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Preliminary results of rootstock evaluation for Estonian sweet cherry cultivar 'Anu'

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Abstract. Mahaleb cherry *(Prunus mahaleb* L.) is the most widely used rootstock for sweet cherries in Latvia, however it has several disadvantages - strong vigour of grafted trees and an intolerance to heavy, waterlogged soils. The aim of the study was to test the suitability of rootstocks of different origins for winter-hard sweet cherry cultivar in Latvian climate. The trial was established in the spring of 2014 at the Institute of Horticulture (LatHort) to test four clonal rootstocks: 'PiKu 1', PHL-A', 'GiSelA 5', 'VSL-1', and generative rootstock *P. mahaleb* (control) grafted with cultivar 'Anu' (Estonian breeding). Cherries were planted at 5×3.5 m in a random block design in three replications with three trees per plot. Tree height, annual growth of shoots, the viability of trees after wintering period and the intensity of flowering and production were evaluated in 2016–2019. Sweet cherry cultivar 'Anu' had the best overall winter-hardiness in the combinations with rootstocks 'GiSelA 5' and *P. mahaleb*. The highest intensity of flowering and production were observed in trees grafted on 'GiSelA 5'. Trees on 'VSL-1' had the highest decease rate and the lowest winter hardiness.

Key words: *P. avium*, *P. mahaleb*, 'GiSelA 5', winter-hardiness, flowering.

INTRODUCTION

Sweet cherries are popular summer fruits in Europe (Hajagos et al., 2012), and their production has stable or increasing trend in most of cherry growing countries (Bujdosó & Hrotkó, 2017). The suitability of cultivar-rootstock combinations to local climate, soil and growing technologies is one of key factors in sweet cherry production (Pal et al., 2017). In Latvia, the total area of sweet cherry plantations is gradually increasing mostly using generatively propagated mahaleb cherry (*Prunus mahaleb* L.) as winter-hard rootstock. However, it has several disadvantages such as strong vigour of grafted trees and an intolerance to heavy, waterlogged soils (Lanauskas et al., 2012).

The cultivation of cherry rootstock 'GiSelA 5' (syn. 'Gi 148/2'), originated in Germany, spreads throughout the world rapidly due to good compatibility with cherry cultivars, reduced vigour and high productivity of grafted trees (Franken-Bembenek, 2005). However, trees on the rootstock 'GiSelA 5' tend to overproduce, therefore, fruit thinning might be needed for highly productive cultivars (Andersen et al., 1999). Cherries grafted on 'GiSelA 5' are more suitable for growing in irrigated orchards (Fajt et al., 2014). In Latvia, 'GiSelA 5' was tested for sweet cherry cultivars 'Iput' (originated in Russia) and 'Krupnoplodnaya' (originated in Ukraine), and it was found as promising rootstock in the plantations with adequate tree densities and growing technologies (Rubauskis et al., 2014).

The rootstock 'PHL-A' (syn. 'PHL 84') is found as the most winter-hardy of the series PHL, created in Czech Republic, however it is not resistant to drought (Blažková, 2004). 'PHL-A' is recommended as reliable rootstock for modern sweet cherry orchards in Czech Republic climatic conditions (Blažková & Hlušičková, 2007).

The rootstock 'VSL-1' was originated in Russia, Krymsk Experimental Breeding Station by crossing of BC-2 (*P. fruticosa* Pall.) and L-2 (*P. lannesiana* Wils.), it is tolerant to drought, cold and cherry leaf spot, and has pronounced dwarfing effect (Kolesnikova, 2003; Eremin, 2008). The rootstock 'PiKu 1' (syn. 'PiKu 4.20') was characterized as the most winter-hardy and resistant to unfavourable growing conditions of PiKu series rootstocks, created in Germany (Fajt et al., 2014). It showed good vitality and high productivity in non-irrigated orchards (Balmer, 2008).

