Rootstock-scion interactions on dwarfing cherry rootstocks in Hungary

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ABSTRACT: In 1997 the Research Institute for Fruitgrowing and Ornamentals set up a comparative rootstock trial to study foreign-bred dwarf cherry rootstocks in the Hungarian climate. Based upon their effects on trunk and canopy growth, rootstocks can be classified into 3 groups: very vigorous (*Cerasus mahaleb* L. Cema, *Cerasus avium* L. C. 2493, Weiroot 13), medium vigorous (Weiroot 158, Weiroot 154, P-HL-A) and dwarfing rootstocks (Weiroot 72, Weiroot 53, GiSelA 5). Differences between the blooming and ripening times of rootstock/scion combinations were also observed. Linda produced the highest cumulative yield followed by Katalin, Germersdorfi 3 and Piramis. The largest fruit diameter was measured in Germersdorfi 3 among the sweet cherry cultivars; the highest ratio of fruits larger than 26 mm was found on Weiroot 72, and the lowest on GiSelA 5. The largest fruit diameter of the sour cherry Piramis was observed in trees on *Cerasus avium* C. 2493.

Keywords: sweet and sour cherry; rootstocks; vigour; yield; fruit diameter; cumulated yield efficiency

In Hungary there is a keen interest in planting intensive orchards of cherry due to some key advantages of this technology. Pathogens and pests can be better controlled, which leads to more effective and environmentally safe plant protection. Pruning and picking are also easier due to the smaller tree size than in "traditional" fruit trees. The fruit tree growth can be controlled mainly by dwarfing rootstocks.

Several series of dwarfing rootstocks were bred by research institutes and universities all over the world in the 1960s and 1970s (Table 1). The Research Institute for Fruitgrowing and Ornamentals in Budapest searches for promising foreign-bred dwarfing rootstocks to use them with its novel sweet cherry cultivars and hybrids. During our trial work we have to take into consideration that dwarfing rootstocks should suit the Hungarian climate. Another important point is the effect of the rootstock on fruit yield and quality. The Hungarian soil is more calcareous and the climate is drier compared to Western Europe, thus lime and drought tolerance is important.

MATERIALS AND METHODS

At the Experimental Farm of the Research Institute for Fruitgrowing and Ornamentals a trial orchard was planted in 1997 with six German-bred dwarfing rootstocks (Weiroot 13, Weiroot 53, Weiroot 72, Weiroot 154, Weiroot 158, GiSelA 5), one Czech-bred rootstock (P-HL-A), and compared with a Hungarian-bred Mazzard seedling (*Cerasus avium* L. C. 2493); the mahaleb seedling Cema, which is used in 70% of the Hungarian sweet cherry orchards, was used as the control. The effect of the rootstocks on scion cultivars was studied on three sweet cherries (Germersdorfi 3, Linda, Katalin) and on one sour cherry cultivar (Piramis).

The control Cema, Mazzard stock and Weiroot 13 were planted at the spacing of 6 × 6 m, and the other combinations were planted at the spacing of 3 m in the row and 6 m between the rows. The trial design consisted of 3 trees per combination in 2 replications. The trees were trained to a central leader. Common winter pruning was used, but after 2001 it was changed to summer pruning.

The average number of the annual sunshine hours at the trial plot was 1,950 hours, the mean annual temperature ranged between 9.9 and 10.0°C, the average temperature of the growing season ranged between 16.7 and 16.9°C, and the average annual precipitation fluctuated between 550 and 700 mm. The soil is classified as pseudo-mycelial calcareous

Table 1. Dwarfing cherry rootstocks and breeding institutions (Callesen 1998; Blažková, Hlušičková 2001; Franken-Bembenek 1995; Treutter et al 1993; Wolfram 2000; Sebőkné, Hrotkó 1988; Eremin-Eremin 2002; Mladin 2003; Battistini, Battistini 2004; Rozpara, Grzyb 2004; Moreno 2004; Hrotkó, Magyar 2004)

