THE INFLUENCE OF PLANTING DISTANCE AND CROWN SHAPE ON THE GROWTH AND PRODUCTIVITY OF CHERRY ORCHARDS

INFLUENȚA DISTANȚEI DE PLANTARE ȘI A FORMEI DE COROANĂ ASUPRA CREȘTERII ȘI PRODUCTIVITĂȚII PLANTAȚIILOR DE CIREȘ

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Abstract.
Cherry cropping systems represent a topic of major interest in both scientific literature and fruit-growing practice. The aim of this study, conducted between 2013 and 2024, was to evaluate the impact of crown shape and planting distance on the growth and productivity of sweet cherry varieties grafted on the Gisela 6 rootstock. Within the research, the varieties Bigarreau Burlat, Ferrovia, and Lapins, evaluated in the 4th–7th years of vegetation, trained as Thin Spindle (TS) and planted at a distance of 5 × 1.5 m, demonstrated superior productivity. Likewise, the varieties Adriana, Ferrovia, and Skeena, planted at a distance of 4 × 2 m, recorded a superior yield throughout the bearing years when using the TS crown shape as well. Compared to the "Vase" and "Kym Green Bush" (KGB) training systems, the TS crown shape consistently provided the highest yields for the Samba, Early Star, and Black Star varieties planted at 4 × 2 m. Overall, the TS crown shape was associated with the highest yields across the entire analyzed fruiting period. It is worth noting that the productivity of early varieties was reduced in certain years due to unfavorable weather conditions during the critical stages of flowering, fertilization, and fruit set.
Keywords: sweet cherry; planting distance; crown shape; productivity.

Rezumat.
Sistemele de cultură pentru cireș reprezintă un subiect de interes major în literatura de specialitate și în practica pomicolă. Scopul acestui studiu, desfășurat între anii 2013 și 2024, a fost evaluarea impactului formei coroanei și al distanței de plantare asupra creșterii și productivității soiurilor de cireș altoite pe portaltoiul Gisela 6. În cadrul cercetării, soiurile Bigarreau Burlat, Ferrovia și Lapins, evaluate în anii 4–7 de vegetație, conduse după sistemul Fus Subțire (FS) și plantate la distanța de 5 × 1,5 m, au demonstrat o productivitate superioară. De asemenea, soiurile Adriana, Ferrovia și Skeena, plantate la distanța de 4 × 2 m, au înregistrat un randament superior pe parcursul anilor de producție tot în

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cazul utilizării formei de coroană FS. Comparativ cu formele „Cupă” și „Kym Green Bush” (KGB), forma coroanei FS a oferit în mod constant cele mai ridicate producții și la soiurile Samba, Early Star și Black Star, plantate la 4 × 2 m. În ansamblu, forma de coroană FS s-a asociat cu cele mai mari randamente pe întreaga perioadă de fructificare analizată. Este de menționat faptul că productivitatea soiurilor timpurii a fost redusă în anumiți ani din cauza condițiilor meteorologice nefavorabile din etapele critice de înflorire, fecundare și legare a fructelor.

Cuvinte cheie: cireș; distanță de plantare; formă de coroană; productivitate.

INTRODUCTION

The cultivation of sweet cherry has undergone significant development over the last two decades, driven by the diversification of both vegetative rootstock assortments and high-quality self-fertile varieties. Given the numerous combinations of scions and rootstocks, variations in planting distance, and different ways of grouping trees based on the available biological material, extensive research has been necessary concerning tree training systems [Long et al., 2014; Balan et al., 2022, 2023]. These studies have led to the promotion and implementation of integrated and sustainable cultivation systems that optimize the use of natural factors and reduce conventional energy consumption, with the aim of achieving competitive and sustainable production [Babuc, 2012; Gjamovski et al., 2016; Sumedrea et al., 2014].

Studies have been conducted regarding the influence of Gisela 6, Maxima 14, and Mahaleb rootstocks on the growth and development of several cherry varieties, including Valerii Cikalov, Record, Ferrovia, Kordia, Regina, Stella, Skeena, Early Star, Samba, Black Star, Bigarreau Burlat, and Lapins, in different combinations and at varying planting distances.

Thus, the aim of the research is to ensure optimal and sustainable production by identifying highly productive scion-rootstock associations adapted to the climatic conditions, the biological potential of the orchard, tree training technologies, the degree of mechanization and manual labor consumption, and the management of economic interests.

MATERIAL AND METHOD

The interaction between canopy shape and planting distance was investigated within six stationary field experiments. The study utilized the varieties: Ferrovia, Kordia, Regina, Skeena, Early Star, Samba, Black Star, Bigarreau Burlat, and Lapins. These were grafted onto the rootstocks Gisela 6, in various association combinations and planting distances. The experimental cherry orchards, with trees grafted on the Gisela 6 vegetative rootstock, were established for the first time in the Republic of Moldova in the southern fruit-growing zone (Cahul) and the central fruit-growing zone (Telenești, Orhei, Criuleni). The experiments were designed according to polyfactorial principles, with the treatment variants arranged in a randomized block system in accordance with the methodology of factorial interaction.

