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TRAINING SYSTEMS FOR ORCHARDS HIGH-DENSITY CHERRIES FROM THE REPUBLIC OF MOLDOVA

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Abstract

The study was conducted between 2010 and 2024 in the central and northern fruit growing area of the Republic of Moldova to evaluate the effect of the cherry (Prunus avium L.) training system on fruit growth, yield and quality, comparing four training systems (Thin spindle; Cup; Kym Green Bush; Improved thin spindle) to five varieties (Early Star, Samba, Black Star, Kordia and Regina) grafted on Gisela 6 rootstocks, with trees planted at a distance of 4x1m and 4x2m. The crowns of the trees, at the age of 6-7 years, formed continuous rows in the direction of the row, covering the soil with the projection of the crown at 61-63.7%, having the lateral area of the crown of 21300-22450 thousand m^2/ha and the volume of the crown of 158 m^3/ha 153858-22450. During the fruiting period the trees have a slower growth rate compared to the growing period. The cumulative yield of the cultivar Samba 8.43-10.88 t/ha and Black Star 7.66-9.84 t/ha, grafted on Gisela 6, during the period of growth and fruiting of the trees was higher for the cherries formed according to the thin spindle crown.

Key words*: sweet cherry cultivar, crown, density, productivity, quality.*

INTRODUCTION

Cherry can be grown in different orchard systems and crown shapes, depending on the soil, light, heat, rainfall, etc., the workforce, the available technology and the fruit production market (Babuc, 2012; Balan et al., 2001; Ivanov, 2012). Management and pruning systems have a primary role in cherry cultivation because the crown structure should facilitate harvesting, as well as tree management operations during vegetation (Asanică, 2012; Balan, 2015; Balan and Ivanov, 2016). Tree management forms can be classified into: improved natural, improved modified natural, artificial with various geometric shapes and internal structures. Currently, in the semi-intensive system, the crown forms used are Spanish Bush, Improved Pot, Naturally Improved Palmeta and in the intensive and super-intensive system - Super Fuss Axis, Thin Spindle, Upright Fruiting Offshoots System (UFO) Super Slender Axe (SSA), Tall Spindle Axe (TSA), Drapeau Marchand, Tall Fusiform Axis (Babuc et al., 2015).

Low-volume crown forms such as Improved Pot, Drapeau Marchand, Spanish Shrub, Naturally Improved Palmeta, Kym Green Bush in combination with medium-vigorous rootstocks (Gisela 12, Krymsk 5, Maxma 14, Piku 1, Piku 4, Ceravium ® PHL A) are grown on fertile and less favorable soils (Babuc et al., 2015; Cimpoieș, 2018). Spindle crown shapes such as Super Fuss Axis, Tall Fusiform Axis, Thin Spindle, Super Slender Axe (SSA), Tall Spindle Axe (TSA), in combination with medium-low (Gisela 6, Krymsk 6, P-HL-C) and medium (Gisela 12, Krymsk, 145, Max, 14, 14). The rootstock of vigor Ceravium ® PHL A) is practiced on fertile and irrigated soils from high-density orchards (Balan et al., 2023, 2024; Balmer, Blanke, 2005). Regardless of the shape of the crown, the maintenance pruning of the crown is used according to the physiological state of the tree to obtain the projected shape. In the first 2-3 years after planting, severe pruning intensifies vegetative growth and delays fruiting. In modern orchards, trees are allowed to grow as freely as possible, with no pruning or minimal pruning required (Blažková, Drahošová, 2012; Elfving, Visser, 2009; Ghena et al., 2004; Агафонов, 1983).

Currently, free-growing spindle crown forms such as Tall Fusiform Axis, Tall Spindle Axe (TSA), Super Slender Axe (SSA), Super Fuss Axis, Thin Spindle, associated with vegetative rootstocks of different vigor in plantations with

high density (2500-3000 trees/ha) are accepted. These crowns allow the formation of continuous, well-ventilated and illuminated rows, the filling of branches with fruit formations, the early entry into fruiting and obtaining large harvests, the making of pruning and harvesting from the ground or from small ladders (Babuc, 2012; Long et al., 2014). Modern fruit growing provides for minimizing pruning during the growing period of trees and replacing them with horizontal routing of shoots to slow down growth and differentiate buds from fruit earlier, as well as early fruiting of trees. Early harvests attenuate the vegetative growth characteristic of this stage. Throughout the fruiting period, tree pruning is carried out by maintenance pruning and fruiting to ensure harvests year after year (Balan et al., 2001; Bennewitz et al., 2011; Cimpoieș, 2000).