Generally, climate in Latvia is classified as temperate, amount of precipitation compensates or exceeds evaporation and the winter-hardiness of woody plants mainly corresponds to the zone 5–6 (Gloning et al., 2013). It should be appropriate for above mentioned rootstocks in the terms of temperature and humidity. However, the closeness of Baltic Sea and diverse impact of continental and maritime air-masses cause considerable fluctuations of temperature during winter and uneven distribution of precipitation, which changes year-to-year. There is a lack of the information about rootstock effect on tree growth, precocity and winter-hardiness for sweet cherry cultivars originated in Northern Europe and grown in the climate influenced by Baltic Sea. The aim of the study was to test the suitability of vigour-reducing rootstocks of different origins ('PiKu 1', 'PHL-A', 'GiSelA 5', 'VSL 1') vs. control rootstock *P. mahaleb* for winter-hard sweet cherry cultivar 'Anu' in Latvian climate.

MATERIALS AND METHODS

The trial was established in the spring of 2014 at the Institute of Horticulture (LatHort) in Pūre, Latvia, where four clonal rootstocks: 'PiKu 1', PHL-A', 'GiSelA 5', 'VSL 1', and generative rootstock *P. mahaleb* (control) were included. Sweet cherry cultivar 'Anu' (Estonian breeding) was grafted on all rootstocks. Cherries were planted at a distance 5×3.5 m in three replications with three trees per plot. The orchard was not equipped for irrigation. The grass was regularly mowed in the inter-rows and herbicides were applied to control weeds around the trees in rows. Pests, and diseases were controlled according to integrated plant protection management. Compound fertilizer, containing 8% of N, 11% of P_2O_5, 23% of K_2O, was given yearly at the rate 25 g m^{-2}. The trees were trained to free-standing central leader. The lateral branches were grown in horizontal position, the semi-upright shoots were bended and the steepest shoots were cut off.

Tree height, growth of annual shoots, the viability of trees after wintering period and the intensity of flowering and production were evaluated from 2016 to 2019. Tree viability after wintering was scored on following scale: 0 – tree is completely dead, 1 – tree has lost ability to grow, 2 – above-ground part is completely damaged, but new shoots are developed, 3 – two and three years old branches and trunks are damaged, 4 – one year shoots are damaged, 5 – tree is in excellent condition. Flowering and production intensity were evaluated according to the scale from 0 to 5, where 0 – no flowers nor fruits developed, 1 – few, scattered flowers or fruits are seen, 2, 3 and 4–abundant flowering and at least several fruits have developed for about 25%, 50% and 75% of clusters on fruiting branches, respectively, 5 – all fruiting branches are abundantly flowering and several fruits have developed in every cluster.

The growth of annual shoots was determined in the autumn, after leaf fall - the length of 5 typical shoots were measured for each tree. Number of dead trees was registered at the end of investigation - in 2019.

Meteorological data were obtained from the automatic meteorological station 'Luft' registering meteorological conditions each 10 minutes. The hydrothermal coefficient (the ratio of between precipitation sum and air temperature sum) was calculated for the period of active vegetation with mean diurnal temperature ≥ 10 °C. The data are shown in the Table 1.

Table 1. Precipitation sum (mm), air temperature sum (°C) and hydrothermal coefficient (HTC) during the periods of active vegetation (with mean diurnal temperature ≥ 10 °C) in 2016–2019

Month	2016		2017		2018		2019	
	mm	°C	mm	°C	mm	°C	mm	°C
May	51.7	41.2	11.8	25.8	9.2	50.2	30.7	26.7
June	38	51.1	45	45.0	18.1	50.6	48.3	54.8
July	75.2	55.0	20.2	50.1	42.6	63.4	117.3	47.1
August	69.6	49.7	10.7	51.1	58.6	57.2	21.1	50.4
September	18.4	40.3	173.9	38.2	32.3	44.8	50.7	36.3
Total	252.9	237.2	263.2	218.2	160.8	266.2	268.1	27.3
HTC	1.06		1.19		0.60		1.30	

During first growing years - in 2014 and 2015, the hydrothermal coefficient calculated for the periods of active vegetation was 1.5 and 0.8, respectively.

