Rootstock effect on the performance of sweet cherry cv. Lapins

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Abstract

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Twelve clonal rootstocks of sweet cherry grafted with the cv. Lapins were tested. Each graft combination included 18 trees divided into six randomized blocks. The trees were spaced at 5 × 3 m and trained as spindles. Tree vigour, yield, fruit size, fruit quality and yield efficiency were evaluated for eleven subsequent years. According to trunk diameter, the most vigorous rootstocks were Gi 497/8, Gi 154/7, Gisela 4 and P-HL-A; 32–41% larger compared with the standard Gisela 5. The highest cumulative yield per tree and yield efficiency were recorded on the rootstocks Gi 154/7 and Gisela 4. The lowest yield was recorded on Damil, Gi 209/1, Gi 195/20, Gi 148/8 and Gisela 5. P-HL-A and Gi 523/02 gave the largest fruit weights and Gi 209/1, Gisela 5 and Gi 195/20 the smallest. Moderate tree die-back was recorded on Gi 154/7 and P-HL-A, low tree mortality on Gisela 4 and Damil. All the trees survived on Gi 497/8. Gisela 4 and Gi 154/7 produced some root suckers.

Keywords: trunk diameter; yield efficiency; fruit weight; tree mortality; root suckers

Vigorous sweet cherry trees are still common in Lithuanian fruit orchards. Seedlings of *Prunus mahaleb* L. and *P. avium* L. or the clonal F12/1 are the major rootstocks used for sweet cherry tree production. The latter two rootstocks are vigorous and difficult to maintain, especially during harvesting. *P. mahaleb* seedlings slightly reduce tree growth vigour but perform poorly in heavier soils (Gyeviki et al. 2008) prevalent in a larger part of Lithuania. Furthermore, compatibility of different sweet cherry cultivars grafted on *P. mahaleb* is unpredictable (Perry 1987).

Many different rootstocks for sweet cherries are available worldwide from different breeding programs like Giesen (Gi), M×M, P-HL, Pi-Ku, GM and Weiroot series (Callesen, Ystaas 1998). Vigour-reducing rootstocks gave an advantage over vigorous ones in modern orchards (Franken-Bembenek 2005). Well-chosen dwarf or semi-dwarf rootstocks increase the efficiency of a sweet cherry orchard. Gisela 5 is a productive and dwarfing rootstock used worldwide (Walther, Franken-Bembenek 1998; Bujdosó et al. 2004; Cmelik et al. 2004; Vercammen 2004). Its share in new plantations is significant (Balmer, Blanke 2005; Franken-Bembenek 2005; Stehr 2008).

In Lithuania, research on clonal rootstocks for sweet cherries in an orchard was started in 1999. The main objective of this trial was to test the effect of rootstocks on growth, yield and fruit quality of cv. Lapins.

MATERIAL AND METHODS

During the period 1999–2009, the agronomic behaviour of the commercially important sweet cherry cv. Lapins grafted on twelve cherry rootstocks was assessed at the Institute of Horticulture located in Babtai at 55°60'N, 23°48'E. The rootstocks were Gisela 4, Gi 497/8, Gi 209/1, Gi 148/8, Gi 195/20, Gi 154/7, Gi 523/02, Weiroot 53, Weiroot 158, P-HL-A and Damil with Gisela 5 as a standard. Each graft combination included 18 trees divided into six randomized blocks. The trees were spaced at 5 × 3 m and trained as spindles. Orchard floor management combined frequently mown grass in the alleyways with 1.5 m wide herbicide strips along tree rows. The soil of the experimental site was Epicalcari-Endohypogleic Cambisol, heavy clay loam moderately rich in phosphorus and potassium, containing 2.2% of humus, pH 7.2. Nitrogen fertilizers were used every spring at a rate of 50–200 g of ammonium nitrate per tree. The orchard was not irrigated.

Climatic conditions in Babtai are characterized by an average annual temperature of 6.8°C and an average annual precipitation of 600 mm, of which 420 mm occur during the warm period. The minimum winter temperatures during this investigation was from –15.4 to –23.7°C.

Trunk diameter (cm) was measured 25 cm above the graft union each fall and trunk cross-sectional area (TCSA) calculated. The number of flower clusters was recorded in 1999. In subsequent years flowering abundance was evaluated on a 0–5 score scale (0 – no flowers, 5 – abundant flowering). The yield was recorded for the whole experimental plot and expressed as kg per tree. Yield efficiency index was calculated as a ratio of yield per tree to TCSA and expressed in kg/cm^2. Individual fruit weights were determined on random samples of 100 fruits per plot. The percentage of soluble solids content (SSC) was measured with a digital refractometer Atago 101 (Atago Co., Ltd., Tokyo, Japan). A sample of 50 fruits per plot was used for SSC measurements. Tree mortality was expressed as the percentage of dead trees at the end of 2009. Rootstock suckering was evaluated on a 0–5 score scale (0 – no suckers, 5 – abundant suckering).

