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EFFECTS OF DWARFING ROOTSTOCKS ON THE VEGETATIVE AND GENERATIVE DEVELOPMENT OF SEVERAL CHERRY CULTIVARS IN PEDOCLIMATIC CONDITIONS OF BISTRIŢA FRUIT REGION

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Abstract

The field trial was conducted in the Bistrita Fruit Region, Romania, to assess the vegetative growth and generative characteristics of `Lapins`, `Tamara`, and `Kordia` sweet cherry cultivars (Prunus avium L.) grafted on 'GiSelA 5', 'GiSelA 6', and 'GiSelA 3' rootstocks. Trees were drip-irrigated and trained as spindle bushes at a density of 1250 trees/ha on molic eutricambosoil. Parameters such as trunk cross-sectional area, canopy volume, leaf area, shoot length and number, tree height, leaf area/fruit ratio, crop load, yield, fruit number per tree, average fruit size, and fruit quality were evaluated. Data showed that trees grafted on 'GiSelA 5' and 'GiSelA 6' induced the most intensive growth characteristics, they proved to be more vigorous when considering trunk cross-sectional area and canopy volume when compared with 'GiSelA 3' rootstock. Higher fruit calibers were obtained at 'Tamara' in comparison with 'Kordia' and 'Lapins' cherry cultivars. Conversely, a higher number of fruits/trees was observed at 'Lapins' cultivar, showing a very intense bearing capacity.

***Key words**: rootstocks, high-density orchard, drip irrigation.*

INTRODUCTION

Sweet cherry cultivation is increasingly popular nowadays both internationally and also in Romania, especially with the implementation of the PNDR programme 4.1a Investments in the fruit orchards. Cherry fruits are highly valued fruits due to nutritional qualities (Szpadzik et al., 2022) and other bioactive parameters such as carotenoids, quercetin (Martini et al., 2019), simple sugars (Nawirska-Olszanszka et al., 2017; Boskov et. al, 2023; Dziadzek et al., 2019), organic acids, vitamins.

Sweet cherry cultivar and rootstock combinations have been recently studied for their effectiveness in controlling tree sizes and maximizing yield efficiency and other technical and economical parameters.

Several breeding programs from Germany (Giessen) aimed to produce dwarfing rootstocks, targeting key orchard production indicators which describe optimum development and bearing processes like, growth, yield, precocity, fruit quality and others (Gyeviki, 2008; Whiting et al., 2005; Martins et al., 2021).

Several dwarf rootstocks suitable for high density orchards were bred recently from the 'GiSelA'series ('GiSelA 3', '5', '12', '13', '17') with different characteristics and different adaptability to distinct pedo-climatical conditions (Aglar et al., 2014; Hrotko et al., 2009; Milic et al., 2019). 'GiSelA 5', 'GiSelA 6' rootstocks were used more recently in Europe and are considered the most productive rootstocks for modern cherry growing (Gjamowski et al., 2016). 'GiSelA' rootstocks derived from the crosses from *Prunus cerasus* and *Prunus canascens* were patented as different selections, they induced precocity, allow tree size control and are very productive (Franken Bambenek, 2010). There are a series of other rootstocks available on the market, such as 'Weigi' ('1', '2', '3', '4') with different size control ability and different adaptation for cherry cultivation (Sjaak, 2024).

Adaptability of 'GiSelA' rootstocks, the relationship with evapotranspiration and irrigation were previously studied in Romania (Jakab et al., 2022; Călinescu et al., 2024) with good results, several other researches revealed the nutritional status, relationship of yield and canopy training systems (Balan, 2024; Bujdosó et al., 2012; Jakab et. al., 2024). The objective of the researches conducted at FRDS Bistrita was to assess the eco-pedological adaptability, vegetative growth and generative characteristics of ‘Lapins’, ‘Tamara’, and ‘Kordia’ sweet cherry cultivars (*Prunus avium* L.) grafted on ‘GiSelA 5’, ‘GiSelA 6’, and ‘GiSelA 3’ scion/rootstock combinations.

MATERIALS AND METHODS

The study was carried out during 2020-2024 in a 5 year old, drip irrigated sweet cherry experimental orchard (*Prunus avium* L.) planted with ‘Lapins’ on ‘GiSelA 5’ and ‘GiSelA 6’, ‘Kordia’ on ‘GiSelA 5’ and ‘GiSelA 3’, respectively ‘Kordia’ on ‘GiSelA 5’ and ‘GiSelA 3’ (knip trees), in a high density plot, planted at 4 x 2 m distance, the adopted training system was the spindle bush. The research orchard is located in Northern Transylvania, Romania at Fruit Research & Development Station Bistrita (FRDS Bistrita). The soil is a deep eutricambosoil with medium NPK and organic matter content. During the study, standard orchard management techniques were applied regarding weed management with herbicide sprays, appropriate fertilization and phytosanitary treatments.