Minimal and average air temperatures during winter and spring periods are presented in the Table 2.

Table 2. Minimal and average air temperature during the winter and spring periods of 2015/2016–2018/2019 (°C)

Month	2015/2016		2016/2017		2017/2018		2018/2019	
	min	average	min	average	min	average	min	average
November	-7.5	4.8	-12.9	1.3	-2.8	3.6	-12.9	1.3
December	-18.4	2.9	-13.8	1.6	-3.3	1.8	-13.8	1.6
January	-22.4	-6.6	-24.6	-2.2	-12.7	-1.5	-11.9	-2.5
February	-5.8	1.6	-15.9	-1.6	-24.9	-6.7	-7.5	-0.6
March	-9.3	1.6	-4.8	2.5	-20.7	-2.1	-9.1	0.8
April	-5.5	6.2	-8.2	4.6	-4.9	7.7	-7.9	9.4
May	0.9	13.7	-5.1	11.2	9	16.7	-3.1	14.3

In the first winter period (2014/2015), the lowest air temperature was -14.8 °C in January.

Statistical analysis of results was performed by analysis of variance in Microsoft Excel with Fischer's test to detect the differences between the means of sample sets at significance level of 0.05. The least significant difference (*LSD*) was calculated for post-hoc analysis.

RESULTS AND DISCUSSION

Tree height of the cultivar ‘Anu’ differed considerably under the influence of rootstocks ($p < 0.001$). The trees on the rootstock *P. mahaleb* were the highest in all years of evaluation reaching 2.9 m in 6th growing year (Table 3). The growth of the trees on ‘GiSelA 5’ was similar - the average tree height reached 2.7 m, which was for 6% lower than for those grafted on *P. mahaleb.* Generally, the rootstock ‘GiSelA 5’ can reduce the height of the tree by 20–40% comparing to vigorous rootstock Mazzard F12/1 (Sansavini & Lugli, 2014). However, strong vegetative growth of juvenile trees on ’GiSelA 5’ in first growing years and delayed growth of mature trees have been observed also in other studies and the beginning of maturity stage seems depending on environment and cultivar (cv.). In the study performed at Washington State University, trunk growth of the trees on ’GiSelA 5’ and Mazzard did not differ until growing year 4, while significant differences were detected in growing year 7 (cv. ’Bing’) (Whiting et al., 2005). In Poland, significantly reduced tree growth under impact of rootstock ’GiSelA 5’ was observed for 5 years old trees (cv. ’Vanda’) (Grzyb et al., 2008), while in Portugal - for 2 years old trees (cv. ’Sweetheart’ and ’Skeena’) (Santos et al., 2005).

Table 3. Influence of rootstock on tree height (m), growth increase (%) and annual shoot length (cm)

Rootstock	Tree height (m)			Growth increase 2017–2019 (%)	Annual shoot length (cm)		
	2017	2018	2019		2017	2018	2019
PHL-A	1.2	1.4	1.6	34.6	27.6	20.6	11.6
PiKu 1	1.9	2.0	2.2	17.7	27.9	17.4	12.2
GiSelA 5	2.3	2.5	2.7	14.0	27.6	18.2	11.4
VSL 1	1.1	1.2	1.3	19.3	24.4	18.3	13.8
P. mahaleb	2.4	2.7	2.9	18.5	30.9	18.1	14.0
$LSD_{0.05}$	0.59	0.52	0.84		9.26	4.98	4.99

Rootstocks ‘VSL 1’ and ‘PHL-A’ significantly reduced tree height comparing to *P. mahaleb*. During first three growing years, trees on the rootstock ‘PHL-A’ had no increase in the height and their annual shoot growth was close to zero. They began to grow faster only in the growing year 4 (in 2017). Over three-year period (2017–2019), the trees on rootstock ‘PHL-A’ had the highest relative increase of tree height (increase by 34%).