Country	Name of research institute	Bred rootstock(s)
Belgium	Centre de Recherches Agronomiques, Gemblox	Camil, Inmil, Damil
Czech Republic	Research and Breeding Institute of Pomology, Holovousy	P-HL series
Denmark	Danish Institute of Agricultural Sciences, Department of Fruit, Vegetable and Food Science, Aarslev	DAN series
France	INRA, Bordeaux	Tabel Edabriz
Great Britain	Horticultural Research Institute, East Malling	Colt
Germany	University of Giessen	GiSelA series
	Technical University Munich, Institute for Fruit-growing, Weihenstephan	Weiroot series
	Federal Centre for Breeding on Cultivated Plants, Institute for Fruit Breeding, Dresden-Pillnitz	Pi-KU series
Hungary	University of Horticulture and Food Industry, Budapest	Magyar, Bogdány, Korponay, Prob
Italy	University of Bologna, Bologna	CAB series
	Vivai Battistini dott. Giuseppe, Martorona di Cesena	Victor
Poland	Research Institute of Pomology and Ornamentals, Skierniewice	Frutana
Romania	Fruit Research Institute Pitesti-Marachineni	IP-C serie
Russia	Krymsk Breeding Station, Krasnodar Region	VC-13, LC-52, L-2, VSL-2
Spain	Department of Pomology, Estación Experimental de Aula Dei, Zaragoza	Adara, Reboldo, Stockton, Morello, Masto del Montana
United States of America	Oregon State University, Oregon	Brokforest, Brokgrow

chernozem (pH: 8, content of $CaCO_3$: 5%, content of organic matter: 2.3–2.5%) (Ambrózy-Kozma 1990; Szűcs unpubl.).

The growth vigour of the combinations was determined on the basis of the trunk diameter measurement 200 mm above the budding point between 2001

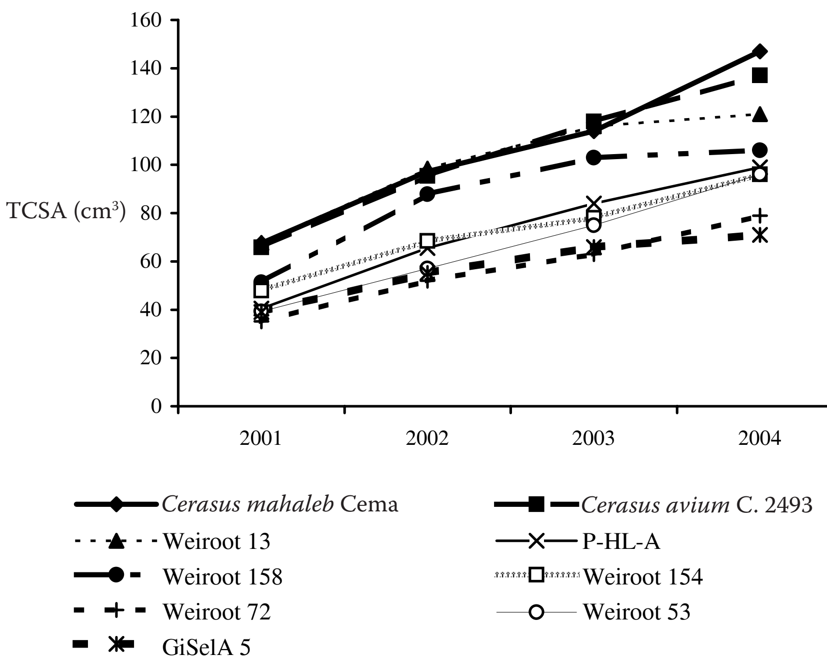

Fig. 1. Effect of the rootstocks on the trunk cross-section area of Germersdorfi 3 (Érd-Elvira major, 2001–2004)