The purpose of this research was to evaluate the effect of the cherry formation system on the growth, yield and quality of cherry fruits (Prunus avium L.) in the central and northern areas of the Republic of Moldova. Theoretical and experimental studies focused on six crown shapes: Naturally improved crown with low volume (control); Thin spindle; Cup; Kym Green Bush; Improved thin spindle.

MATERIALS AND METHODS

The study was carried out between 2010 and 2024 in the central and northern fruit growing area of the Republic of Moldova at Ustia LLC "Staragrogroup" Dubasari district and ProdCar LLC, Negureni commune, Telenesti district and in the cherry orchard of the Sermofarm company, Sturzeni village, Riscani district.

Experience 1 was established in the autumn of 2015 with the Early Star, Samba, Black Star cherry varieties, grafted on the Gisela 6 rootstock, with the trees planted at a distance of 4x2 m. Low-volume crown shapes have been studied: Thin spindle; Cup; Kym Green Bush.

Experience 2 was organized in Sturzeni, in the spring of 2018 with the Kordia and Regina varieties, grafted on Gisela 6, at a distance of 4 x 1 m. Trees are led by the classic slender spindle crown and improved thin spindle.

In all orchards, the varieties are grouped in bands of 8-10 rows of each cultivar, with the rows of trees oriented from north to south. The formation of the crown and the vigor of the trees were controlled by the method of double sectoral pruning (Babuc, 2012) and the cutting of branches that exceed half of the growth vigor of the branches on which they are located, with the aim of optimizing the growth ratio of the vegetative and reproductive organs in order to accelerate the entry of the trees into fruiting. The half-skeleton branches are periodically renewed by rotation once every 3-4 years.

The researches were carried out, in terms of tree formation and pruning, according to the methodical guidelines for carrying out investigations with fruit species (Moiseicenco et al., 1998). To determine the influence of the crown formation system of cherry trees on the growth, fruiting and productivity of trees, the following were performed: biometric analyses (trunk diameter, crown height and width, average and sum length of annual branches, yield, fruit mass and diameter); biochemical analyses (dry matter, total sugar content, titratable acidity, fruit fermity) (Balan et al., 2001).

The morphological studies of the trees were carried out annually, at the end of the growing season. At 32 trees, the height of the trees and the width of the crown were measured, at 4 trees, the number of vegetative branches, the average and total length of the annual branches was determined.

The harvest was determined at the maturity stage of fruit consumption, for each tree separately by weighing the fruits from 32 trees in the variant and calculating the arithmetic average, and the yield was reported per hectare. During the fruit development and ripening period, the diameter and mass of the cherries were determined using a template (VOEN, Germany) with holes of 24, 26, 28, 30, 32, 34 and 36 mm, corresponding to a mass of 7, 8.5, 10, 11.5, 13, 14.5 and 16 g, respectively. These analyses were recorded on 20 cherries in four identical samples (n=80) of each variety. The average weight of the cherries was determined at the time of harvest by weighing a 1 kg sample of cherries using a digital scale (model AS 82/220.X2) with an accuracy of ± 0.01 g, and by counting the cherries in each sample.

The soluble substance content in the fruit was measured directly in the orchard using a digital refractometer (models ATAGO N-20E and

DR201-95), with results expressed as a percentage of Brix.

Titration acidity was established by neutralization with 0.1 N NaOH solution in the presence of phenolphthalein, expressed as malic acid in %. Fruit hardness was measured using an AGROSTA 100 penetrometer produced by Firm Tech with a favorable measurement value for cherry fruits above 250 g/mm^2 (Long et al., 2014). For the interpretation of the scientific results, methods such as analysis, synthesis, tabulation, comparison, and graphing were employed. The data were processed and presented as average values over the research years.

The study results were verified through analysis of variance (ANOVA) using Microsoft Office Excel 2003. Differences between the treatment options were compared at a significance level of 0.05 using the Tukey test (Dospëkhov, 1985).