Rootstock ‘PiKu 1’ showed the tendency to decrease tree height. However, the differences of the height between the trees grafted on ‘PiKu 1’ and *P. mahaleb* did not exceed *LSD* in two of the three evaluation years.

The effect of the rootstock on annual shoot growth was less discovered. Generally, the annual shoot length tend to be shorter for the trees grafted on clonal rootstocks comparing to those grafted on *P. mahaleb*. During growing years 3 to 6, annual shoot length decreased gradually for all grafting combinations wich could be explained by the completion of juvenile phase of trees.

Assessing tree viability and winter damages, significant differences were observed between rootstocks ($p < 0.001$). The trees on the rootstocks *P. mahaleb* and ‘GiSelA 5’ were in the best condition (Fig. 1). Only few trunk damages (bark splitting) and slight damages of shoots were observed for the trees on these rootstocks. There were no dead trees on the rootstock 'GiSelA 5' and small amount of dead trees (16.7%) on the rootstock *P. mahaleb*.

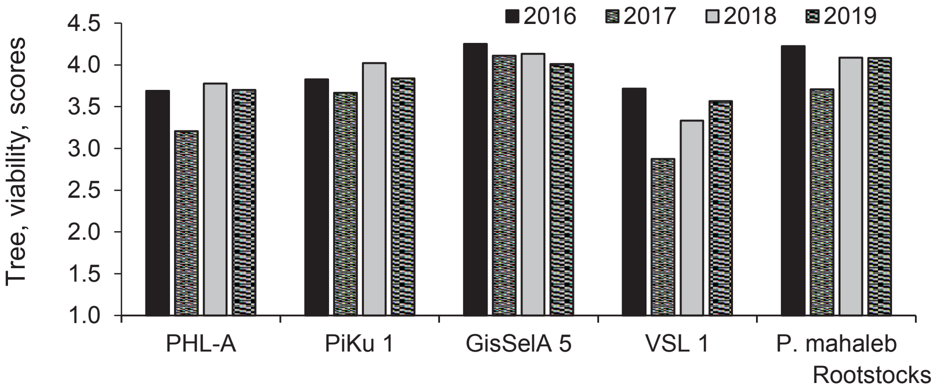

Figure 1. Influence of rootstocks on tree viability after wintering.

Tree viability decreased significantly under the influence of the rootstock 'VSL 1'. Trees on the 'VSL 1' had the highest level of winter damages on trunks and shoots among the evaluated rootstocks during all evaluation years. Trees showed essential splitting of bark and gumming.

In 2019, the highest amount of dead trees (33% of the total) for cultivar 'Anu' was recorded on the rootstock 'VSL 1' (Fig. 2), which could be an indicator of incompatibility of this rootstock with the cultivar, although the compatibility of the rootstock with other sweet cherry cultivars previously was assessed as good (Eremina, 2017). 'VSL 1' rootstock was originated in continental climate and it might be unsuitable for winters with sharp temperature fluctuations.

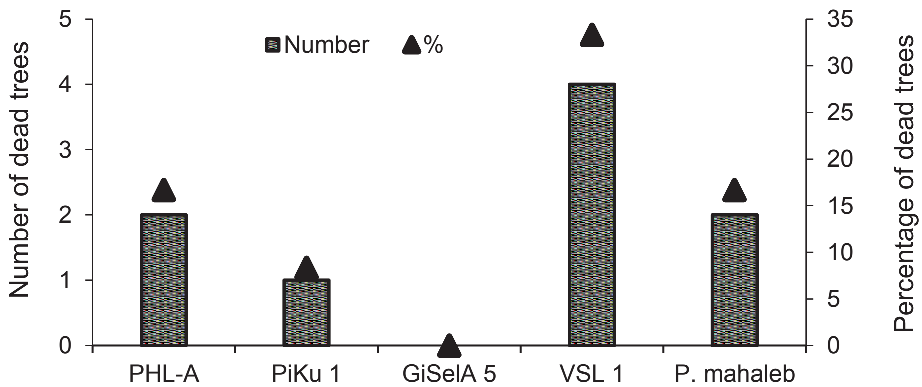

Figure 2. Influence of rootstocks on the amount of dead trees.