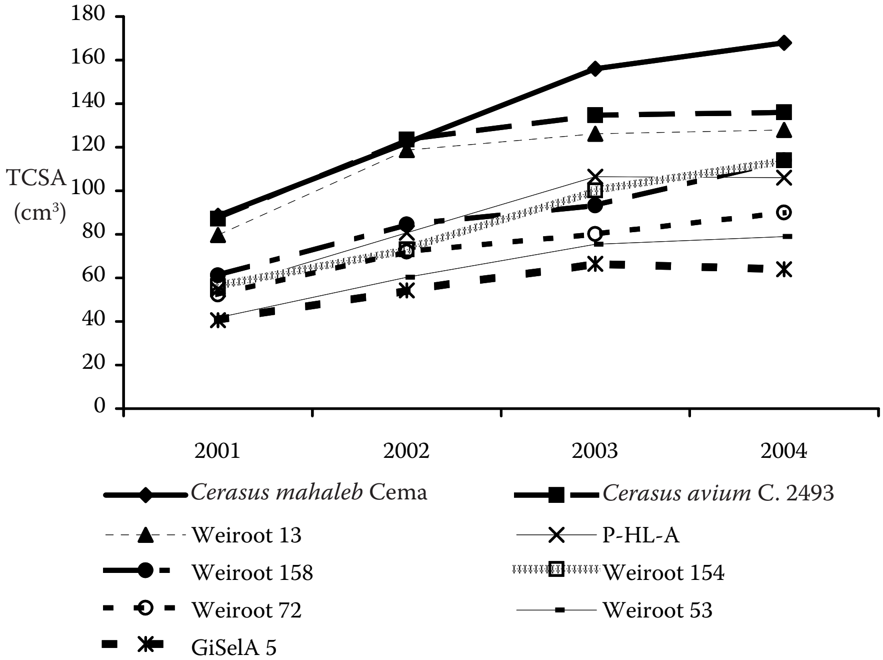

Fig. 2. Effect of the rootstocks on the trunk cross-section area of Linda (Érd-Elvira major, 2001–2004)

and 2004. The statistical analyses were done with Duncan's Multiple Range Test. The time of blooming data were assessed in 2001, 2002, 2003 and 2004 when 5% of the buds were open. In the cropping years 2001 to 2004 the yield of the individual trees was estimated and the fruit diameter was determined by measuring 60 fruits/combination. The effect of the rootstocks on the productivity of scion cultivars was shown by a cumulated yield efficiency index (CYEI), which is the ratio of 4 years' cumulated yield and the trunk cross-section area measured in 2003.

RESULTS AND DISCUSSION

Figs. 1–4 show values of the trunk cross-section area of the combinations. The *Cerasus avium* L. C. 2493 (the dwarfing effect of the trees on *Cerasus avium* L. C. 2493 was just 7–20% less compared to the control) and Weiroot 13 (the dwarfing effect of the trees on Weiroot 13 was between 9 and 24%) were very vigorous. The canopy shape of all the scion cultivars was steeper and slimmer when budded on P-HL-A (dwarfing effect: 33–39%) than on any other rootstock. Weiroot 158 proved to be the best adapted to the Hungarian climate. Its dwarfing effect was between 28 and 36% compared to the control; furthermore, the trees were drought tolerant and regenerated well after summer pruning. Weiroot 154 (dwarfing effect: 33–44%), Weiroot 72 (dwarfing effect: 47–70%), Weiroot 53 (dwarfing effect: 35–53%) and GiSelA 5 (dwarfing effect: 52–62%) rootstocks induced greater dwarfing with roots

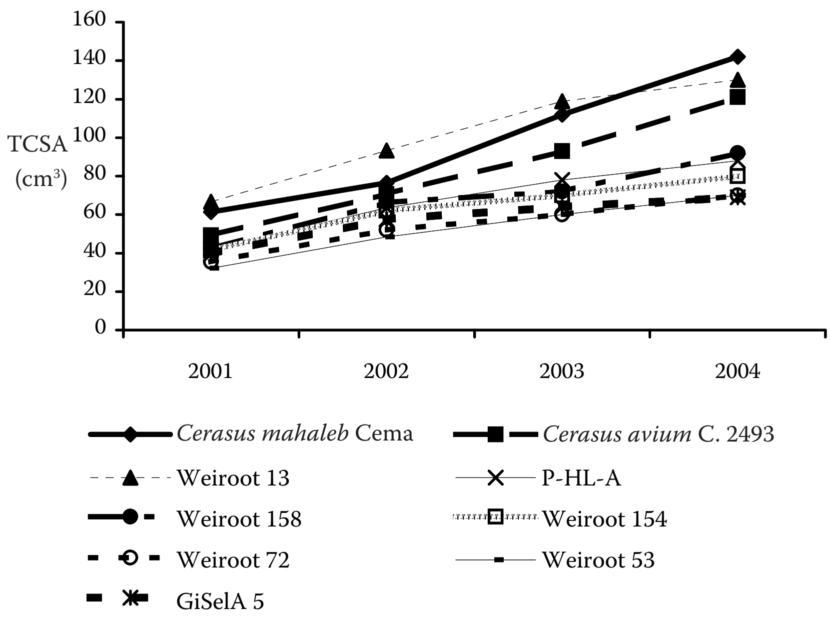

Fig. 3. Effect of the rootstocks on the trunk cross-section area of Katalin (Érd-Elvira major, 2001–2004)