The experimental plots are characterized by flat to slightly fragmented terrain, fertile soils, moderate water availability, and weak erosion processes. Predominant strong winds come from the north, and the frost-free period ranges from 180 to 190 days. The first frosts are visible from mid-October, the last frosts in mid-May. In recent decades, the average air temperature in the region was 11.2-11.9°C, and during the vegetation period it was 16.8-17.5°C. The average annual duration of sunshine is 1950 hours in the north and 2210 hours in the south, which is 50-55% of the possible duration. The average annual air temperature in the country, according to multiannual data, was 10.9°C, and during the vegetation period - 17.3°C (Balan et al., 2021). The duration of the vegetation period of 180-185 days with temperatures above 10°C is about 2200-2300 hours annually, and the frost-free period is about 280-290 days.

Agrotechnical measures shall be carried out in accordance with the agrotechnical guidelines in force. The orchards are irrigated by dripping, and Watermark transducers installed at a depth of 20, 40 and 60 cm in each plot are used to monitor soil moisture. The water is distributed through the network with drippers fixed 40 cm from the ground in the direction of the row. The soil in the orchards in the first two years, after planting the trees, was maintained as worked land, but in the following years the distance between the rows is maintained with artificial grass. The strips between the rows, 2 - 2.5 m wide, with weeds that grow naturally and artificially, are pruned as needed and remain as mulch. Herbicides or 2-3 mechanical pruning are applied along the row of trees, with a probe cutter. Soil maintenance, irrigation, fertilization and protection of trees from diseases and pests are carried out as appropriate (Babuc, 2012).

RESULTS AND DISCUSSIONS

Modern fruit growing requires crown shapes that maximize the conversion of solar energy into fruit, as well as labor productivity during manual pruning and harvesting. These considerations required the research approach of a large number of cherry crowns under different ecological conditions.

Tree growth. The height of the cherry trees differs depending on the shape of the crown (Table 1).

Table 1. Height and length of the crown of cherry trees depending on the variety and crown shape, cm
(Gisela rootstock 6, planting distance 4 x 2 m, age of the trees 4-7 years)

Crown shape	Tree height, cm				Crown length, cm			
	2018	2019	2020	2021	2018	2019	2020	2021
Early Star variety								
Thin spindle	377.0	378.3	369.6	385.0	125	175	211	240
Cup	340.3	342.6	333.3	348.7	144	192	220	251
Kym Green Bush	318.3	316.0	295.0	319.7	150	200	232	240
Samba variety								
Thin spindle	385.0	400.0	400.0	375.0	134	185	200	250
Cup	362,6	346.3	351.6	363.5	146	176	234	245
Kym Green Bush	321.6	300.0	315.0	312.2	145	195	230	250
Black Star variety								
Thin spindle	378.3	392.3	392.0	397.5	145	214	215	245
Cup	329.0	355.0	348.3	354.1	162	222	200	250
Kym Green Bush	307.0	306.3	312.0	318.4	138	195	229	250
DL 5%	53.2	42.9	39.8	62.7	-	-	-	

The shape of the thin spindle crown is highlighted by a higher height of the tree, compared to the cup shape and Kym Green Bush. The Early Star variety, in the 4th year after planting, recorded a tree height of 318.3-377.0 cm, being higher in the case of the thin spindle crown. In the following years 2019-2021, the increase in height was similar to that of 2018, in the sense that the most vigorous trees were recorded in the crown of the thin spindle. The Kym Green Bush system forms lower crowns compared to the cup shape and the thin spindle. The Samba variety of medium to high vigor, in the years of study, has formed trees with a height of 300-321.6 cm in the crown shape Kym Green Bush up to 375-400 cm in the shape of a thin spindle crown, and the crown shape cup occupies an intermediate position (346.3-363.5 cm).
The height increases of the trees of the Black Star variety are similar to the trees of the Early Star and Samba varieties in that the smallest trees were in the case of trees formed according to the Kym Green Bush system (306.3-318.4 cm). Thus, the height of the Early Star, Samba and Black Star cherries, grafted on the Gisela 6 rootstock, was significantly higher in the trees formed after the thin spindle crown compared to the Kym Green Bush system and was not always significantly ensured by the crown shape of the cup. The width of the crown of cherry trees depends on the shape of the crown and the age of the trees (Figure 1).

