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Cultivar and rootstock effect on sweet cherry fruit density and fruit drop

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Abstract. The yield formation of sweet cherries occurs in a relatively short time and has been influenced by various factors. Shortly after blooming, the incompletely fructified fruits drop off the trees. Later, the second fruit drop is mostly is related to resource availability and sink-source relations in the trees. The aim of the study was to evaluate the initial fruit density, fruit drop and final fruit density for eleven sweet cherry cultivars and the impact of rootstocks, year-to-year differences and growing systems. Fruit density on a sample branches was detected in 2022 – 2024 after the initial fruit drop and the second fruit drop. Generally, the number of fruits reduced by 24 – 86% during their development and it was affected by growing season, cultivar and rootstock. The lowest level of fruit drop was shown by the cultivars 'Paula' in growing system with VOEN cover and drip irrigation. Fruit drop was significantly less for the trees grown on the rootstock 'Latvijas Zemais' (*Prunus cerasus L.*) comparing to the trees on the rootstocks P7 and Mahaleb cherry (*Prunus mahaleb* L.).
Key words: sweet cherry, rootstocks, growing system, *Prunus mahaleb*, *Prunus cerasus*, VOEN cover.

Introduction

Premature drop of partially developed fruits is one of yield limiting processes. The development of cherry fruits starts with a rapid increase in size (initial phase, associated with cell division), followed by a retarded growth associated with pit hardening, and resumption of rapid growth and final swell – cell-expansion dry matter accumulation (Vignati *et al*., 2022).

After the flowering, the first drop of fruitlets was related to lack of pollination, incomplete fructification (Bradbury, 1929) and to flower quality in terms of nitrogen and carbohydrate content preserved in the previous growing season (Sanzol & Herrero, 2001). As fruit development continues, the premature abscission was associated with limiting environmental factors, plant hormonal balance and sink-source relationship (Ayala & Lang, 2008; Racskó *et al*., 2006) as well as with the injuries of endocarp and embryo (Tukey, 1936) and the damages caused by pests and diseases (Racskó *et al*., 2006).

Research on photoassimilate distribution showed the competitive relationship between vegetative and generative organs of sour cherries and strong sink properties of vegetative shoots, and fruit generally have priority when leaves and fruit are in competition for resources (Flore & Layne, 1999). Also, in the research of sweet cherry cultivars grafted on rootstocks Gisela 5 and Gisela 6, the fruit acted as priority sinks *vs* new shoots for photoassimilate partitioning with the highest sink strength in the stages of rapid growth (Ayala & Lang, 2008). However, a retardment of photosynthesis by shading could induce early fruit drop (Flore & Layne, 1999).

The vigour of new shoots is closely related to the pruning intensity and shoot position in the canopy. Though, new shoot pruning in the spring and branch position did not show a pronounced effect on fruit drop (Gatti, 2023).

The intensity of premature fruit drop varied with fruit development stage among the growing sites and years showing the importance of environmental factors (Blanusa *et al*., 2006, Gatti 2023). The increase in fruit drop was observed both after the periods with low (but still positive) and high (above 30 °C) temperatures (Gatti, 2023). It consisted to a previously determined positive relation of photosynthesis and temperature in the range from 17 to 30 °C for Prunus species (Sams & Flore, 1983). As the climate changes, the impact of temperature fluctuations and other environmental factors may become even more significant.

Cultivars also differ in the fruit set and in their sensitivity to environmental conditions (e.g., temperature, rainfall), which regulate premature abscission of fruits. In Latvia, which is located in the

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Northern part of the sweet cherry distribution area, the assortment of grown cultivars includes both the introduced ones from different countries both the local cultivars with different ancestors and requirements for environmental conditions (Ruisa, 1998). Significant interaction of the cultivar and photo assimilate availability on fruit set and premature fruit retention was determined for sweet cherries 'Sylvia' and 'Kordia' (Quentin *et al*., 2013). However, the productivity of a tree is also related to fruit set and to initial and final fruit amount, which could be characterized by fruit density. After an abundant initial number of fruits at the beginning of their development, fruit drop at some extent could avoid overproduction of tree and low fruit quality.