The data were treated by the ANOVA procedure in the SAS statistical program. The differences between treatments were estimated using the LSD test ($P < 0.05$).

RESULTS AND DISCUSSION

The trunk diameter of the standard Gisela 5 achieved 7.3 cm at the end of the experiment (Table 1). None of the tested rootstock significantly decreased trunk diameter. Eight rootstocks significantly increased trunk diameter. The most vigorous were trees on Gi 497/8, Gi 154/7, Gisela 4 and P-HL-A with a trunk diameter increase from 32 to 41%. Gisela 5 is usually ranked as a semi-dwarf or a dwarf rootstock (Cmelik et al. 2004; Balmer,

Table 1. Tree performance and yield quality of Lapins sweet cherries

Rootstock	2009 trunk diameter (cm)	2004–2009		1999–2009 tree die-back (%)
		average fruit weight (g)	SSC (%)	
Gisela 5	7.3	6.1	17.0	56
Gisela 4	9.8	6.9	16.9	6
Gi 497/8	9.9	7.3	16.9	0
Gi 209/1	6.6	5.8	17.2	72
Gi 148/8	8.5	6.4	17.7	33
Gi 195/20	6.6	6.2	17.5	42
Gi 154/7	9.9	7.3	16.7	17
Gi 523/02	8.7	7.6	15.9	40
Weiroot 53	8.1	7.3	16.7	33
Weiroot 158	8.4	7.0	17.8	33
P-HL-A	9.6	7.7	16.8	17
Damil	7.2	7.2	17.1	6
LSD_{05}	0.78	0.39	1.17	–

SSC – soluble solids content

Table 2. Flowering of Lapins sweet cherries

Rootstock	No. of flower clusters per tree	Flowering abundance, (0–5 score scale[1])				
	1999	2000	2001	2002	2003	average
Gisela 5	1.4	4.0	2.4	3.2	1.0	2.6
Gisela 4	4.0	3.8	2.5	3.4	2.6	3.1
Gi 497/8	5.9	3.9	3.1	3.1	1.9	3.0
Gi 209/1	5.8	4.0	3.0	2.5	0.9	2.6
Gi 148/8	0.0	4.5	1.5	3.3	1.2	2.6
Gi 195/20	3.5	3.3	2.8	3.1	1.7	2.7
Gi 154/7	0.1	4.0	1.3	2.7	2.4	2.6
Gi 523/02	0.0	2.3	2.3	2.7	1.7	2.2
Weiroot 53	11.5	3.0	3.2	3.1	1.5	2.7
Weiroot 158	0.7	3.6	2.3	3.4	2.0	2.8
P-HL-A	3.3	2.8	2.0	1.3	1.5	1.9
Damil	0.2	2.4	1.4	1.4	0.7	1.5
LSD_{05}	2.36	0.58	0.61	0.78	0.63	0.46

[1]0 – no flowers, 5 – abundant flowering

Blanke 2005). These experiments showed that Gi 209/1, Gi 195/20 and Damil were of the same growth vigour as Gisela 5. Gi 497/8 followed by Gisela 4 were the most vigorous rootstocks in a similar experiment performed in the Czech Republic. Intermediate tree vigour was observed on Gi 154/7 and P-HL-A. The least vigorous trees were on Gi 195/20, Weiroot 158 and Weiroot 53 (Blažková, Hlušičková 2007). Weiroot 158 and Weiroot 53 were of intermediate vigour in our experiment. Since the cultivar was the same in both locations, the differences could be explained by soil variation. Rootstocks originated from *P. cerasus* like the Weiroot series respond positively to heavy clay loam soils due to better water holding capacity. In Hungary, Gi 497/8 is rated as semi-vigorous, Weiroot 158, Damil, Gi 154/7, Weiroot 53 as semi-dwarfs, Gi 195/20 and Gisela 4 as dwarf rootstocks (Gyeviki et al. 2008).