Figure 1. Crown width of cherry trees of the Samba variety according to the crown shape, cm (Gisela rootstock 6, planting distance 4 x 2 m, age of trees 4-7 years)

The trees at the age of 4, in the Samba variety, had a crown width from 150 cm in the shape of the crown of the cup to 166 cm in the case of the Kym Green Bush system. As the trees aged, the width of the crown also increased, reaching maximum sizes in years 6-7 after planting. Thus, at the age of 6 the width of the crown was 230-236 cm and 246-253 cm at the age of 7, being larger and larger in the form of the Kym Green Bush. The Early Star and Black Star varieties manifested themselves identically to the Samba variety, forming a crown of optimal size in the 6-7 years after planting in the orchard. The width of the crown depends on the distance between the rows and the height of the trees. The width in the basal part of the crown, in the Early Star, Samba, Black Star cherry varieties, grafted on the Gisela 6 rootstock, planted at a distance of 4 x 2 m, was maintained at about 250 cm, regardless of the shape of the crown.
The morphological parameters of the crown allowed to calculate the lateral area and volume of the crown, as well as the level of ground cover with the projection of the crown, (Table 2).
The indicators of the vegetative ensemble of the orchard are phytometric parameters that determine the productivity of the plantation from a theoretical and practical point of view, including the use of solar energy in the photosynthesis process, as well as the management of orchard maintenance (Balan et al., 2018; Jackson, 1980; Odier, 1978). Early Star cherries at the age of 4 years use over 50% of the area reserved for planting, and at the age of 7 years the soil cover with crown projection has increased to 61-63.7%, being higher in the case of the Kym Green Bush training system. At the age of 4 years, the lateral area of the crown is 20850-21900 thousand m^2/ha and 21300-22450 thousand m^2/ha at the age of 7 years. The volume of the crown, being an indicator of the synthesis of the dimensional parameters of the vegetative ensemble of the plantation, was from 13666-18881 m^3/ha in 2018 and increased to 15688-20535 m^3/ha in 2021. Trees formed without a central shaft, according to the crown cup and Kym Green Bush formed a higher volume by 29.1-38.2% in 2018 and by 18.9-30.9% in 2021, compared to the thin spindle crown shape. a tree height of 318.3-377.0 cm, being higher in the case of the thin spindle crown. In the following years 2019-2021, the increase in height was similar to that of 2018, in the sense that the most vigorous trees were recorded in the crown of the thin spindle.

Table 2. Structure of the vegetative ensemble of cherry trees, of the Early Star variety depending on age and crown shape (Gisela rootstock 6, planting distance 4 x 2 m, age of trees 4-7 years)

Crown shape	Crown height, cm	Crown width, cm		Land cover level, %	Crown side area, m^2/ha	Crown volume, m^3	
		At the base	at the top			tree	Ha
Year 2018, age of trees – 4 years							
Thin spindle	377	210	80	52.5	20850	10.9	13666
Cup	340	220	195	55	21875	14.1	17637
Kym Green Bush	318	235	240	58.7	21900	15.1	18881
Year 2021, age of trees – 7 years							
Thin spindle	385	244	82	61	21300	12.5	15688
Cup	348	243	186	60.7	22050	14.9	18661
Kym Green Bush	319	255	260	63.7	22450	16.4	20535

The morphological parameters of the structure of the vegetative ensemble in cherry trees of the Samba and Black Star varieties also formed the highest values of the lateral surface, the volume of the crown and the level of soil cover with the projection of the crown, were in the trees formed according to the crown of the cup and Kym Green Bush.

In conclusion, we note that the geometric structure of the vegetative ensemble of the fruit plantation of the Early Star, Samba, Black Star varieties, grafted on the Gisela 6 rootstock, planted at a distance of 4 x 2 m, ensures an optimal structure for the penetration of solar energy into the center of the crown in the roofs and sub-roofs, which are garnished with the largest possible volume of productive branches. The above-mentioned varieties form a continuous crown volume in the row direction, which at the age of 4 years receives more than 50% of solar energy, and at the age of 7 - over 60%.