Biometrical measurements were made regarding the height of tree, trunk cross-sectional area 15 cm above grafting point, volume of trees, length of shoot growth, and the yield per tree (kg/tree). The measurements were done in September at the end of vegetation period, on 14 trees/combination. The trees were subjected to standard irrigation treatments, drippers 2 L h^{-1} flow rate, placed in line, 1m apart. Watermark Spectrum transducers were installed at 20-40 cm deep in the direction of the row.

The trunk diameter was measured with a digital caliper and the height of trees and length of the branches was measured using a measure tape. The statistical analyses were performed using XLSTAT software version 2018.1 (Addinsoft, Paris, France).

RESULTS AND DISCUSSIONS

Meteorological data recorded at FRDS Bistrita showed that the temperatures recorded in the last five years fluctuated with an increasing tendency (Table 1). Annual average temperatures were between 9.5°C (2021), to 11.63°C (2024) with absolute maximum temperatures between 33.6°C (2021) ranging 36.9°C (2024). Regarding the rainfall, data showed that it ranged between 678.9 mm to 784.5 mm. The average value of annual rainfall in Bistrita region is around 758.8 mm (Table 1). Researches showed that in the summer period, is mandatory to implement the drip irrigation, due to the uneven distribution of rainfall. The necessary water amount required was calculated using the FAOSTAT ETP Calculator, which employed the Pennmann-Monteth ETr formula.

Table 1. Climate indicators 2020-2024

Climate indicators	2020	2021	2022	2023	2024
Average annual temp. (°C)	10.1	9.5	11.2	10.9	11.63
Absolute maximum temp.(°C)	33.7	33.6	35.6	36.40	36.9
Rainfall (mm)	678.9	784.5	759.3	765.7	743.2

Research data for the evapotranspiration water quantity during the vegetative season in Bistrita area, showed that the value ranged between 623 to 694 mm with an increasing tendency also, in the last years. Total water deficit calculated showed that in 2022 it was a -249 mm, in 2023 was -220.50 mm and in the last year of experiment even lower: -268.9 mm (Table 2).

Table 2. Evapotranspiration, rainfall and water deficit (2022) in the experimental plot

Months	2022		
	Eto	Rainfall	Difference
March	71.3	0.7	-70.6
April	67.3	102.3	35
May	107.8	70.5	-37.3
Iune	132.9	18	-114.9
Iuly	131.3	35.4	-95.9
August	112.4	78.2	34.2
TOTAL	**623**	**305.1**	**-249.5**

Due to higher monthly temperatures there were higher evapotranspiration also, thus, the calculated Eto values are higher. In 2023 water deficit was more pronounced, in the summer periods (Table 3).

Table 3. Evapotranspiration, rainfall and water deficit (2023) in the experimental plot

Months	**2023**		
	Eto	**Rainfall**	**Difference**
March	67.5	38.20	-29.30
April	75.5	80.2	4.70
May	116.4	24.8	-91.60
Iune	111.5	86.8	-24.70
Iuly	121.2	108	-13.20
August	138	71.6	-66.40
TOTAL	**630.1**	**409.6**	**-220.50**

In the summer period we can observe that there is constantly a water deficit starting with the month of June, but especially in 2024 in the months July (-57.70 mm) and August (-88.90 mm) (Table 4).

Table 4. Evapotranspiration, rainfall and water deficit (2024) in the experimental plot

Months	**2024**		
	Eto	**Rainfall**	**Difference**
March	48.90	50.0	1.1
April	101.80	64.80	-37.00
May	127.40	62.00	-65.40
Iune	149.00	128.00	-20.80
Iuly	148.50	90.80	-57.70
August	119.30	30.40	-88.90
TOTAL	**694.9**	**426.00**	**-268.9**

In 2024 a hail event was recorded and affected the leaves and tree branches and also the fruits. Observations regarding plant physiology showed that the implementation of drip irrigation systems in cherry plantations with cultivars grafted on ‘GiSelA 3’ and ‘GiSelA 5’ is mandatory.

