m	19.0	17.5	10.5
		5 m×4 m	20.0	18.0	11.5
Gisela 5	Valery Chkalov	5 m×3 m	19.0	16.5	12.0
		5 m×4 m	20.0	17.0	13.5

Source: *compiled by the authors*

Thus, as can be seen from Table 5, there are no differences in the density of generative formations by rootstock variant, only in the combination of Antipka and Krupnoplidna, worse preservation of bouquet branches was observed on a four-year-old tree compared to Valery Chkalov sweet cherry, which is explained by the early ripening of this variety and spring frosts that were recorded during the experiment. According to the layout, it was found that the 5 m×4 m plot had 14% more generative formations at the age of two and three years than the 5 m × 3 m plot. On trees of four years of age, the density of bouquet branches did not depend on the layout.

The last two indicators that show the formation of the productivity of the varieties of these sweet cherries are the number of flowers per generative bud and the quality of the fruit. On average, the trees formed 2.77 flowers per fruit bud. Depending on this indicator, both sweet cherry varieties showed a tendency to increase yields in terms of fruit quality (Table 6). This suggests that higher yields can be achieved by introducing clonal rootstocks and by introducing cherry seedlings. Also, it should be noted that the average fruit weight was 5% higher in the 5 m × 4 m plot. These results confirm the influence of the feeding area on fruit size. The fruits of Krupnoplodnaya sweet cherry had an average weight of 7.3 g and 23.8 mm in diameter, and the fruits of Valery Chkalov sweet cherry had an average weight of 10.4 g and 28.0 mm in diameter.

Table 6. *Structure of predicted yields by rootstock variant and placement scheme*

Rootstock variants	Variety of sweet cherry	Plot size	Number of bouquet branches, pcs	Number of flowers per fruit bud, pcs	The yield of sweet cherry plantations, t/ha
Antipka	Krupnoplidna	5 m × 3 m	944.4	2.59	4.5
		5 m × 4 m	789.6	2.60	5.1
Gisela 5	Valery Chkalov	5 m × 3 m	1521.2	3.12	5.2
		5 m × 4 m	1146.3	3.19	5.5

Source: *compiled by the authors*

Thus, as can be seen from this research, both sweet cherry varieties on Antipka and Gisela 5 rootstocks have good yields in temperate climates. According to a set of indicators of actual and specific yields, it was proved that this technology is optimal in improving fruiting performance. The yield indicators obtained in this study meet not only the requirements of the state standards of Ukraine in the agricultural industry but also the international standards of the United Nations Economic Commission for Europe. Thus, this study proved that the genotype of the variety has the same influence on the physical parameters of fruit quality as the construction elements of rootstock plantations, intermediate inserts, and tree layout.

DISCUSSION

Today, the implementation of optimal agricultural practices requires improving the technical and organisational capabilities of growing planting material in a shorter time frame, while preserving the biological characteristics of crops and varieties. Maintaining the potential yield of plantations under current environmental conditions is virtually impossible due to the uncontrolled impact of these natural conditions on fruit yields. Therefore, the entire process of plantation care should be aimed at improving the production process of trees.

Achievements in the agricultural industry are fragmented, with some advanced studies assessing potential yields based on several factors: the intake and absorption of photosynthetically active radiation, moisture availability of plantings, soil fertility and plant uptake of nutrients, while some studies only consider the impact of anthropogenic factors. This diversity in research does not allow for the creation of a single technology for realising the yield potential of plants. According to S. Szilágyi *et al.* (2022) and H. Sarisu (2021), this process requires a comprehensive study. For example, the authors prove that the methodology of integral assessment of the realisation of yield potential by breeds and varieties is based on determining the degree of influence of individual weather factors on yield. That is, for industrial agriculture, it is important to determine the predicted yield based on a comprehensive analysis of the elements of the yield structure or the process of plant productivity formation.

This was the research aims – to predict the potential yield of the KrupnQoplidna and Valeriy Chkalov sweet cherry varieties using clone rootstocks and Magaleb cherry seedlings, where each of the rootstock variants was used to adjust the potential of sweet cherries, adapting it to temperate climate conditions and increasing demand in the international market.