The aim of the research was to evaluate the initial fruit density, fruit drop during the medium stage of fruit growth and final fruit density for eleven sweet cherry cultivars and the impact of rootstocks, year-to-year differences and growing systems.

Materials and methods

The site of the experiment

The research was carried out in two sweet cherry orchards with different growing systems, which were located at the Institute of Horticulture (LatHort), in Dobele (56.610704, 23.300483). One orchard was equipped with VOEN cover and drip irrigation. Soil characteristics in this orchard: slightly alkaline clayic Podzoluvisol soil (pH 7.3) with organic matter content of 2.3 %, plant-available phosphorus (P_2O_5), and potassium (K_2O) were 203 mg kg^{-1} P_2O_5 and 253 mg kg^{-1} K_2O, respectively. The trial was planted in the spring of 2015 at distances 3 to 4.5 m. The cultivars (cvs.) 'Paula' and 'Artis' (developed in Latvia, Insitute of Horticulture), 'Radica' and 'Bryansk 3-36' (introduced from Russia), 'Donetckiy 42-37' (introduced from Ukraine) and 'Techlovan' (introduced from Czech Republic) were grown on the rootstocks Mahaleb cherry (*Prunus mahaleb* L.), 'Latvijas Zemais' (*P. cerasus* L.) and P7 (*P. padus* L. ^{x} (*P. cerasus* L. ^{x} *P. avium* L.)). There were three replications with 2 - 4 trees for each cultivar/rootstock combination in the plot. Trees were topped at 3 – 3.50 m height to fit them under the cover and pruned to maintain canopy in a pyramidal form.

In the second orchard, the trees were grown in an open field without irrigation. The trial was planted in 2003 – 2010 at distances 3 to 5 m. Soil characteristics in this orchard slightly alkaline clayic Podzoluvisol soil (pH 7.3) with organic matter content of 2.3 %, plant-available phosphorus (P_2O_5), and potassium (K_2O) were 94 mg kg^{-1} P_2O_5 and 141 mg kg^{-1} K_2O, respectively. The cultivars 'Paula', 'Aija', Aleksandrs' (initial name AM 10-12-6) and 'Elfrīda' (originated in Latvia) as well as 'Kompaktnaya Venyaminova', 'Bryansk 3-36' and 'Bryanskaya Rozovaya' (introduced from Russia) were grown on the rootstock Mahaleb cherry, there were 4 – 8 trees of each cultivar. Trees were topped at 3 – 4 m height according to the tree vigour and pruned to maintain canopy in pyramidal or vase form.

The measurements and calculations

The data were collected in 2022 – 2024. The typical 3 – 4 years old sample branch at similar strength and position was chosen and labelled for each tree. In total, the branches from 52 trees were assessed in the orchard with VOEN cover and drip irrigation, and from 50 trees – in the orchard without cover and irrigation, The length of the fruiting part was measured. Fruits were counted after the initial fruit abscission and shortly before ripening, after final premature fruit abscission. Fruit density was calculated as the number of fruits per 1 m of fruiting part length on the sample branches. The fruit density after the initial premature fruit abscission was defined as initial fruit density (FDe1) whereas fruit density shortly before ripening – as final fruit density (FDe2).

The fruit drop (FDr) during the medium stage of fruit growth was calculated as the decrease in fruit density in percent between the both counting times.

Air temperature and precipitation

During the research years, the air temperature and precipitation amount varied considerably. The average, minimal and maximal temperature as well as precipitation sum and number of rainy days were shown for flowering and fruit development periods – from flowering to the end of initial fruit drop and after – to the end of final fruit drop, in Table 1. In 2022, the weather after sweet cherry flowering and during initial fruit drop differed from other years with a large amount of precipitation and more rainy days. In 2023, the flowering time was colder in general than in other years, moreover, the frosts occurred during and after the flowering, but the precipitation amount and rainy-day number were lower than in other years. In 2024, the air temperature approached 0 °C during the flowering but did not drop below it.