Research data showed that the most intensive vegetative growth (Table 5) of the cherry cultivars in shoot length parameter, was observed at ‘Lapins’/‘GiSelA 5’ cultivar in 2022 (65.5 cm) with close values at ‘Lapins’/‘GiSelA 5’ cultivar (65.8 cm) being in the same statistical class as ‘Kordia’ cultivar on both rootstocks; in 2023 data showed that the growth of shoots was quite similar, ‘Lapins’ cultivar had higher growth parameters (Table 6), on both rootstocks than the other cultivars.

Regarding the height of trees in the period 2022-2023, trees grew almost in the same growth pattern, higher values being registered for ‘Lapins’ cultivar grafted on both rootstocks (‘GiSelA 5’, ‘6’) ranged between 291-317 cm. In 2024 data showed again that the highest values were registered again for ‘Lapins’ cultivar on both rootstocks, with significant difference for ‘Lapins’ cultivar grafted on ‘GiSelA 6’ (347 cm); for the other cultivars ‘Tamara’ and ‘Kordia’ on ‘GiSelA 5’ and ‘GiSelA 3’, the registered values were close (247-272 cm). The statistical analysis showed that also in 2023 there were significant differences between ‘GiSelA 5’ and ‘GiSelA 6’ rootstocks, and there were significant differences regarding ‘GiSelA 3’ also. In our researches, data showed that the smallest vegetative growth was observed at ‘Tamara’ grafted on ‘GiSelA 3’ rootstock combination, having the smallest vigor.

Trunk cross-sectional area (TCSA) of the fruit trees is a useful index for the estimation of fruit yield and other vegetative growth parameters. In 2022 results showed (Table 5) that the lowest vigor was registered on ‘GiSelA 3’ rootstock with slight differences between ‘Tamara’ (10.6 cm^2) and ‘Kordia’ cultivars (12.2 cm^2). Higher values were recorded from the beginning in the other rootstock combinations ‘Lapins’ on ‘GiSelA 5’ and ‘GiSelA 6’, respectively ‘Tamara’ cultivar, ranging 15.63-16.05 cm^2.

Table 5. Vegetative parameters measured (2022) in the cherry plot

Cultivar/ rootstock	**2022**		
	Shoot length	**Height of trees (cm)**	**TCSA (cm^2)**
‘Tamara’ / Gi. 3	54.5 ^{bc}	214.5 ^{a}	10.6 ^{a}
‘Tamara’ / Gi. 5	63.0 ^{c}	240.1 ^{b}	15.9 ^{b}
‘Lapins’ / Gi. 5	65.8 ^{c}	238.8 ^{a}	16.0 ^{b}
‘Lapins’ / Gi. 6	65.5 ^{c}	308.2 ^{b}	16.2 ^{b}
‘Kordia’ / Gi. 5	48.5 ^{b}	247.7 ^{a}	15.6 ^{b}
‘Kordia’ / Gi. 3	32.9 ^{a}	229.8 ^{a}	12.2 ^{ab}

*Duncan’s multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Significant differences were observed at ‘Lapins’ cultivars on both rootstocks in 2023, showing the growth superiority of this rootstock combination. The characteristics of vigor showed that ‘Tamara’ cultivar with both rootstocks (‘GiSelA 3’, ‘GiSelA 5’) achieved the same growth as ‘Kordia’ grafted on ‘GiSelA 5’ (Table 6). Distinct growth pattern was observed at ‘Lapins’ on ‘GiSelA 5’ and more pronounced growth was observed at ‘GiSelA 6’. In the third year of development the vigor differences were observable between variants.

Table 6. Vegetative parameters measured (2023) in the cherry plot

Cultivar/ rootstock	2023		
	Shoot length	Height of trees (cm)	TCSA (cm^2)
'Tamara' / Gi. 3	23.3^{a}	225.4^{a}	16.90^{a}
'Tamara' / Gi. 5	18.4^{a}	248.6^{ab}	18.60^{a}
'Lapins' / Gi. 5	44.1^{b}	291.2^{cd}	34.94^{b}
'Lapins' / Gi. 6	43.0^{b}	317.9^{d}	46.30^{c}
'Kordia' / Gi. 5	19.2^{a}	276.0^{bc}	20.60^{a}
'Kordia' / Gi. 3	23.6^{a}	270.3^{bc}	31.90^{b}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

In 2024 data showed that the highest values regarding trunk cross sectional area were registered for 'GiSelA 6' rootstock with 'Lapins' cultivar (46.32 cm^2), followed by 'GiSelA 5' cultivar with 'Lapins' (35.59 cm^2) being in the same statistical class (Table 7).