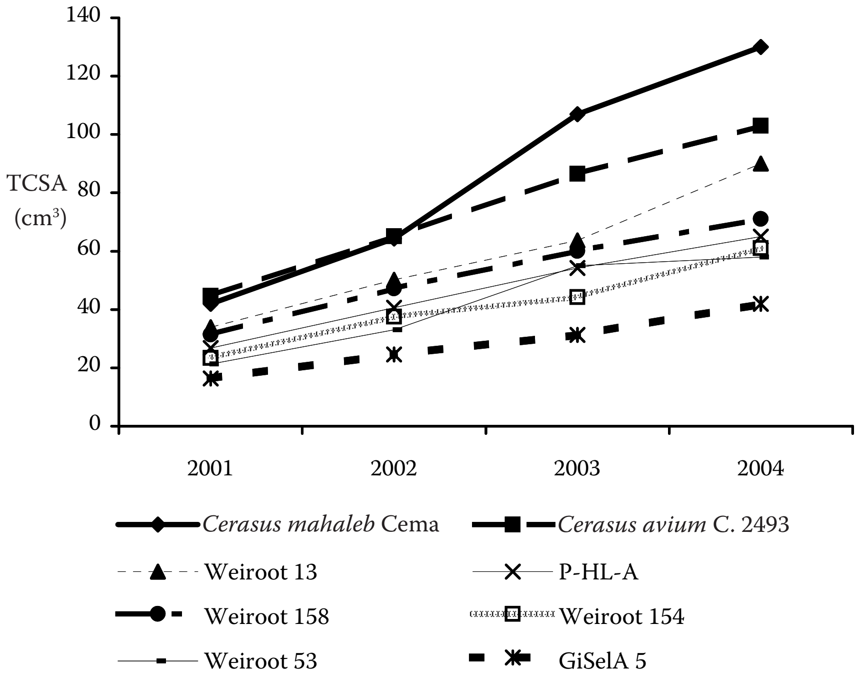

Fig. 4. Effect of the rootstocks on the trunk cross-section area of Piramis (Érd-Elvira major, 2001–2004)

distributed in the surface layers of the soil. For this reason these trees were drought sensitive. A further disadvantage was that these trees were not anchored well, so a strong wind could uproot the tree (we saw this phenomenon on Weiroot 53). The trees budded on GiSelA 5 showed some negative features: early blooming time, a tendency for overloading and barewood formation. Our results confirm the findings in literature concerning the evaluation of these rootstocks (Treutter et al. 1993; Franken-Bembenek 1995; Stehr 1996, 2003 unpubl.; Blažková, Hlušičková 2001; Lichev, Lankes 2003; Hrotkó, Magyar 2004).

The dwarfing effects of the rootstocks on the sweet and sour cherry cultivars were different. However, the succession of the vigour induced by the rootstocks was visible and similar with each of the cultivars in the following order: Cema, *Cerasus avium* L. C. 2493, Weiroot 13, P-HL-A, Weiroot 158, Weiroot 154, Weiroot 72, Weiroot 53, GiSelA 5.

The growth of the Piramis sour cherry cultivar was satisfactory only on *Cerasus mahaleb* L. Cema and on Weiroot 13; the other rootstocks produced too a small trunk cross-section area and inadequate shoot growth, which is essential for the renewal of fruiting branches. These rootstocks induced a greater dwarfing effect again (P-HL-A 40%, Weiroot 158 34%, Weiroot 154 43%, Weiroot 53 45%, GiSelA 5 60%), thus their use was problematic.

Table 2. Effects of the rootstocks on the beginning of blooming and ripening time (Érd-Elvira major, 2004)