The data were processed using analysis of variance (ANOVA) and Duncan's test for post-hoc analysis in SPSS. Considering the differences between the growing systems in different orchards, the year-to-year difference and cultivar effect were determined for each orchard separately, but the rootstock effect was based on the data from orchard with VOEN cover and drip irrigation. The growing system effect was determined only for that cultivars-rootstock combinations which were present in both orchards (i.e. cvs. 'Paula' and 'Bryansk 3-36' on the Mahaleb cherry rootstock).

Table 1

Air temperature and precipitation during sweet cherry flowering, initial fruit drop and final fruit drop (data obtained in Latvian Environment, Geology and Meteorology Centre)

Year	Period	Dates	Temperature, °C			Sum of precipitation, mm	Number of the days with precipitation
			average	min	max		
2022	flowering	5th – 15th May	10.6	0.1	19.6	4.10	4
	initial fruit drop	16th May – 3rd June	11.44	2.00	21.40	70.70	13
	final fruit drop	4th June – 20th June	15.64	7.10	23.60	43.20	8
2023	flowering	27th April – 6th May	6.3	-2.5	17.0	2.2	2
	initial fruit drop	7th May – 29th May	13.50	-2.30	27.50	6.2	1
	final fruit drop	30th May – 16th June	14.86	1.90	27.50	0	0
2024	flowering	2nd – 12th May	9.73	0.40	21.2	15.20	4
	initial fruit drop	13th May – 21st May	15.50	4.10	24.70	4.5	1
	final fruit drop	22nd May – 12th June	17.16	6.30	27.10	30	10

Data processing

Results and discussion

Year to year differences

In 2023, during the flowering and beginning of fruit development and initial fruit drop, the spring frosts at -2.5 and -2.3 °C damaged flowers and fruitlets of sweet cherries in both orchards. The initial and final fruit density (FDe1 and FDe2) was significantly lower in 2023 than in other years. The FDe2 in 2022 and 2024 (31 and 29) corresponds to the average sweet cherry fruit density (32) detected previously in Dobele, in the year with a high productivity, whereas FDe2 in 2023 (12) was not so low as previously detected FDe (2), in the year with low yield after late cold damages (Feldmane, unpublished data). In the orchard with

Table 2

Fruit density and fruit drop of sweet cherry cultivars grown with VOEN cover in 2022 – 2024

Cultivars, parameters	Initial fruit density (FDe1)			Fruit drop (FDr), %			Final fruit density (FDe2)		
	2022	2023	2024	2022	2023	2024	2022	2023	2024
‘Techlovan	34 ab	14 a	79 c	44	64	43	19	4 a	36 b
‘Donetckiy 42-37’	70 bc	20 a	40 ab	50	61	39	33	8 ab	23 ab
‘Artis’	73 bc	24 a	84 c	67	64	50	25	8 ab	36 b
‘Radica’	58 abc	52 b	28 a	42	59	43	33	22 b	16 a
‘Paula’	64 abc	28 a	61 bc	47	48	40	34	14 ab	38 b
‘Bryansk 3-36’	79 c	53 b	52 abc	48	64	51	41	18 ab	27 ab
Statistical parameters									
Mean	63 Y	32 X	58 Y	50 W	60 V	44 W	31 T	12 U	29 T
p-value (cultivars)	0.06	0.01	0.01	0.13	0.08	0.84	0.20	0.01	0.01
p-value (growing seasons)	<0.01			<0.01			<0.01		

a, b - the means in the columns marked with distinct lowercase letter differed significantly at the level p-value <0.05 by Duncan's test