Table 7. Vegetative parameters measured (2024) in the cherry plot

Cultivar/rootstock	2024		
	Shoot length	Height of trees (cm)	Trunk cross-sectional area TCSA (cm^2)
'Tamara' / Gi. 3	40.89^{a}	247,6^{a}	17,56^{a}
'Tamara' / Gi. 5	43.53^{a}	250,7^{a}	19,89^{a}
'Lapins' / Gi. 5	51.47^{c}	320,9^{b}	35.59^{c}
'Lapins' / Gi. 6	60.14^{c}	343,4^{b}	46.32^{c}
'Kordia' / Gi. 5	49.52^{c}	272,2^{a}	22,71^{a}
'Kordia' / Gi. 3	44.02^{c}	270,3^{a}	32.10^{b}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Among the low vigor rootstock combinations grafted on 'GiSelA 3', 'Kordia' (32.10 cm^2) grew more vigorously when compared with 'Tamara' (17.56 cm^2). Results showed that the weakest growth was registered in 'Tamara'/ 'GiSelA 3' combination.

A certain tree die-back was observed as shown in Tables 8-10, sporadically. In 2022 a minor tree die-back was observed at 'Tamara' cultivar (Table 8) on 'GiSelA 3' and 'GiSelA 5'.

Regular conventional phytosanitary treatment was applied. Research data showed that no suckering was observed at the studied rootstocks (Tables 8-10).

Table 8. Tree die-back, suckering and canopy volume (2022) in the cherry plot

Cultivar/ rootstock	2022		
	Tree die-back %	Suckering (points)	Canopy volume (m^3)
'Tamara' / Gi. 3	7,14	0	0.30^{a}
'Tamara' / Gi. 5	7,14	0	0.70^{b}
'Lapins' / Gi. 5	0	0	0.75^{a}
'Lapins' / Gi. 6	0	0	0.85^{a}
'Kordia' / Gi. 5	7.14	0	0.95^{a}
'Kordia' / Gi. 3	0	0	0.35^{a}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

For 'Kordia' grafted on 'GiSelA 5' in 2023 the phenomena was repeated (Table 9).

Table 9. Tree die-back, suckering and canopy volume of tree crown (2023) in the cherry plot

Cultivar/rootstock	2023		
	Tree die-back %	Suckering (points)	Canopy volume (m^3)
'Tamara' / Gi. 3	14,28	0	1,51^{a}
'Tamara' / Gi. 5	7,14	0	2,46^{d}
'Lapins' / Gi. 5	0	0	1,91^{c}
'Lapins' / Gi. 6	0	0	2.52^{d}
'Kordia' / Gi. 5	0	0	2.02^{c}
'Kordia' / Gi. 3	0	0	1.65^{b}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

In 2024 just a single case of tree die-back was observed in 'Kordia'/'GiSelA 5' (Table 10).

Table 10. Tree die-back, suckering and canopy volume of tree crown (2024) in the cherry plot

Cultivar/ rootstock	2024		
	Tree die-back %	Suckering (points)	Canopy volume (m^3)
'Tamara' / Gi.3	0	0	1.78^{a}
'Tamara' / Gi.5	0	0	2.62^{cd}
'Lapins' / Gi.5	0	0	2.42^{bc}
'Lapins' / Gi.6	0	0	2.72^{d}
'Kordia' / Gi.5	7.14	0	1.72^{b}
'Kordia' / Gi.3	0	0	1.82^{a}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Regarding canopy volume of tree crown, results showed that in 2022 the smallest values were achieved on 'GiSelA 3' rootstocks, on 'Tamara' and 'Kordia'. On 'Lapins' cultivar results showed values ranged 0.75-0.85 m^3 (Table 8). In 2023 canopy volume registered higher values in

'Lapins'/'GiSelA 6' and 'Tamara' on 'GiSelA5' being in the same statistical class followed by 'Lapins' and 'Kordia' both grafted on 'GiSelA 5' (Table 9). In 2024 canopy volume registered slightly higher values than in 2023 and differences between cultivar/rootstock combinations were more evident, highest values were registered again on 'Lapins' cultivar grafted on 'GiSelA6' cultivar followed by slight differences of 'Tamara' and 'Lapins' on 'GiSelA 5'. 'Tamara' and 'Kordia' on 'GiSelA 3' had the lowest canopy volume.

Regarding the vegetative growth (Table 11) characterized by the indicator number of shoots showed that in 2022 the cultivar 'Lapins'/'GiSelA 6' gave the most intensive growth in terms of number of shoots followed by 'Tamara', 'Lapins', 'Kordia' grafted on 'GiSelA 5'.