Rootstocks	Varieties							
	Germersdorfi 3 (dd, mm)		Linda (dd, mm)		Katalin (dd, mm)		Piramis (dd, mm)	
	blooming time	ripening time	blooming time	ripening time	blooming time	ripening time	blooming time	ripening time
Cerasus mahaleb Cema	21. 4.	24. 6.	22. 4.	21. 6.	19. 4.	1. 7.	22. 4.	14. 6.
Cerasus avium C. 2493	20. 4.	24. 6.	21. 4.	21. 6.	20. 4.	3. 7.	22. 4.	14. 6.
Weiroot 13	20. 4.	24. 6.	20. 4.	21. 6.	18. 4.	28. 6.	21. 4.	14. 6.
P-HL-A	20. 4.	24. 6.	21. 4.	23. 6.	19. 4.	1. 7.	22. 4.	14. 6.
Weiroot 158	20. 4.	24. 6.	20. 4.	21. 6.	21. 4.	29. 6.	21. 4.	14. 6.
Weiroot 154	22. 4.	24. 6.	20. 4.	23. 6.	19. 4.	30. 6.	22. 4.	14. 6.
Weiroot 72	21. 4.	23. 6.	21. 4.	23. 6.	20. 4.	30. 6.	–	–
Weiroot 53	22. 4.	23. 6.	21. 4.	23. 6.	21. 4.	1. 7.	22. 4.	14. 6.
GiSelA 5	19. 4.	22. 6.	20. 4.	23. 6.	19. 4.	1. 7.	20. 4.	14. 6.

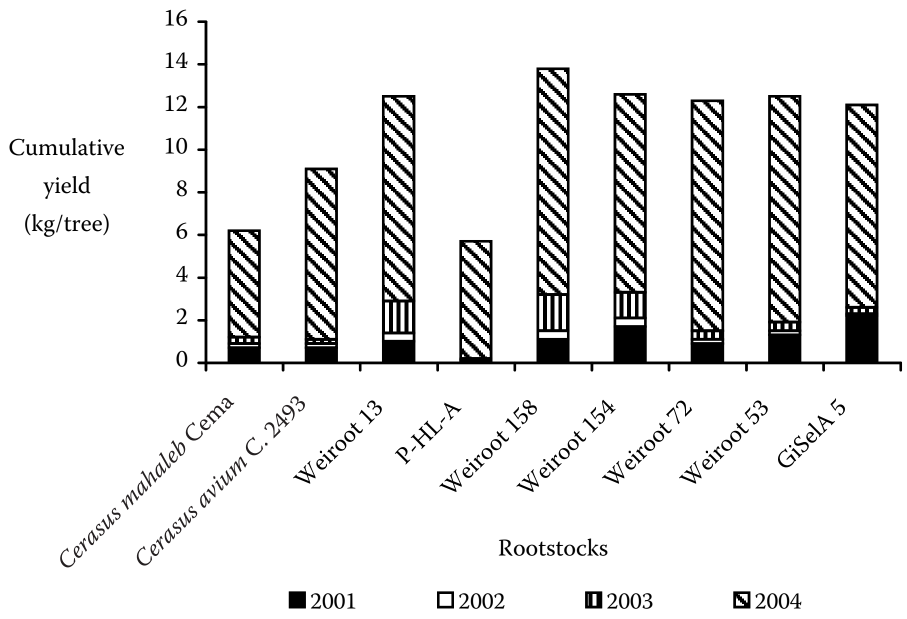

Fig. 5. Effect of the rootstocks on the cumulative yield of sweet cherry cultivar Germersdorfi 3 (Érd-Elvira major, 2001–2004)

Blooming and ripening time

All the scion cultivars budded on GiSelA 5 started blooming 1 or 2 days earlier than the control. This should be kept in mind when choosing pollinators for a newly planted orchard on various rootstocks.

There were also small differences in the ripening time of the rootstock/scion combinations. The Germersdorfi 3 cultivar ripened on every rootstock almost at the same time, except on GiSelA 5, which ripened the earliest (Table 2).

Yield and fruit quality

It is very important to produce high quality and attractive fruits which would be competitive in the markets.

There were differences in the beginning of bearing between the rootstock/scion combinations. The first fruits appeared on GiSelA combinations in the third leaf (in 2001); the trees budded on the other rootstocks one year later. In 2002 the yield was very poor due to spring frost damage, observed mainly in GiSelA 5 combinations, which