The growth of the annual branches is determined by the variety, the age of the trees and the shape of the crown (Figure 2).

During the growing period of the trees, the length of the annual branches, by years, was constantly decreasing. For example, in the Samba variety, the average length of the annual branches was 75.2-80.4 cm in the 4th year after planting, 61.4-71.7 cm in the 5th year, 35.8-42.7 cm in the 6th year and only 32.5-34.8 cm in the 7th year after planting. The shape of the Kym Green Bush crown recorded higher annual growth values compared to the thin spindle and cup crown, but they are not always statistically assured. The annual growth of the Early Star and Black Star varieties recorded values similar to the Samba variety, in the sense that as the trees age, the length of the annual branches decreases.

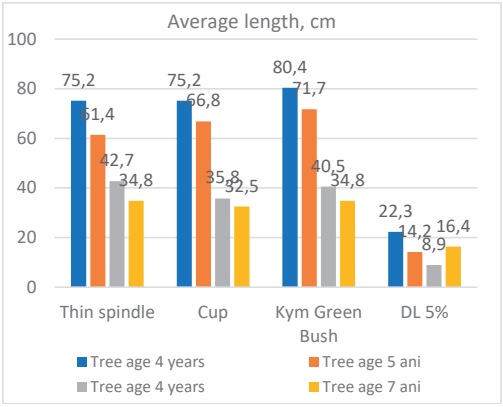

Figure 2. Average length of annual branches of cherry trees of the Samba variety according to crown shape, cm (Gisela rootstock 6, planting distance 4 x 2 m, age of trees 4-7 years)

The total length of annual cherry branches differs from variety to variety, from the age of the trees and from one crown shape to another (Figure 3).

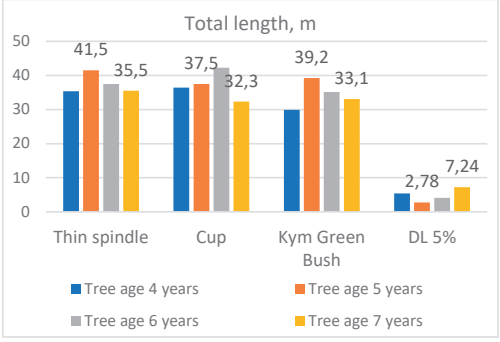

Figure 3. The sum length of the annual branches of the cherry trees of the Samba variety according to the crown shape, m (Gisela rootstock 6, planting distance 4 x 2 m, age of the trees 4-7 years)

Thus, at the beginning of the growth and fruiting period of the trees, the total length of the annual branches increases, and towards the end of this period the growth on the tree attenuates to the optimal level in order to obtain constant harvests of quality fruits. In addition, a balance is established between growth and fruiting (Babuc, 2012; Wertheim, 1997).

Fruit yield. During the period of tree growth and fruiting, the average cherry fruit harvest, in the first 7 years of fruiting, demonstrates that the Early Star variety had a lower yield compared to the Samba and Black Star varieties. This decrease in yield in the Early Star variety is due to the fact that the variety with the earlier fruit ripening period is in more unfavorable conditions (rain, frost) for the development of reproductive organs (flowers, fruits).

If we refer to the influence of the shape of the crown, it can be seen that the thin spindle crown during the period of growth and fruiting of trees has advantages compared to cup-shaped crowns and Kym Green Bush. For example, in the Samba variety, fruit production (8.70 t/ha) in most years was significantly higher compared to cup-shaped crowns and Kym Green Bush. The same pattern was recorded for the Early Star and Samba varieties, in the sense that the highest distinctly significant values with 11.8-18.4% (cup) and 20-29% (Kym Green Bush) were for trees formed after the thin spindle crown.

Orchard productivity is the basis for calculating the efficiency of tree cultivation technology, including variety-rootstock association, planting distance, crown shape, tree pruning period and method, as well as orchard management (Balan et al., 2021; Budan, Amzar, 1992; Ivanov, 2023; Ivanov et al., 2018; Pește anu et al., 2019; Stehr, 2008).

Thus, cultivation systems are obtained that are suitable for the conversion of solar energy with a high coefficient by trees. For these reasons, the success of an orchard is appreciated by its precocity, constant yield and competitive fruit quality on the market (Babuc, 2012; Ivanov et al., 2023).