In 2023 it was observed that 'Lapins' cultivar grafted on 'GiSelA 6' and '5' rootstocks had a higher number of shoots than the other combinations.

In terms of shoot growth in 2024 one can observe that 'Kordia' grafted on both rootstocks gave quite the same growth characteristics as 'Tamara' grafted on 'GiSelA 3', presenting the lowest values and conversely in the 'Tamara'/'GiSelA 5' rootstock combination the results showed higher values being close to 'Lapins'/'GiSelA 5' combination.

Results regarding leaf area (m^2) showed that in 2022 the most intensive leaf development was specific at 'Lapins' cultivar grafted on 'GiSelA 5' and 'GiSelA 6' rootstocks.

In 2022 leaf development ranged between 0.89-1.65 m^2 with significant differences between cultivars (Table 11).

Table 11. The number of shoots and leaf area parameters in the cherry plot during 2022

Cultivar/ rootstock	2022	
	Number of shoots (no)	**Leaf area (m^2)**
'Tamara' / Gi. 3	32.64^{a}	0.89^{a}
'Tamara' / Gi. 5	45.64^{c}	1.11^{b}
'Lapins' / Gi. 5	45.84^{c}	1.35^{d}
'Lapins' / Gi. 6	53.64^{d}	1.65^{e}
'Kordia' / Gi. 5	47.84^{c}	1.28^{c}
'Kordia' / Gi. 3	38.07^{b}	1.15^{bc}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

In 2023 leaf area surface indicator showed a higher development phase as trees developed in terms of canopy volume, registering a leaf development ranged between 1.74-2.52 m^2 (Table 12).

As in 2022, also in 2023 it was observed that the highest development was specific to 'Lapins' cultivar (2.22-2.52 m^2), followed by 'Kordia' cultivar on 'GiSelA 5' and 'GiSelA 3' (2.18-2.32 m^2) and finally, 'Tamara' cultivar (1.74-1.87 m^2).

Table 12. The number of shoots and leaf area parameters in the cherry plot during 2023

Cultivar/rootstock	2023	
	Number of shoots (no)	**Leaf area (m^2)**
'Tamara' / Gi. 3	35^{a}	1.74^{a}
'Tamara' / Gi. 5	44^{b}	1.87^{b}
'Lapins' / Gi. 5	50^{c}	2.22^{c}
'Lapins' / Gi. 6	58^{d}	2.52^{e}
'Kordia' / Gi. 5	40^{ab}	2.32^{d}
'Kordia' / Gi. 3	37^{a}	2.18^{c}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Results showed the same tendency in 2024, but the registered values were even higher, ranging 2.42-2.90 m^2 (Table 13).

Table 13. The number of shoots and leaf area parameters in the cherry plot during 2024

Cultivar/rootstock	2024	
	Number of shoots (no)	**Leaf area (m^2)**
'Tamara' / Gi. 3	38^{a}	2.42^{a}
'Tamara' / Gi. 5	45^{b}	2.76^{cd}
'Lapins' / Gi. 5	55^{c}	2.84^{de}
'Lapins' / Gi. 6	64^{d}	2.90^{e}
'Kordia' / Gi. 5	41^{a}	2.70^{bc}
'Kordia' / Gi. 3	39^{a}	2.64^{b}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Results regarding generative processes showed adequate tendencies of flowering, so the blooming started in 2021, one year after planting, but with few flowers, trees began flowering with abundance in 2022 (Table 14) and culminating in 2023, with a very good flower set, which continued in 2024 also.

Table 14. The generative buds evaluation and flowering abundance in the cherry plot (2022)

Cultivar/ rootstock	2022	
	Generative buds evaluation (%)	Flowering abundance (0-5 score scale[1])
'Tamara' / Gi. 3	48[a]	3.2[a]
'Tamara' / Gi. 5	63[b]	3.6 [a]
'Lapins' / Gi. 5	64[a]	4.2 [a]
'Lapins' / Gi. 6	69[a]	4.5 [a]
'Kordia' / Gi. 5	47[a]	3.7 [a]
'Kordia' / Gi. 3	55[a]	3.9 [a]

[1]0 - no flowers; 5 - abundant flowering

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Generative buds evaluation (Tables 14-16) showed that more than 61% of buds transformed to generative buds, this percent being even higher in 2023. Highest generative buds were formed in 2023 in 'Lapins'/'GiSelA 6' and 'Tamara'/'GiSelA 5' cultivars (Table 15).