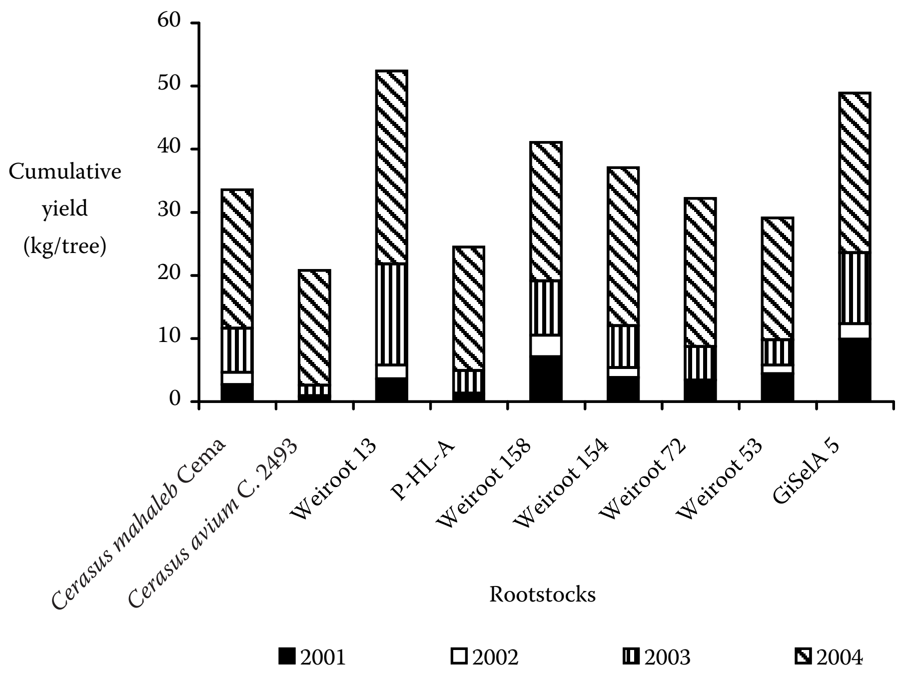

Fig. 6. Effect of the rootstocks on the cumulative yield of sweet cherry cultivar Linda (Érd-Elvira major, 2001–2004)

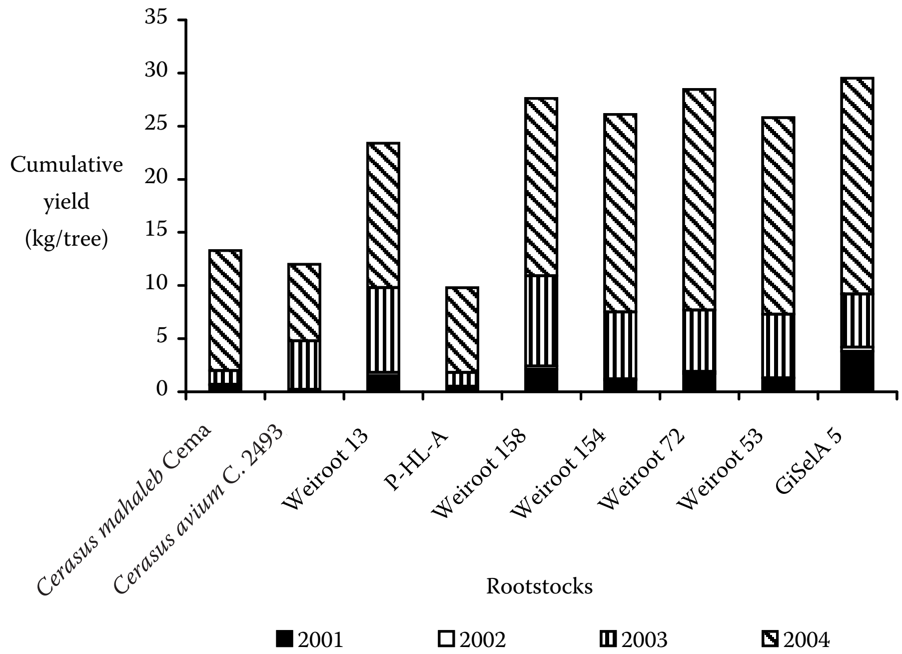

Fig. 7. Effect of the rootstocks on the cumulative yield of sweet cherry cultivar Katalin (Érd-Elvira major, 2001–2004)

Table 3. Effects of the rootstocks on the fruit diameter (Érd-Elvira major, 2001–2004)

Rootstocks	Varieties			
	Germersdorfi 3 (mm)	Linda (mm)	Katalin (mm)	Piramis (mm)
Cerasus mahaleb Cema	25.1	23.8	23.9	23.7
Cerasus avium C. 2493	23.7	24.0	24.5	24.9
Weiroot 13	25.4	23.5	24.1	23.5
P-HL-A	24.4	23.6	25.4	23.1
Weiroot 158	25.8	23.5	25.4	23.9
Weiroot 154	24.6	23.1	23.9	22.9
Weiroot 72	25.5	24.7	23.6	–
Weiroot 53	26.1	23.2	23.9	23.2
GiSelA 5	25.8	23.2	24.1	23.4