The soils across all experimental orchards consist of relatively homogeneous clay-loam chernozems, featuring a moderately deep to deep humus profile, which provides favorable conditions for the growth and development of sweet cherry trees. Weather stations were installed in the experimental orchards to monitor environmental parameters and plant conditions.

Atmospheric precipitation during the research period ranged from 432.4 to 681.0 mm, with over 70% falling as rainfall during the warm period of the year. In the southern region, the mean annual temperature between 2013 and 2016 ranged from 12.06 to 14.25 °C, reaching its highest level in 2015. In the central region during the 2012–2022 period, air temperatures, precipitation, and relative air humidity at the beginning of the vegetative season created favorable conditions for flowering, pollination, fruit set, and development, with the exception of 2017 and 2021, when temperatures dropped below freezing.

Agrotechnical measures were carried out according to current recommendations for orchards. Soil tillage, irrigation, fertilization, and plant protection against diseases and pests were applied as needed.

The studies were conducted in the following orchards:

Telenești: Established in 2010, with varieties Adriana, Ferrovia, Skeena, grafted onto Gisela 6 rootstock, planted at a distance of 4×2 m, utilizing Improved Natural Canopy (CNA), Cup (Vase), and Thin Spindle (TS) canopy shapes.

Cahul: Established in 2010, with varieties Bigarreau Burlat, Ferrovia, Lapins, grafted onto Gisela 6 rootstock, at planting distances of 5×1.5 m, 5×2 m, and 5×2.5 m, utilizing CNA and TS canopy shapes.

Orhei: Established in 2003 with varieties Valerii Cikalov and Record (grafted onto Mahaleb), and in 2011 with Ferrovia, Kordia, Regina, grafted onto Gisela 6 rootstock, at distances of 6×5 m and 4×2.5 m, utilizing CNA, Vase, and TS canopy shapes.

Criuleni: Established in 2015 with varieties Early Star, Samba, Black Star (Gisela-6 rootstock), at a distance of 4×2 m, utilizing CNA, TS, and Kym Green Bush (KGB) canopy shapes. For each experiment, morphological descriptions, biometric measurements, and statistical processing of the results were performed [Доспехов, 1985].

RESULTS AND DISCUSSIONS

Cherry trees grafted onto Mahaleb rootstock, planted at a distance of 6×5 m and aged 11–14 years, reached optimal canopy parameters. During the period of full bearing, the Valerii Cikalov and Record varieties, grafted onto Mahaleb, recorded yields ranging from 6.7 t/ha at 12 years of age up to 29.2 t/ha at 17 years of age. Yields varied significantly from one year to the next, and the differences between the varieties were not always statistically significant. Over the 8 experimental years, the average harvests were similar: 15.03 t/ha for Valerii Cikalov and 16.54 t/ha for Record, with these differences proving to be not statistically significant [Balan et al., 2022, 2023a].

For trees trained as TS, the increase in canopy width was greater with increasing distance between trees in the row. In the 3rd year of vegetation, at a planting distance of 5×1,5 m, the canopy width was 245 cm, while at 5×2.5 m, the

value reached 260 cm. For TS-trained trees, the largest values for the studied indices were consistently found at the 5×2 m planting distance throughout the research period.

In the first four years of fruiting, the yield of Bigarreau Burlat, Ferrovia, and Lapins varieties, grafted onto Gisela 6, progressively increased year by year (Table 1). Yield Dependence on Distance: In the first two fruiting years, the harvest was independent of the distance between trees in the row. Yield per Hectare: In the 7th year, at 5×1.5 m, the harvest was 17.98–18.94 t/ha, while at 5×2.5 m, the harvest decreased to 14.61–15.63 t/ha (a reduction of 21.2–23.1%), a statistically significant difference. Ferrovia and Lapins showed the same trend: higher yields per hectare were recorded and statistically assured at the smaller planting distances.