Table 15. The generative buds evaluation and flowering abundance in the cherry plot (2023)

Cultivar / rootstock	2023	
	Generative buds evaluation (%)	Flowering abundance (0-5 score scale[1])
'Tamara' / Gi.3	54 [a]	3.6 [a]
'Tamara' / Gi.5	63 [a]	4.0 [a]
'Lapins' / Gi.5	61 [a]	4.3 [a]
'Lapins' / Gi.6	65 [a]	4.6 [a]
'Kordia' / Gi.5	48 [a]	3.1 [a]
'Kordia' / Gi.3	57 [a]	3.2 [a]

[1]0 - no flowers; 5 - abundant flowering
*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Generative buds in 2024 showed the same tendency, ranged between 57-69 %.
Flowering tendency with highest scores were found in 'Lapins' cultivar on both rootstocks followed by 'Kordia' and 'Tamara' on 'GiSelA 5' rootstock (Table 16). Data showed that values of 4.7-4.9 on a scale with a maximum of 5.0 scoring the maximum points represent the highest rankings, thus adequate flowering process was registered. The other rootstock/ scion combinations behaved also appropriate, however the 'Lapins' cultivar being considered the most abundant variant regarding blooming.

Table 16. The generative buds evaluation and flowering abundance in the cherry plot (2024)

Cultivar / rootstock	2024	
	Generative buds evaluation (%)	Flowering abundance (0-5 score scale[1])
'Tamara' / Gi. 3	57 [a]	3.7 [a]
'Tamara' / Gi. 5	65 [a]	3.9 [a]
'Lapins' / Gi. 5	57 [a]	4.7 [a]
'Lapins' / Gi. 6	69 [a]	4.9 [a]
'Kordia' / Gi. 5	65 [a]	3.8 [a]
'Kordia' / Gi. 3	58 [a]	3.7 [a]

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Regarding blooming stages, we can conclude that in 2022 the pedicel elongation and the starting of flowering was in the 27.04-02.05 period, depending on the studied cultivars (Table 17). No differences in blooming were observed due the rootstocks.
In 2022 full flowering was observed in early May, 'Lapins' cultivar being earlier with a few days than the other two studied cultivars.

Table 17. Phenology of flowering sweet cherry cultivars on 'GiSelA' rootstocks '3', '5', '6' in 2022

Cultivar/ rootstock	2022		
	Starting of flowering	Full flowering	Flowers fading
'Tamara' /Gi. 3 'Tamara' / Gi. 5	27.04	05.05	10.05
Lapins' /Gi. 5 'Lapins' / Gi.6	02.05	03.05	15.05
'Kordia' /Gi.5 'Kordia' / Gi.6	29.04	04.05	11.05

In 2023 full flowering occurred earlier when compared with 2022 between 24.04-01.05.2023, with slight differences in blooming depending the cultivar (Table 18).

Table 18. Phenology of flowering sweet cherry cultivars on 'GiSelA' rootstocks '3', '5', '6' in 2023

Cultivar/ rootstock	2023		
	Starting of flowering	Full flowering	Flowers fading
'Tamara' /Gi. 3 'Tamara' / Gi. 5	22.04	27.04	02.05
'Lapins' /Gi. 5 'Lapins' / Gi. 6	20.04	24.04	30.04
'Kordia' /Gi. 5 'Kordia' / Gi. 6	27.04	01.05	07.05

Figure 1. Flowering phase in the research plot (2024)

In 2024 the start of flowering was observed at the end of April between 30.03-05.04, the full flowering occurred between 02-11 April (Table 18).

Table 19. Phenology of flowering sweet cherry cultivars on 'GiSelA' rootstocks '3', '5', '6' in 2024

Cultivar/ rootstock	2024		
	Starting of flowering	Full flowering	Flowers fading
'Tamara' /Gi. 3/5	02.04	11.04	20.04
'Lapins' /Gi. 5/6	30.03	02.04	15.04
'Kordia' /Gi. 5/6	05.04	10.04	22.04

Regarding the yield per tree, results showed that scion/rootstock combinations behaved differently.

In the experiment conducted on both rootstocks, the 'Tamara' cultivar demonstrated a similar yield (Table 20), ranging from 0.88-1.20 kg/tree in 2022 and 1.61-1.63 kg/tree in 2023.