In contrast to traditional sweet cherry growing technologies, the main requirements for rootstocks on intensive planting trees, according to J. Ortega-Vidal *et al.* (2021) and K. Németh-Csigai *et al.* (2023) is to reduce the volume of crowns due to a decrease in tree growth force, which will allow to compact the planting, adapt to the soil and climatic conditions of the growing area, increase the rate of fruiting and increase the yield of high quality, simplify the reproduction procedures, reduce root shoots and increase disease resistance. And as this study proves, this technology successfully copes with these requirements. This is confirmed by the high predicted yields.

The main countries where the search for modern technologies for growing cereals began were Germany, the Czech Republic, the USA, Italy, and France. In Ukraine, these technologies are just beginning to develop, but the first results of their implementation are noticeable.

One such organic technology is implemented without the use of synthetic chemical pesticides and mineral fertilisers (Mero *et al.*, 2023). T. Herasko (2021) proves the effectiveness of this technology by studying the impact of the physiological state of sweet cherries on their yield. In his study, the author shows how the water regime, the content of photosynthetic pigments in the leaves and the biochemical composition of the fruit affect yield indicators. Preserving the organic characteristics of the soil is considered the basis of organic technology in horticulture. Blackening contributes to the maintenance of the soil in the garden, namely, maintaining the required level of beneficial soil microorganisms, optimal soil temperature and moisture. This study showed that after introducing sod in the form of mowed natural grasses into the aisles of an unirrigated garden, the soil cools down to 28°C, compared to 37°C in the control plot (black fallow), meaning that the use of natural grasses as sod maintains a moderate soil temperature, which allows for sufficient moisture to be maintained. And the analysis of biologically active substances in sweet cherry leaves indicates that the content of sugars, titratable acids, phenolic substances, ascorbate, and glutathione is preserved compared to those trees whose soil was not subjected to sodding. The author notes that the use of this technology is a concern for the environment and healthy eating. In addition, this technology is aimed at the European market, where organic sweet cherries meet standards without the use of synthetic chemical pesticides and mineral fertilisers. However, this technology is not used on an industrial scale in Ukraine due to the lack of scientific research and the low efficiency of this technique in terms of accelerating and increasing sweet cherry fruiting. And the question of the optimal soil maintenance system for an organic orchard remains with the grower. Instead, the use of rootstock technology allowed to increase the yields of the Krupnoplidna and Valeriy Chkalov varieties.

Another technology that can be used in modern agriculture to achieve predictable yields is seed stratification. This technology makes it possible to control the process of tree germination from the very beginning and accelerate the time of seed maturation. In their study, S. Tabakov *et al.* (2020) and R. Marini (2020) applied the stratification technology to such sweet cherry varieties as bird cherry, Antipka cherry, and common cherry. All these varieties are actively used for rootstock technology, but before using them as rootstocks, it is necessary to check their properties as cherries. The stratification period for these cherries lasted 110-140 days for Bird cherry; 90-120 days for Antipka cherry; 120-180 days for common cherry. Stratification is the process of internal ripening of stone fruit seeds, which involves placing the seeds in a room with an average monthly temperature of 4°C, pre-mixed with any substrate (sand, sawdust, peat) and water. During stratification, the seeds absorb moisture evenly, which helps them to undergo internal maturation and germination. The complexity of this technology is timely sowing, as the germination process is rapid, and the weather conditions must be suitable for the biological properties of the seeds. The sweet cherry seeds were sown in autumn and treated with growth stimulants: gibberellic acid, cytokinin, ethylene, and thiourea. After the seedlings germinated in spring, they were placed according to the 7 m × 5 m scheme, the author of the article notes the inappropriateness of such placement, because, at an older age under such conditions, the trees will lose 50-60% of solar energy and nutrients, because cherries slowly absorb the feeding area. The study of this article proves that the 5 m × 4 m layout is more optimal for better production of photosynthetic products by trees.

The creation of a sufficient area of the assimilation apparatus is extremely important in the formation of a high yield and quality of fruits. According to the studies of E. Vignati *et al.* (2022), L. Kapoor *et al.* (2022), and A.J. Simkin *et al.* (2020), with an increase in the ratio of leaf area to the number of fruits on the tree, all indicators of sweet cherry fruit quality increased. It is noted that 32 cm^2 leaf surfaces are required to increase the weight of 1 g of fruit. The data obtained in the study of the article confirm this fact, namely, the leaves of trees in the 5 m × 3 m arrangement had 54% less leaf surface area than the leaves of trees in the 5 m × 4 m arrangement. Therefore, the compaction process should preserve all the physiological properties of sweet cherries, i.e., be reasonable.