The Early Star and Samba cherry trees, grafted on the Gisela 6 rootstock, planted at a distance of 4 x 2 m, began to bear fruit in the 4th year after planting with a yield of 2.31- 3.67 t/ha (Table 3).

Table 3. Fruit harvest of cherry trees by variety and crown shape, t/ha (Rootstock Gisela 6, planting distance 4 x 2 m, age of trees 4-10 years, SRL "StarAgroGroop")

Crown shape	Year 2018	Year 2019	Year 2020	Year 2021	Year 2022	Year 2023	Year 2024	Intercede (2018-2024)
Early Star variety								
Thin spindle	2.94	7.17	4.87	9.45	11.01	3.64	4.01	6.16
Cup	2.31	6.40	4.25	8.27	9.41	4.06	3.81	5.50
Kym Green Bush	2.56	5.35	3.54	7.67	9.51	3.84	3.49	5.14
DL 5%	-	1.23	0.56	0.87	0.62	1.24	1.46	-
Samba Variety								
Thin spindle	3.67	16.97	4.08	16.26	9.89	8.16	17.15	10.88
Cup	2.80	14.53	3.58	12.88	8.11	6.84	15.51	9.19
Kym Green Bush	2.19	12.96	4.04	10.30	8.27	7.21	14.05	8.43
DL 5%	-	1.34	1.1	1.72	1.16	0.28	1.15	-
Black Star variety								
Thin spindle	0	13.01	10.29	5.50	9.39	9.96	10.92	9.84
Cup	0	12.01	9.45	3.73	8.81	8.11	9.67	8.63
Kym Green Bush	0	10.62	7.66	3.90	7.96	7.65	8.22	7.66
DL 5%	-	2.13	1.41	0.39	0.28	1.17	1.34	-

The data presented show that the Early Star variety has had a modest fruit yield over the years. Over the years, the spindle crown formation system has recorded the highest fruit yields (2.94-11.01 t/ha) compared to the cup crown forms (2.31-9.41 t/ha) and Kym Green Bush (2.56-9.51 t/ha), but they have not always been significantly ensured. The yield of the Early Star variety, with fruit ripening in the first half of June, was 5.14-6.16 t/ha on average over 7 years of fruiting. The Samba variety, with the fruit ripening period in the second decade of June, was more productive compared to the Early Star variety. Thus, the trees formed after

the thin-spindle crown had a yield of 3.67-9.89 t/ha, and the harvest was clearly significant compared to the Kym Green Bush system, but the difference was not always statistically ensured compared to the shape of the cup.

The Black Star variety, self-fertile, with an average fruit ripening period, entered fruiting in the 5th year after planting, with a yield of 7.66-9.84 t/ha, on average over the first 6 years of fruiting. In this variety, the highest harvest values, distinctly significant, were the trees formed according to the shape of the thin spindle crown. For example, in 2020 the yield of the Black Star variety was 7.66-10.29 t/ha, being 7.6% higher in the case of the cup shape and 34% higher than the Kym Green Bush system.

Effects of fruit quality parameters. The quality of the fruits is directly related to the maintenance, formation and pruning of the crown as well as to the cultural management applied in the orchard (Balan, Ivanov, 2014; Balan et al., 2021; Blažková, Drahošová, 2012; Manziuc, Fedorciucov, 2021). Regardless of the cropping system, fruit quality requires cherries to be picked at the right time, firm, uniform in color, and resistant to cracking, crushing, and hollowing out (Balan et al., 2017).

Table 4. Influence of the variety on the quality of fruits in cherry trees (Gisela rootstock 6, planting distance 4 x 2 m, thin spindle crown, tree age 6 years, year 2021)

Variety	Fruit diameter, mm	Cherry mass, g	Fruit firmness, kg/cm^2	Soluble dry matter, %	Titratable acidity, mg malic acid 100 g^{-1}
Early Star	28.58	10.71	2.79	17.4	0.71
Samba	30.23	11.92	3.04	18.5	0.69
Blak Star	30.48	12.05	2.89	19.2	0.72
DL 5%	0.53	0.75	-	-	-