Table 20. Yield (kg/tree) in the research plot

Cultivar/roots.	2022	2023	2024	Cumul.
'Tamara' /Gi. 3	0.9 ^{a}	1.7 ^{a}	8.8 ^{a}	11.3
'Tamara' / Gi. 5	1.2 ^{a}	1.6 ^{a}	7.3 ^{a}	10.1
'Lapins' / Gi. 5	0.9 ^{a}	3.7 ^{b}	9.3 ^{a}	13.4
'Lapins' / Gi. 6	1.4 ^{a}	4.9 ^{c}	10.2 ^{a}	16.5
'Kordia' / Gi. 5	0.4 ^{a}	0.7 ^{a}	7.6 ^{a}	13.4
'Kordia' / Gi. 3	1.2 ^{a}	0.9 ^{a}	8.0 ^{a}	10.4

In 2023, 'Kordia' and 'Tamara' cultivars provided quite similar values in terms of yield, being in the same statistical class, higher values were registered and 'Lapins'/'GiSelA 5' cultivar (3.7 kg/tree) and even higher values at 'Lapins'/'GiSelA 6' cultivar combination (4.9 kg/tree). In 2024 again the highest yield was recorded at 'Lapins'/'GiSelA 6' rootstock followed by 'Lapins'/'GiSelA 5' rootstock (9.3-10.2 kg/tree). There were no statistical differences between the means. Our findings indicate that the 'Lapins'/'GiSelA 6' rootstock yielded the highest cumulative yield followed by the cultivar 'Kordia' and 'Lapins' cultivars on the same 'GiSelA 5' rootstock.

When compared with 2024 a significant growth of yield was observed, thus was a 7.3-8.8 kg/tree production recorded.

In researches effectuated by Suran et al. (2022), differences in yield and yield efficiency were significant, the experimental plot being in the 4th year. In 'GiSelA 6', the yield was very low with 0.88 kg tree^{-1}. The highest yield was in 'GiSelA 3' and 'PiKu 1' with 5.17 and 4.05 kg tree^{-1}.

Being in the first years of development of trees, the mean fruit weight (Table 21) of 'Tamara' cultivar was found to have close values (14.57 g in 2022, 14.82 g in 2023, 13.70 g in 2024) between the two rootstocks, but on 'GiSelA 5' the fruits seemed to be larger, however the differences were small. Fruit size may vary depending on many factors, such as climate, high temperatures, rainfall or adverse negative effects (dry periods in summer).

Similar results of fruit parameters were obtained by researches in Czech Republic (Vavra et al., 2020), reporting fruit sizes of 29.5 mm, weight 12.4 g, SSC of 18.3°Brix, but in a slight colder climate with 8.1°C and an annual average rainfall of 655 mm. In our research the results obtained indicate higher values of average fruit weight and SSC values due to probable higher average annual temperatures and drip irrigated conditions.

The results presented in Table 21 shows that the soluble solids content of sweet cherries grown in 2022 ranged from 22.80-23.92°Brix.

Table 21. Average fruit weight and soluble solids content of fruit during 2022 in the cherry plot

Cultivar/ rootstock	2022	
	Average fruit weight (g)	Soluble solids (°Brix)
'Tamara'/ Gi. 3	14.47 ^{a}	22.80 ^{a}
'Tamara'/ Gi. 5	14.68 ^{a}	23.92 ^{a}
'Lapins' / Gi. 5	10.6 ^{a}	19.8 ^{a}
'Lapins' / Gi. 6	10.3 ^{a}	19.7 ^{a}
'Kordia' / Gi. 5	9.8 ^{a}	19.8 ^{a}
'Kordia' / Gi. 3	10.6 ^{a}	19.9^{a}

*Duncan's multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

The soluble solids content in 2023 ranged from 23.75-24.30^{0} Brix (Table 22).

Table 22. Average fruit weight and soluble solids content of fruit during 2023 in the cherry plot

Cultivar/ rootstock	2023	
	Average fruit weight (g)	Soluble solids (°Brix)
‘Tamara’/ Gi. 3	14.78 ^{a}	23.75 ^{a}
‘Tamara’/ Gi. 5	14.87 ^{a}	24.30 ^{a}
‘Lapins’ / Gi. 5	9.85 ^{a}	19.9 ^{a}
‘Lapins’ / Gi. 6	10.35 ^{a}	20.1 ^{a}
‘Kordia’ / Gi. 5	10.53 ^{a}	19.5 ^{a}
‘Kordia’ / Gi. 3	10.12 ^{a}	20.1 ^{a}

*Duncan’s multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

In 2024 soluble solids presented a similar tendency but the registered values had a lower level. The ‘GiSelA 3’, ‘GiSelA 5’ and ‘GiSelA 6’ varieties showed little influence in their soluble solids content in the analysed period given the absence of significant differences between the values from each cultivar grafted on different rootstock (Table 23).