Table 1

Yield of cherry trees, of the Bigarreau Burlat variety, grafted on Gisela 6, depending on planting distance and crown shape, t/ha

Crown shape	Planting distance	Tree age				Average (4-7 years)
		4 years	5 years	6 years	7 years	
Reduced-Volume Improved Natural Canopy	5x1.5	0.79	5.96	11.41	17.98	9.03
	5x2	0.40	4.89	9.15	15.16	7.40
	5x2.5	0.32	3.72	8.00	14.61	6.66
Thin Spindle	5x1.5	0.71	6.33	12.20	18.94	9.51
	5x2	0.50	5.12	11.82	16.16	8.40
	5x2.5	0.40	4.17	10.20	15.63	7.61
DL 5%	-	-	-	0.851	1.237	-

Influence of Canopy Shape: The positive influence of higher densities on the yield per unit area was evident and statistically assured in the first four years of fruiting, with the 5×1.5 m distance (1333 trees/ha) proving superior to 5×2.5 m. In the 4th fruiting year, varieties Bigarreau Burlat, Ferrovia, and Lapins, at 5×1.5 m and trained as TS, recorded the highest productions of 17.54–20.07 t/ha. The 5×2.5 m distance (15.63–17.54 t/ha) and the Improved Natural Canopy (14.61–16.15 t/ha) proved less favorable.

The cherry varieties Adriana, Ferrovia, and Skeena, grafted onto Gisela 6 and planted at 4×2 m, came into bearing in the 4th year after planting, with an initial harvest of 0.625–1.56 t/ha (Table 2). Ferrovia proved more productive initially, with a yield of 1.12–1.562 t/ha. In the 2nd fruiting year, harvest significantly increased to 4.25–5.00 t/ha. In year 6 (2016), the harvest further tripled, reaching 11.87–13.00 t/ha for Adriana, 13.25–14.12 t/ha for Ferrovia, and 16.00 t/ha for Skeena. In Year 7, the fruit yield doubled compared to the previous year, peaking at 26.25–28.00 t/ha for Skeena. Statistically significant yield increases were recorded for Ferrovia and Skeena, irrespective of the training system, compared to Adriana. The highest average yield was obtained by the Skeena variety (14.58 t/ha) when trained in the TS canopy form. This was followed by Ferrovia (12.93 t/ha). The lowest average yield was recorded for Adriana (10.67 t/ha) in the CAN.

Table 2

Yield of cherry trees grafted onto Gisela 6, depending on variety and canopy shape, t/ha.

Variety	Tree Age (years)								Mean over experimental 8 years
	4	5	6	7	8	9	10	11	
Reduced-Volume Improved Natural Canopy									
Adriana	0.62	4.37	11.87	21.88	10.87	12.96	13.37	9.32	10.66
Ferrovia	1.12	4.88	13.25	24.75	15.75	15.22	10.79	14.28	12.51
Skeena	0.62	4.25	16.00	26.25	16.88	17.58	17.04	16.65	14.41
Thin Spindle									
Adriana	0.87	4.50	13.00	22.50	10.75	14.82	13.12	10.82	11.30
Ferrovia	1.56	5.00	14.12	24.50	12.70	15.39	13.51	16.64	12.92
Skeena	0.37	4.38	16.00	28.00	14.00	17.50	17.42	18.99	14.58
DL 5%	-	0.435	0.971	1.315	1.429	1.423	2.305	1.314	-

Early Star and Samba cherry trees, grafted onto Gisela 6 and planted at 4×2 m, began fruiting in year 4 with yields of 2.19–3.67 t/ha (Table 3). Trees trained as TS yielded 3.67–17.15 t/ha and their harvest were significantly superior to the KGB system, though the difference was not always significant compared to the Vase shape. Data generally indicate that the TS canopy form produced the highest yields during the growth and fruiting periods in most years, compared to Vase or KGB.

Table 3

Fruit yield of cherry trees, Samba variety, grafted on Gisela 6, depending on the crown system, t/ha

Crown Training System	Year 2018	Year 2019	Year 2020	Year 2021	Year 2022	Year 2023	Year 2024	Average (2018–2024)
Thin Spindle	3.67	16.97	4.08	16.26	9.89	8.16	17.15	10.88
Vase	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	-

Early Star showed more modest yields over the years, averaging 5.14–6.16 t/ha over a 7-year fruiting period. The self-fertile variety Black Star entered production in the 5th year, with yields of 7.66–9.84 t/ha in the first 6 years. The highest, distinctly significant harvest values were recorded for trees trained as TS. For example, in 2020, Black Star's FS harvest was 7.66–10.29 t/ha, which was 7.6% higher than Vase and 34% higher than KGB.

CONCLUSIONS

This study addressed the issue of promoting **sustainable and integrated cultivation systems** for sweet cherry, aiming to ensure an early entry into economic bearing and to obtain high-quality, healthy, and market-competitive fruit

production. From a technological perspective, **tree training and pruning** have a major impact and represent the most crucial interventions for maintaining the optimal balance between vegetative growth and fruiting. The Thin Spindle canopy type consistently demonstrated the **highest yields** across the analyzed varieties (Bigarreau Burlat, Lapins, Ferrovia, Kordia, Regina, Skeena, Samba, Early Star, and Black Star) compared to CNA, Vase, and KGB.

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