Y, X - the means in the rows marked with distinct uppercase letter differed significantly at the level p-value <0.05 by Duncan's test

VOEN cover and drip irrigation, FDr in 2023 was higher than in other years (60 % vs 44 and 50 %, $p< 0.05$) (Table 2). However, in the open field orchard, in spite of the dry weather conditions, the fruit drop during medium stage of fruit growth (FDr) was less in 2023 than in 2022 and 2024 (38% *vs* 59 and 55%, $p< 0.05$) (Table 3). It might indicate the effect on vegetative shoot and fruit source-sink relations on FDr when moderate water shortage declined shoot growth and diverted the photo assimilates to fruit growth. During fruit development, the maximum air temperature observed in our study was 27.50 °C – below the critical temperature of 32 °C which increased the fruit drop of cv. 'Regina' in South Tyrol, Italy (Gatti, 2023).

Cultivar effect in the orchard with VOEN cover and drip irrigation

In both orchards, the cultivar effect on FDe1, FDr and FDe2 varied depending on growing season peculiarities. Therefore, the cultivar effect was analysed in the context with weather conditions in the current year.

Cv. 'Techlovan' was the most sensitive to spring frosts having high FDr and the lowest FDe2 in 2023. In opposite, high fruit density and low FDr for cv. 'Techlovan' was observed in 2024 with the warmest weather during flowering and fruit development. Cv. 'Techlovan' showed a sensitivity to flowering conditions resulting in low fruit set also in the study carried out in Poland (Szpadzik *et al.*, 2019).

Cv. 'Donetckiy 24-37' responded to spring frosts in 2023 with one of the lowest FDe1 and FDe2 whereas in warm weather for fruit development in 2024, the fruit drop was the lowest among the cultivars. Additionally, the FDe in 2024 might be a promoted by the low productivity in previous year.

Cv. 'Artis' had high FDe1 in the years without frosts (2022, 2024) and high FDe2 in the year with warm weather during the flowering and fruit development (2024). Still, the FDr was high indicating the sensitivity to frosts, unrealized yielding potential and the need of improved growing methods for this cultivar.

Cv. 'Radica' showed the highest tolerance to spring frosts in 2023 with high values of FDe1; and lowest FDr in 2022 which was abundant with the precipitation. FDr remained at an average level in 2023 and 2024. However, in 2024, cv. 'Radica' had the lowest FDe1 and FDe2 among the cultivars. The possible reasons could be inadequate development of flower buds in the previous dry summer and intensive pruning which was applied to fit the tree under the VOEN cover.

Cv. 'Paula' had medium FDe1, and it was considerably affected by spring frosts in 2023 (Table 2). However, its FDr was one of the lowest among the cultivars in the orchard with VOEN cover in spite of the variable weather conditions. It resulted in FDe 2 above the average level compared to others and to relatively stable productivity.

Cv. 'Bryank 3-36' differed from other cultivars with high FDe1 in 2022 and 2023 indicating the tolerance to spring frosts and cool and wet weather during fruit development. Its FDr fluctuated around the average level, still, the FDe2 in 2022 and 2023 was one of the highest. The increase of FDr and decrease of FDe2 was observed in 2024, possibly also due to too intensive pruning under the VOEN cover. Previously, cvs. 'Paula' and 'Bryansk 3-36' were tested on the rootstock Mahaleb cherry in open field, in the years without spring frosts and recommended for growing due to good winterhardiness and fruit quality (Ruisa & Krasnova, 2013).

Cultivar effect in the open field orchard

Cv. 'Aija' responded well to warm flowering and fruit development time in 2024, but the cool, rainy weather (2022) and spring frosts (2023) during this time lead to fruit density which was unstable, below the medium level or even the lowest one, and fruit drop – above the average level.