Table 23. Average fruit weight and soluble solids content during 2024 in the cherry plot

Cultivar/ rootstock	2024	
	Average fruit weight (g)	SSC content of fruits (°Brix)
‘Tamara’/ Gi. 3	13.70 ^{a}	19.5 ^{a}
‘Tamara’/ Gi. 5	13.34 ^{a}	20.5 ^{a}
‘Lapins’ / Gi. 5	10.53 ^{a}	20.16 ^{a}
‘Lapins’ / Gi. 6	9.63 ^{a}	19.9 ^{a}
‘Kordia’ / Gi. 5	10.53 ^{a}	22.1 ^{a}
‘Kordia’ / Gi. 3	10.21 ^{a}	21.6 ^{a}

*Duncan’s multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P≤0.05)

Observations showed that there were also higher values of individual fruits in Tamara measured above 13 g in our researches, showing the fact that there is an inner genetical capacity of the cultivar to bear higher weight fruits in optimal environmental and nutrition conditions.
According polish researches (Spadzik et al., 2022) in the climate conditions of Central Poland ‘Tamara’ fruits weighed 12 g and were around 30 mm in diameter.
It is important to note that the tasting characteristics of cherry fruits depend also on their soluble solids content but other characteristics too. According to research conducted in Nordic countries (Lanauskas, 2023) such as Lithuania and Norway, the acceptable threshold for SSC values ranges between 14.2 and 16°Brix. Our results corroborated with the results of other foreign and Romanian researchers (Balan et al., 2024) confirmed that the SSC values of the sweet cherries during our experiments were in the optimum range, indicating that they meet consumer demands

CONCLUSIONS

The growth vigor and generative characteristics of ‘Lapins’, ‘Tamara’ and ‘Kordia’ sweet cherry cultivar was evaluated in the present research, rafted on rootstocks ‘GiSelA 3’ and ‘GiSelA 5’ and ‘GiSelA 6’, general conclusions based on several biometrical characteristics showed different growth and bearing characteristics of scion rootstock-combinations. In terms of trunk cross-sectional area ‘Lapins’ cultivar grafted on both ‘GiSelA 5’ and ‘GiSelA 6’ cultivars grew the most intensively followed by ‘Kordia’ cultivar on ‘GiSelA 5’ and ‘Tamara’ cultivar on both ‘GiSelA 3’ and ‘GiSelA 5’ cultivars. Regarding the shoot length parameter generally conclusion is that ‘Lapins’ and ‘Kordia’ cultivars are in the same statistical class on the three rootstocks (‘GiSelA 3’, ‘5’, ‘6’), ‘Tamara’ cultivar presented lower values on ‘GiSelA 3’ and ‘5’. The height of the trees indicator was similar for both rootstock systems (‘GiSelA 5’, ‘6’) achieving good and optimum growing heights, specific for tall spindle axe training systems. A small tree die-back phenomenon was still observed in 2023-2024, ranging from 7-14% of trees, with no specific explanation, however due to natural causes. The canopy volume of trees showed significant differences between scion-rootstock combinations, the highest values being observed on ‘GiSelA 6’ and ‘5’ rootstock systems. ‘GiSelA 3’ grafted trees (‘Tamara’ and ‘Kordia’) showed smaller values. The number of shoots indicator showed the same pattern, the highest number of shoots was recorded on ‘Lapins’ cultivar on both rootstocks, and in opposite way the lowest number was recorded on ‘Tamara’ and ‘Kordia’ on the ‘GiSelA 3’ rootstock.
Trees began flowering with abundance in 2022 and this tendency appeared to remain in all the other years with a very good flower set. In the experimental years no significant differences induced by the rootstock were observed until

now. Regarding the cumulative yield per tree indicator results showed that the highest values were obtained at 'Lapins' cultivar grafted on 'GiSelA 6' and 'GiSelA 5' with close cumulative values, followed by 'Kordia' cultivar grafted on 'GiSelA 5' cultivar. The average fruit weight was the highest in 'Tamara' cultivar with a good soluble solids content, with very good aroma and tasting qualities, probably due also to the complex genetics of the cultivar and also to soil-climate phenomena. Until now, a very good soil and climate adaptability was observed in the studied rootstock-scion combinations and no compatibility problems or other phyisiological problems were detected.

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