Trees started to bloom in planting year. The most precocious were trees on Weiroot 53. They had on average 11.5 flower clusters. Trees on Gisela 4, Gi 209/1 and Gi 497/8 formed significantly more flower clusters than those on standard Gisela 5 (Table 2). In Lithuania, the weather conditions are not very favourable for sweet cherry production. Spring frosts during flowering frequently reduce the fruit set or completely kill the flowers. During the experiment this situation happened in 2000–2004 and 2007. In 2000–2003 and 2007, the temperature during flowering dropped to –5 to –7.7°C and the yield was completely lost. In 2004, frosts of –3.2°C significantly decreased the yield. Dry periods during the growth season in 2005 and 2006 might have had a negative influence on fruit set as well. The most abundant flowering in 2000 was on Gi 148/8, Gisela 5, Gi 209/1, Gi 154/7, Gi 497/8, Gisela 4 and Weiroot 158 (Table 2). In 2001, a significantly higher flowering score was on Weiroot 53 and Gi 497/8. In 2002, the least flowering trees were on P-HL-A and Damil. The flowering of the rest of the trees was similar to that of the standard Gisela 5. In 2003, the trees exhibiting most abundant flowering were on Gisela 4, Gi 154/7, Weiroot 158, Gi 497/8, Gi 195/20 and Gi 523/02. On average, in 2000–2003 significantly more abundant flowering in comparison with the standard Gisela 5 was on rootstock Gisela 4. The least flowering trees were on P-HL-A and Damil. Due to the spring frosts, the first fruit yield was recorded only in the 6th leaf. During the experiment, the highest yield per tree was recorded in the 10th leaf on Gisela 4 and Gi 154/7 – 12.1–12.3 kg (Table 3). In the rest of the years the yield was lower, but these rootstocks were the most productive. Cumulative yield per tree on Gisela 4 was 35.8 kg and on Gi 154/7 – 39.9 kg. The lowest yield was recorded on Damil, Gi 209/1, Gi 195/20, Gi 148/8 and Gisela 5. Overall, the yield in the current experiment was lower than that obtained in similar investigations (Gyeviki et al. 2008; Sitarek, Grzyb 2010). A higher

Table 3. Yield (kg/tree) of Lapins sweet cherries

Rootstock	2004	2005	2006	2008	2009	Cumulative
Gisela 5	3.1	0.9	0.5	4.3	3.1	11.9
Gisela 4	6.4	6.2	3.7	12.1	7.4	35.8
Gi 497/8	4.3	3.3	2.4	6.2	5.8	22.0
Gi 209/1	3.2	1.0	0.5	3.6	2.2	10.5
Gi 148/8	3.2	1.0	0.9	4.0	1.9	11.0
Gi 195/20	2.4	1.4	1.3	2.8	2.7	10.6
Gi 154/7	6.0	5.8	4.6	12.3	11.2	39.9
Gi 523/02	2.4	3.5	3.0	7.1	5.5	21.5
Weiroot 53	2.5	2.0	2.3	7.6	4.9	19.2
Weiroot 158	2.7	2.4	1.4	6.8	4.0	17.3
P-HL-A	1.3	2.7	1.6	5.3	5.6	16.5
Damil	1.2	1.0	1.0	2.7	2.4	8.3
LSD_{05}	3.23	2.60	1.10	2.56	1.76	5.16

yield obtained on Gi 154/7 and Gisela 4 agrees with the results from other studies (Papachatzis 2006; Blažková, Hlušičková 2007). However, low yield on rootstock Gisela 5 was unexpected. The trees on this rootstock usually produce high yields despite growth reduction (Walther, Franken-Bembenek 1998; Stehr 2005; Tomaszewska, Nychnerewicz 2006; Robinson et al. 2008).

The yield efficiency index demonstrates the relationship between tree vegetative growth and productivity parameters. Usually it is expressed as fruit weight per trunk cross-sectional area unit. The trees on Gi 154/7 and Gisela 4 had the highest cumulative yield efficiency – 0.69 and 0.65 kg/cm² of TCSA, respectively (Table 4). These rootstocks were yield efficient in other studies as well (Perry et al. 1997; Blažková, Hlušičková 2007; Gyeviki et al. 2008). The trees on Gi 209/1, Weiroot 53 and Gi 523/02 showed good yield efficiency in some years. The trees on rootstocks Gi 148/8, Damil, P-HL-A, Gi 195/20, Gisela 5 and Weiroot 158 were the least yield-efficient. These findings, especially for Gisela 5 rootstock, vary in numerous reports (Cmelik et al. 2004; Vercammen et al. 2006; Cantín et al. 2010).

Table 4. Yield efficiency (kg/cm² of TCSA) of Lapins sweet cherries

Rootstock	2004	2005	2006	2008	2009	Cumulative
Gisela 5	0.12	0.03	0.02	0.12	0.07	0.36
Gisela 4	0.15	0.14	0.07	0.19	0.10	0.65
Gi 497/8	0.11	0.08	0.05	0.09	0.07	0.40
Gi 209/1	0.13	0.04	0.01	0.11	0.07	0.36
Gi 148/8	0.09	0.02	0.02	0.08	0.03	0.24
Gi 195/20	0.09	0.05	0.05	0.07	0.08	0.35
Gi 154/7	0.15	0.12	0.09	0.18	0.15	0.69
Gi 523/02	0.09	0.13	0.08	0.16	0.09	0.56
Weiroot 53	0.12	0.07	0.07	0.18	0.10	0.54
Weiroot 158	0.08	0.06	0.04	0.12	0.07	0.37
P-HL-A	0.05	0.07	0.04	0.09	0.08	0.33
Damil	0.07	0.04	0.04	0.08	0.06	0.29
LSD_{05}	0.038	0.035	0.030	0.046	0.029	0.103