Cv. 'Elfrīda' showed the lowest FDe1 and FDe 2, and highest FDr in the years 2022 and 2024 which were favourable for most of other cultivars. However, in the dry season of 2023 with spring frosts, cv. 'Elfrīda' had the highest FDe1 and FDe2, and lowest FDr indicating high frost and drought tolerance.

Cv. 'Bryansk 3-36' in an open field orchard had FDe1, FDr and Fde2 close to the average level, indicating medium and stable productivity in the years with frosts, variable air temperature and abundance or lack of precipitation.

Cv. 'Paula' in the open field orchard did not respond well to the prolonged rain in 2022 having relatively low FDe but FD - above the average. Spring frost caused low FDE1 and FDE 2 in 2023, in return these indices were above the average level in 2024.

Cvs. 'Kompaktnaya Venyaminova' and 'Bryanskaya Rozovaya' had high FDe1 and FDe2, and low FDr in the years without frosts. In 2023, after spring frosts and dry weather during fruit development, the fruit density and fruit drop were close to average level. FDr was rather stable – about 40 – 54%, which means, that 40 – 54% of fruitlets set after the flowering developed to ripen fruit.

Cv. 'Aleksandrs' had high FDe1 and FDe2 in the years without frosts. Its fruit drop in general as well as fruit density in the year with spring frosts was close to average level.

Generally, FDr in our study varied from 44 to 86% between the cultivars. Significant cultivar effect was

Table 3

Fruit density and fruit drop of sweet cherry cultivars grown in open field in 2022 – 2024

Cultivars, parameters	Initial fruit density (FDe1)			Fruit drop (FDr), %			Final fruit density (FDe2)		
	2022	2023	2024	2022	2023	2024	2022	2023	2024
‘Aija’	89	13 a	74 ab	60 ab	51	52	35 bcd	6 a	33 a
‘Elfrīda’	43	76 c	47 a	86 c	34	64	6 a	50 b	16 a
‘Bryansk 3-36’	72	42 ab	74 ab	57 ab	31	60	28 abc	28 a	25 a
‘Paula’	68	25 ab	119 b	67 bc	24	49	19 ab	19 a	60 b
Ķompaktnaya Venyaminova’	108	41 ab	63 a	44 a	42	51	59 d	23 a	32 a
‘Bryanskaya Rozovaya’	105	45 b	125 b	54 ab	40	51	48 cd	27 a	61 b
‘Aleksandrs’	101	36 ab	143 c	49 ab	37	50	42 bcd	21 a	69 b
Statistical parameters									
Mean	84 U	40 T	92 U	59 W	38 V	55 W	35 X	25 Y	38 X
p-value (cultivars)	0.07	0.01	<0.01	0.01	0.11	0.73	<0.01	<0.01	<0.01
p-value (growing seasons)	<0.01			<0.01			0.02		

a, b - the means in the columns marked with distinct lowercase letter differed significantly at the level p-value <0.05 by Duncan’s test

Y, X - the means in the rows marked with distinct uppercase letter differed significantly at the level p-value <0.05 by Duncan’s test

also determined in the study on sour cherries, where fruit drop varied from 71.5 to 92.4% (Davarynejad *et al*., 2014). The cvs. ‘Bryanskaya Rozovaya’, ‘Kompaktnaya Venyaminova’ and ‘Aleksandrs’, which final fruit density in the year with frosts was close to average level, were recommended for growing also due to good winterhardiness of the trees, tolerance to leaf spot and good productivity in former study done in open field, in the years without spring frosts (Ruisa, 1998). However, the crop load of 132-135 cherry fruits per 4 years old branch for Solaxe-trained trees of cv. ‘Summit’ on the rootstock Tabel® Edabriz was considered as an optimal for balanced productivity and fruit quality in France (Lauri & Claverie, 2007) which could be related to a higher FDe2 than in our study.