The damage of annual shoots with medium level was observed for the trees grafted on 'PHL-A' and 'PiKu 1'. The amount of dead trees did not differ from control. Trees on rootstocks 'PHL-A' and 'PiKu 1' died more in the first years after planting, when minimal air temperature dropped below 20 °C in winter: -22.4 °C in 2016, -24.6 °C in 2017 and -24.9 °C in 2018. Tree death could also be influenced by prolonged drought periods in 2015 and in 2018.

Trees on the rootstocks ‘GiSelA 5’ and *P. mahaleb* had high flowering intensity during 2017 to 2019 without significant differences observed between them (Table 4). The effect of other rootstocks on flowering intensity was rather inconsistent and depended on the year.

In the spring of 2017 and 2019, the weather conditions were unfavourable for fruit development. During flowering time, the lowest air temperature, recorded at the meteorological station in Pūre, was -5.1 °C in 2017 - at the beginning of flowering, and -3.6 °C in 2019 - at full bloom. In 2017, which was the first production year, the yield due to spring frosts was reduced. In 2019, trees bloomed well on all rootstocks, however spring frost destroyed cherry yield completely.

Table 4. Intensity of flowering and productivity (scores 0–5 with 5 being the best)

Rootstock	Intensity of flowering				Productivity	
	2017	2018	2019	average	2017	2018
PHL-A	1.1	1.2	4.0	2.1	0.3	0.6
PiKu 1	2.6	3.3	4.3	3.4	2.3	2.1
GiSelA 5	4.1	4.6	4.5	4.4	2.6	4.3
VSL 1	3.2	0.2	3.7	2.4	0.5	0.1
P. mahaleb	3.4	3.8	4.5	3.9	2.8	3.6
$LSD_{0.05}$	1.9	1.7	0.3	1.3	1.9	1.2

The productivity of the trees on the rootstocks ‘GiSelA 5’ and *P. mahaleb* was higher than of those on other clonal rootstocks both in 2017 and 2018. The cultivar ‘Anu’ grafted on *P. mahaleb* started to bear fruits in growing year 4 showing the precocity similar to the trees on ‘GiSelA 5’. It could indicate advanced development of flower buds and high resistance in winter and spring frosts of sweet cherry cultivar ‘Anu’ under the influence of rootstocks ‘GiSelA 5’ and *P. mahaleb* in Latvia.

Our results for the rootstock ‘Gisela 5’ were consistent to other studies in northwest Croatia and in Romania, showing high productivity and yield intensity of trees grafted on that rootstock in the first cropping years (Biško et al., 2017; Pal et al., 2017).

In contrary, the effect of the rootstock PHL-A’ on productivity of grafted trees in Latvia conditions completely differed from the results obtained in Poland (Rozpara et al., 2004). In our study, prolonged drought in the summer of 2018 could be one of the reason of low productivity for the trees on rootstock PHL-A.

CONCLUSIONS

Sweet cherry cultivar ‘Anu’ in the combinations with rootstocks ‘GiSelA 5’ and *P. mahaleb* had the best overall winter-hardiness and the most vigorous growth of trees at least until the growing year 6.

Trees on rootstocks ‘GiSelA 5’, ’PiKu 1’ and *P. mahaleb* had the highest flowering intensity among rootstocks evaluated.

The productivity of cultivar ‘Anu’ during first yielding years decreased under the influence of rootstocks ‘VSL 1’ and ‘PHL-A’.

The cultivar ‘Anu’ had the lowest tree viability and highest level of winter-damages on the rootstock ‘VSL 1’.

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