TCSA – trunk cross-sectional area

The largest mean fruit weight was found on P-HL-A and Gi 523/02 – 7.7 and 7.6 g, respectively (Table 1). The most productive trees on rootstocks Gi 154/7 and Gisela 4 produced big fruits, too. The smallest fruits were from the trees on Gi 209/1, Gisela 5 and Gi 195/20. Fruit size from the trees on Gisela 5 rootstock depends on crop load and soil moisture (Vercammen 2004; Vercammen et al. 2006). Dry periods during some growth seasons might affect fruit size in our experiment. The average fruit weight in the trial was about 7 g. In most cases it was less in comparison with similar experiments (Sansavini, Lugli 1998; Blažková, Hlušičková 2007). Fruit size (weight) depends on many factors. Soil and climate conditions are among them. Since growing conditions for sweet cherry are not optimal in Lithuania, the country does not belong to the sweet cherry production region.

The SSC was in the range from 15.9 to 17.8% (Table 1). The fruits on Gisela 5 accumulated 17.0% of soluble solids. Significant differences of SSC content were not found between Gisela 5 and the rest of the rootstocks. The SSC is one of the fruit quality parameters affecting fruit taste. Crisosto et al. (2003) found that most consumers of sweet cherry cvs Brooks and Bing prefer the fruit with SSC not less than 16%. In Norway, the threshold value of SSC for acceptable quality in sweet cherries is 14.2% (Vangdal 1985). Sweet cherries of Lapins cv. grown during our experiment met these requirements.

High tree mortality was a big problem. In total, 56% of Gisela 5 trees died-back during the experiment (Table 1). The highest percentage of dead trees was found on Gi 209/1. Low tree mortality was on Gisela 4 and Damil, moderate on rootstocks Gi 154/7 and P-HL-A. The reasons for tree loss were not identified. The symptoms of scion-rootstock incompatibility were not evident. It was noticed that leaves on the spurs of the trees on Gisela 5 were narrowed. The studies with the same rootstocks reported high mortality of the trees on Gisela 4, Damil, Gi 497/8 (Hilsendegen 2005; Kappel et al. 2005). Conversely, all trees survived on the rootstock Gi 497/8 in our experiment. A high rate of tree mortality of Lapins cv. on Weiroot 158 was recorded in the Czech Republic (Blažková, Hlušičková 2007). This rootstock was ranked as well adapted in Hungary (Bujdosó, Hrotkó 2005). It is evident that the effects of sites and climates on rootstock survival are important factors.

The trees on rootstocks Gisela 4 and Gi 154/7 produced root suckers (data are not presented). Sucker formation strength was scored by 0.8 and 2.3 points, respectively. Abundant sucker formation on the mentioned rootstocks was recorded in other experiments too (Papachatzis 2006; Gyeviki et al. 2008). Suckering was not a problem for the rest of the rootstocks.

CONCLUSIONS

The growth vigour of Lapins sweet cherry trees grafted on different rootstocks was in the following range: Gi 209/1 = Gi 195/20 ≤ Damil ≤ Gisela 5 < Weiroot 53 ≤ Weiroot 158 ≤ Gi 148/8 ≤ Gi 523/02 < P-HL-A ≤ Gisela 4 ≤ Gi 497/8 ≤ Gi 154/7. The most vigorous rootstocks Gi 497/8, Gi 154/7, Gisela 4 and P-HL-A increased tree trunk diameter by 32 to 41% in comparison with Gisela 5.

The highest average annual yield per tree and yield efficiency were recorded on Gi 154/7 and Gisela 4. The lowest yielding trees were on Damil, Gi 209/1, Gi 195/20, Gi 148/8 and Gisela 5.

The largest fruit weight was found on P-HL-A and Gi 523/02. The most productive trees on rootstocks Gi 154/7 and Gisela 4 produced relatively large fruits. The smallest fruits were from trees on Gi 209/1, Gisela 5 and Gi 195/20.

High tree mortality was recorded on rootstocks Weiroot 53, Weiroot 158, Gi 148/8, Gi 523/02, Gi 195/20, Gisela 5 and Gi 209/1. All the trees survived on the rootstock Gi 497/8. Low tree mortality was found on Gisela 4 and Damil, moderate on Gi 154/7 and P-HL-A.

Suckering of trees on rootstocks Gisela 4 and Gi 154/7 scored respectively by 0.8 and 2.3 points (0–5 score scale). Sucker formation was not a problem with the rest of the tested rootstocks.

Despite light suckering, the rootstock Gisela 4 was the most efficient for the sweet cherry cv. Lapins in Lithuania.

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