Growing system effect

For the cv. ‘Paula’ grown with the VOEN cover and drip irrigation, the productivity was more stable than in the open field orchard. In the years without spring frosts, the FDe2 was 25 – 32 under the VOEN cover, which ensured high productivity whereas in the open field orchard it varied from 19 (low productivity) to 60 (overproduction). In 2023, the FDe 2 was 19 in both orchards in spite of the higher FDe1 in the growing system with VOEN cover. Therefore, the growing system with VOEN cover and drip irrigation was more favourable for fruit set and the beginning of fruit development also in the spring with frost incidence. However, the effects of the unfavourable spring conditions were apparently long-lasting and after limited the productivity of trees to equal level in both orchards. One of shortages for growing systems with covers is reduced sunlight for the trees (Stone *et al.*, 2024) which could provoke the fruit drop additionally.

On the contrary, cv. ‘Bryansk 3-36’ had more stable productivity in the open field orchard – FDe 2 varied from 25 to 28 among the years in spite of the variable FDe1, FDr, different weather conditions and frosts. In the growing system with VOEN cover and drip irrigation, the FDe2 fluctuated from 15 (in 2023) to 34 (in 2022), most probably due to the strong vigour of the trees on all rootstocks, which required too intensive pruning. Similarly, less flowering intensity and less productivity after the crown restriction in growing system with VOEN cover was reported by E. Rubauskis for cv. ‘Krupnoplodnaya’ with large canopy volume (Rubauskis *et al*., 2013[a]; Rubauskis *et al*., 2013[b]).

In our study, after spring frosts, the FDe1 for cv. ‘Bryansk 3-36’ was higher in the growing system with VOEN cover and drip irrigation, however, the fruit drop was also high, which resulted in low FDe2.

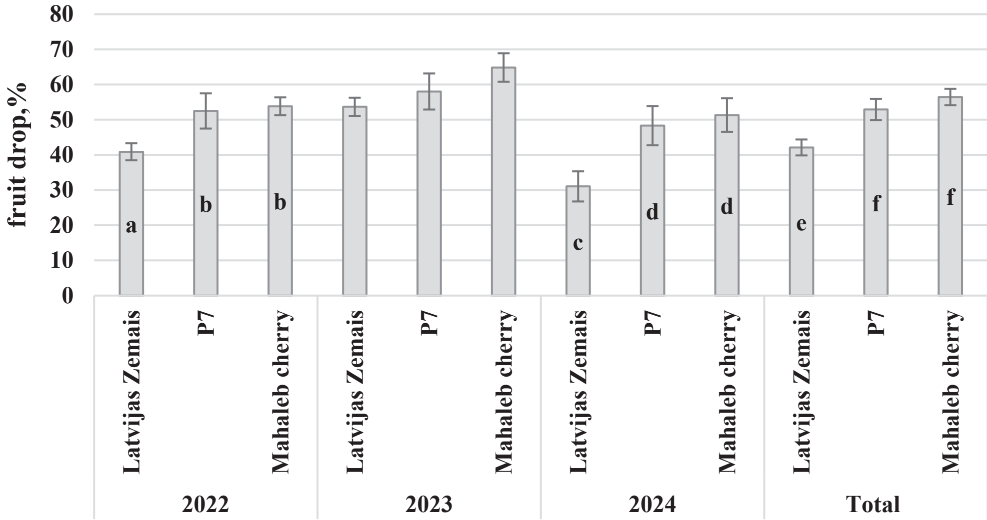

Figure 1. The effect of the rootstock on fruit drop of sweet cherries grown with VOEN cover and drip irrigation in 2022 – 2024 (error bars represent standard error, the means marked with distinct letters differed significantly within each period at the level p<0.05 by Duncan's test).