The budding technology is becoming increasingly widespread in the global nursery industry. This technology is based on replacing a part of the rootstock bark with a part of the bark with a cuttings eye. This can be done from early May to late August, regardless of the degree of bark lag. This technology has gained popularity due to its ease of implementation and high scion survival rate. Scion survival is one of the most important elements of the structure of plant productivity formation. High-quality budding results in a higher survival rate of the eyes than in traditional rootstock grafting. Thus, in the studies of T. Arsov *et al.* (2020), sweet cherries, the rootstocks of which were treated with the budding technique, gave high fruit quality indicators. In modern market conditions, this indicator is responsible for fruit size, colour, density, stem length and taste. As noted above, the use of rootstock technology allows the achievement of the predicted yield with high-quality fruits, and the budding method will ensure the assimilation of the rootstock by the trees.

CONCLUSIONS

Modern technologies for intensive sweet cherry cultivation involve considering all physiological processes (occurring inside the plant) and external factors such as climate, soil, and irrigation conditions. The transition to intensive sweet cherry cultivation, using weak rootstocks on vigorous plant varieties and vice versa, requires considering such technologies as thickening tree layouts and developing varieties with high genetic yield potential. Consideration of these patterns gives the desired results in predicting sweet cherry yields.

Thus, it was possible to prove that both plant varieties produced enough yield depending on the potential of the variety. However, the trees of the Valery Chkalov variety were characterised by a greater number of increments and total annual fruit growth compared to the Krupnoplidna sweet cherry variety. Trees of the variety Valery Chkalov are characterised by greater vigour of tree growth in terms of a set of indicators, however, in a few years the crowns of such trees reach large sizes, become branched and the quality of the fruit decreases. Sweet cherries become smaller in diameter than is customary in today's market conditions, and profitability decreases as a result. Thus, it has been proven that the use of Gisela 5 clone rootstock inserts balances the physiological potential of the Valeriy Chkalov variety and maintains high-quality fruiting. In turn, the Krupnoplidna variety also showed a high fruiting potential (5.1 t/ha) with a smaller amount of annual growth. This is explained by the fact that under the influence of the insertion of Magaleb cherry seedlings (Antipka), this variety begins to bear fruit earlier than the Valery Chkalov cherry variety and passes the age periods of tree development faster.

That is, under the conditions described in this study, the natural potential of the varieties is somewhat adjusted, but the yield does not deteriorate. The prospect of further research may be additional field studies over several years to study the yield potential of these sweet cherry varieties on the specified rootstock variants in temperate climates.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Аналіз сучасних технологій вирощування сортів черешні в умовах помірного клімату

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Анотація. Актуальність дослідження зумовлена необхідністю оптимізації систем вирощування плодових культур з урахуванням погодних умов. Метою досліджень є відпрацювання технології щеплення інтенсивних насаджень черешні на малих та середніх підщепах. Провідним методом у досягненні мети дослідження став польовий дослід. Основними результатами дослідження є: наведено провідні технології підвищення врожайності сортів черешні залежно від впливу стресових факторів середовища; обґрунтовано використання технології клонової підщепи в насадженнях черешні в умовах помірного клімату. За комплексом показників формування продуктивності прогнозували врожайність насаджень різних конструкцій. А саме, виявлено схему сортопідщепних поєднань інтеркалярного розміщення, його довжину та параметри комплексу росту рослин; визначено показники фізіологічної активності, росту, продуктивності, якості плодів та економічної ефективності в інтенсивних насадженнях черешні. Встановлено, що застосування цієї технології дозволить підвищити врожайність та покращити якісні показники плодів черешні за рахунок виведення сортів з компактною кроною, що дозволить ущільнити насадження. Проаналізовано, що кліматичні умови є головним чинником у процесі формування врожаю. Визначено перелік стресових факторів помірного клімату, що впливають на врожайність черешні. Доведено, що впровадження технології клонової підщепи є найбільш ефективним для вирощування інтенсивних насаджень черешні в умовах помірного клімату. Практична мета досліджень – визначення та перевірка комплексу елементів фізіологічних показників потенційної врожайності насаджень черешні різних конструкцій, впровадження їх у виробництво та використання в подальшій селекції

Ключові слова: плодові дерева; кісточкова рослина; садівництво; урожайність; інноваційні способи розмноження; оптимальні умови вирощування