The diameter of cherries is a morphological indicator of quality and serves as a basis in the technological production process, including the modification of post-harvest fruit processes such as packaging, sorting and marketing of cherries (Ivanov et al., 2015; Long et al., 2014; Mitre et al., 2012; Mong et al., 2004; Pește anu et al., 2018; Șarban, 2021). The size of the fruit differs from the care of the orchard and the climatic conditions, being significantly higher in the Samba and Black Star varieties, compared to the Early Star variety (Table 4). The cherries of the studied varieties are of high quality, especially in the Black Star variety, in which the diameter was 30.48 mm with a mass of 12.5 g. The soluble dry matter in the fruit was 17.4-19.2%, titratable acidity - 0.69-0.72 mg malic acid 100 g^{-1} and 2.79-3.04 kg/cm^2 fruit firmness. It should be noted that the quality parameters of the Early Star, Samba and Blak Star varieties, grafted onto the Gisela 6 rootstock, are variety-specific values and differ slightly from the climatic conditions.

Cherry trees in high-density orchards, due to the strong apical dominance and the natural tiering of branches, are stripped in the basal part of the crown (Balan et al., 2001). The improved thin spindle is used in high-density plantations, in various tree formation combinations. The process of forming cherries in an improved thin spindle form includes a well-developed axis, at the base of which, between 60-100 cm in height, 4-6 permanent semi-skeletal branches are selected, radially around the axis, followed by a long zone of 90-100 cm free of branches, then the axis is trimmed with weak semi-skeletal and fruit branches (Balan et al., 2024). This procedure allows the formation of conical crowns, with a well-developed central axis and covered with semi-skeletal branches and fruit branches, which decrease in size from the base to the top of the tree and ensure optimal use of solar energy to increase the size and quality of the fruits.

The preliminary results of the improved thin-spindle crown form are promising (Table 5). The yield of trees of the Regina (4.56-4.76 kg/tree) and Summit (6.63-6.91 kg/tree) varieties, grafted on Gisela 6, does not differ from the crown formation system, however, the diameter of fruits of 30 mm and more is greater in the case of tree formation according to the improved

thin-spindle system. For example, in the Summit variety formed after the improved Thin-stem crown, fruits with a diameter of 22-26 mm and 26-30 mm decreased by 10.08% and 9.53% respectively, but fruits with a diameter of 30 mm and more increased by 19.6%. The same pattern was also recorded in the Regina variety.

Table 5. Distribution of cherry fruits by variety and crown shape
(Gisela rootstock 6, planting distance 4 x 1 m, 7 years)

Crown formation system	Yield, kg/tree	Fruit diameter, mm		
		22-26	26-30	> 30
		Fruit weight, %		
Regina variety				
Thin spindle	4.76	23.53	50.03	26.43
Thin spindle improved	4.56	15.03	46.82	38.16
Summit variety				
Thin spindle	6.91	25.21	51.06	23.73
Thin spindle improved	6.63	15.13	41.53	43.33

CONCLUSIONS

The research, carried out between 2010 and 2024, aimed to increase the productivity of cherry plantations by identifying a cherry tree training system to obtain efficient competitive fruit crops and maintain a balance between growth and fruiting.

The crowns of the Early Star, Samba, Black Star varieties, at the age of 6-7 years, formed continuous rows in the direction of the row with a width of about 250 cm, regardless of the shape of the crown. The level of soil cover with crown projection at the age of 7 years increased to 61-63.7%, the lateral area of the crown was 21300-22450 thousand m^2/ha, and the crown volume increased to 15688-20535 m^3/ha in 2021.

The annual growth of Early Star, Samba, Black Star varieties recorded higher values (75.4-92.4 cm) during the tree growth period and decreased (45.2-49.5 cm) during the fruiting period when a balance between growth and fruiting is established (42.2-48.2 cm).

The yield of the trees grafted on Gisela 6, during the growth and fruiting period, was 5.14-6.16 t/ha for the Early Star variety, 8.43-10.88 t/ha for the Samba variety and 7.66- 9.84 t/ha for Black Star, being higher for the cherries formed according to the thin spindle crown.

The process of forming cherries into an improved thin spindle shape (Balan et al., 2024) should be further analyzed to identify methods to maintain trees in physiological balance between growth and fruiting, during the period of full fruiting.

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