Table 4

Fruit density and fruit drop of sweet cherry cultivars grown with VOEN cover in 2022 – 2024

Cultivars, parameters	Fruit drop (FDr), %			p-value (rootstocks within one cultivar-combination)
	Latvijas Zemais	P7	Mahaleb cherry	
'Artis'	46 Y	69 YX	83 X	<0.01
'Bryansk 3-36'	47	47 b	58	0.20
'Techlovan	45	55 ab	50	0.35
'Donetckiy 42-37'	43	50 ab	55	0.65
'Radica'	32 U	45 b U	62 W	0.06
'Paula'	43	43 b	49	0.74
Statistical parameters				
Mean	42 Y	53 X	56 X	-
p-value (cultivars within one rootstock-combination)	0.38	< 0.01	0.35	-
p-value (rootstocks)	<0.01			-

a, b - the means in the columns marked with distinct lowercase letter differed significantly at the level p-value <0.05 by Duncan's test

Y, X - the means in the rows marked with distinct uppercase letter differed significantly at the level p-value <0.05 by Duncan's test

Rootstock effect

The rootstocks P7 and Mahaleb cherry did not differ in terms of FDe1, FDr and FDe2 of grafted cultivars. The mean FDe1 for P7 and Mahaleb cherry was 5.07 and 5.36, mean FDe2 – 2.45 and 2.92, respectively. The trees grafted on 'Latvijas Zemais' showed a tendency of lower FDe1 (4.72 on average) and similar FDe2 (2.91 on average) to others. FDr for the trees grafted on 'Latvijas Zemais' was significantly less than for other rootstocks in two of three study years and in the total assessment (Figure1).

Less fruit drop for the trees grafted on the rootstock 'Latvijas Zemais' than on control – Mahaleb rootstock, was observed each year for each cultivar. Therefore, the effect of the rootstock was similar for all cultivars and cultivar-rootstock interaction was not statistically significant (p=0.28). The results of fruit drop for cultivar- rootstock combinations are shown in Table 4.

Outlook for further research and fruit growing

All parameters – initial and final fruit density as well as fruit drop revealed significant differences between growing seasons. Differences in initial and final fruit density were attributed to the cultivar properties whereas differences in fruit drop – rather to rootstock traits. Considering that the methods for FDe and FDr detection were relatively time-saving and the results showed acceptable sensitivity and accuracy, they are prospective for applying in further research of fruit development of different cultivar-rootstock combinations influenced by various growing conditions. Additionally, the FDe can be detected by field measurements as well as adapted for image analysis. The results would be applicable for designing of new cherry trials and commercial plantations timely anticipating the most likely deviations of the productivity for cultivar-rootstock combinations (low yield due to poor development of fruits or overproduction).

Conclusions

The initial and final fruit density of sweet cherry cultivars strongly varied depending on growing season and spring frost incidence. Sweet cherry cultivars 'Elfrīda', 'Bryansk 3-36' and 'Radica' showed a tolerance to spring frosts with relatively high final fruit density after frost incidence.

Cultivar 'Paula' had low fruit drop and stable productivity when grown under VOEN cover with drip irrigation. This growing system facilitated initial fruit density also after the incidence of spring frosts for sweet cherry cultivars 'Paula' and 'Bryansk 3-36'.

Rootstock 'Latvijas Zemais' diminished sweet cherry fruit drop for the cultivars grafted on it in the growing system with VOEN cover and drip irrigation.

References

Ayala, M. & Lang, G.A. (2008) 13C-Photoassimilate partitioning in sweet cherry on dwarfing rootstocks during fruit development. *Acta Horticulturae* 795, 625-632

Blanusa, T., Else, M.A., Davies, W.J. & Atkinson, C.J. (2006) Regulation of sweet cherry fruit abscission: the role of photo-assimilation, sugars and abscisic acid. *Journal of Horticultural Science & Biotechnology,* 81(4), 613–620. DOI: 10.1080/14620316.2006.11512113

Bradbury, D. (1929) A comparative study of the developing and aborting fruits of *Prunus cerasus*. *American Journal of Botany*, 7(16), 525-542.

Cittadini, E.D., van Keulen, H., de Ridder, N., Vallés, M., Rodríguez, M. & Peri, P. (2008) Effect of fruit-to-leaf area ratio on fruit quality and vegetative growth of 'Bing' sweet cherry trees at optimal leaf area index. *Acta Horticulturae*, 795, 677–680.

Davarynejad, G.H., Nyéki, J., Szabo, T., Lakatos, L. & Szabó, Z. (2014) Fruit drop pattern of sour cherry cultivars. *Acta Horticulturae*, 1020, 185–189. DOI: 10.17660/ActaHortic.2014.1020.26

Flore, J.A. & Layne, D.R. (1999) Photoassimilate production and distribution in cherry. HortScience, 34(6), 1015–1019.

Gatti G. (2023) Investigating the causes of late fruit drop in 'Regina' sweet cherry (Prunus avium). Doctoral dissertation. Alma Mater studiorum Universita di Bologna

Lauri, P.È. & Claverie J. (2005) Sweet cherry training to improve fruit size and quality – an overview of some recent concepts and practical aspects. *Acta Horticulturae*, 667, 361–366

Quentin, G., Close, D.C., Hennen, L.M.H.P. & Pinkard, E.A. (2013) Down-regulation of photosynthesis following girdling, but contrasting effects on fruit set and retention in two sweet cherry cultivars. Plant Physiology and Biochemistry, 73, 359–367. DOI: 10.1016/j.plaphy.2013.10.014

Racskó, J., Soltsz, M., Szabó, Z., & Nyeki, J. (2006) Fruit drop: II. Biological backgrounds of flower and fruit drop. International Journal of Horticultural Science 12(3), 103–108 DOI: 10.31421/IJHS/12/3/667

Rubauskis, E., Skrīvele, M., Ruisa, S. & Feldmane, D. (2013)[a] Effect of crown restriction on the growth and productivity of sweet cherries. Proceedings of the Latvian Academy of Sciences. Section B, 67(2), 151–156. https://doi.org/10.2478/prolas-2013-0023

Rubauskis, E., Skrīvele, M., Ruisa, S. & Feldmane, D. (2013)[b] Effects of VOEN cover on the growth and yield of two sweet cherry cultivars. Proceedings of the Latvian Academy of Sciences. Section B, 67(2), 157–161. https://doi.org/10.2478/prolas-2013-0024

Ruisa, S. & Krasnova, I. (2013) Assessment of sweet cherry cultivars and selections in Latvia. Acta Horticulturae, 976, 161–166. https://doi.org/10.17660/ActaHortic.2013.976.20

Ruisa, S. (1998) Genetic resources of Latvian sweet cherries and their use. Acta Horticulturae, 468, 153–160. DOI: 10.17660/ActaHortic.1998.468.17

Sanzol, J. & Herrero, M. (2001) The ''effective pollination period'' in fruit trees. *Scientia Horticulturae* 90(1), 1–17, DOI: 10.1016/S0304-4238(00)00252-1

Sams, C.E. & J.A. Flore. (1983) Net photosynthetic rate of sour cherry (Prunus cerasus L. 'Montmorency')

during the growing season with particular reference to fruiting. *Photosyn. Res*. 4, 307–316
Szpadzik, E., Krupa, T., Niemiec, W. & Jadczuk-Tobjasz, E. (2019) Quality of selected sweet cherry (Prunus avium) cultivars in the conditions of Central Poland. *Acta Scientiarum Polonorum Hortorum Cultus,* 18(3), 117–126
Stone, C.H., Sidhu, R.S., Swarts, N.D. & Close, D.C. (2024) A review of the production challenges for sweet cherries grown under protected cropping systems. *Acta Hortic*. 1395, 179-186. DOI: 10.17660/ActaHortic.2024.1395.24
Vignati, E., Lipska, M., Dunwell, J.M., Caccamo, M. & Simkin, A.J. (2022) Fruit development in sweet cherry. *Plants* 11, 1531 DOI: 10.3390/plants11121531

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