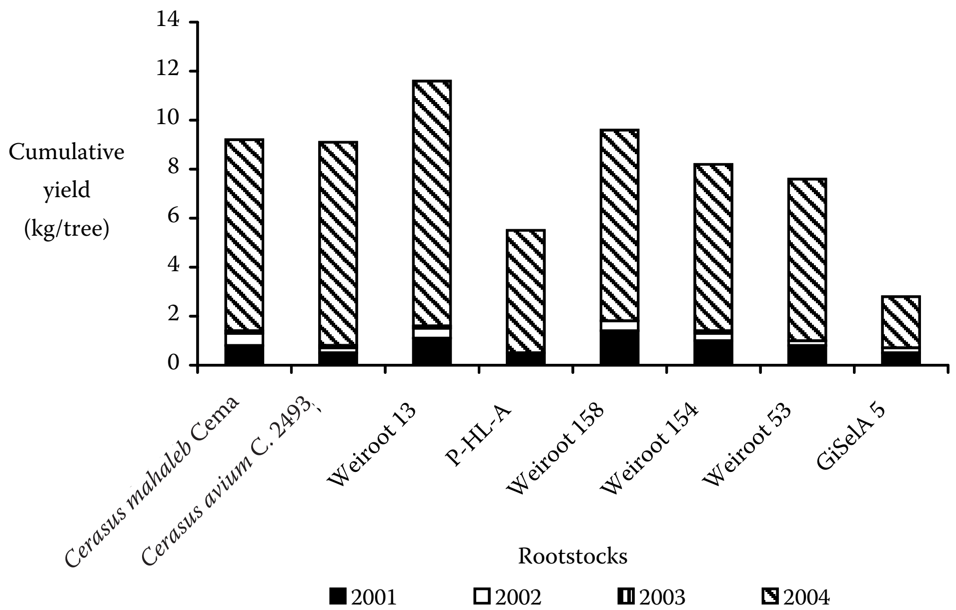

Fig. 8. Effect of the rootstocks on the cumulative yield of sour cherry cultivar Piramis (Érd-Elvira major, 2001–2004)

Table 4. Proportions (%) of cracked fruits in the sweet cherry cultivars Linda and Katalin after 4 and 24 hours from the start of the trial (Érd-Elvira major, 2003 and 2004)

Rootstocks	Linda		Katalin	
	after 4 hours (%)	after 24 hours (%)	after 4 hours (%)	after 24 hours (%)
Cerasus mahaleb Cema	6	90	30	84
Cerasus avium C. 2493	4	100	50	96
Weiroot 13	8	100	20	86
P-HL-A	6	100	14	68
Weiroot 158	4	100	14	86
Weiroot 154	12	92	18	90
Weiroot 72	4	82	18	82
Weiroot 53	8	100	18	72
GiSelA 5	12	88	16	80

Table 5. Relative frequency (%) of the fruit diameter in the sweet cherry cultivar Linda, average of the 6th–8th years after planting (Érd-Elvira major, 2002–2004)

Rootstocks	20.1–22 mm	22.1–24 mm	24.1–26 mm	26.1–28 mm	28.1–30 mm
Cerasus mahaleb Cema	6	44	44	6	
Cerasus avium C. 2493	3	45	45	7	
Weiroot 13	9	46	34	11	
P-HL-A	7	52	20	21	
Weiroot 158	18	50	21	11	
Weiroot 154	16	68	16		
Weiroot 72	18	26	33	22	1
Weiroot 53	46	15	34	5	
GiSelA 5	18	58	21	3	

started blooming earlier than the other combinations.

It is very important to choose a suitable dwarf rootstock for an intensive cherry orchard to produce consistent crops and high yields. By selecting the rootstock, earlier or later blooming time can be achieved. The difference in the blooming time of the cultivars may be detrimental to the yield. The cultivar Linda produced the highest cumulative yield. This cultivar produced 2–3 times more than Katalin, which was the second highest yielding one. Katalin was followed by Germersdorfi 3 and Piramis. Among the sweet cherry cultivars the trees on GiSelA 5 and on Weiroot 158 had the highest yield. In the case of the sour cherry cultivar, the trees on Weiroot 13, on Weiroot 158 and on *Cerasus mahaleb* L. Cema were the most productive. Linda and Katalin were the most precocious; the other cultivars produced one year later. Certainly, there were large differences between the rootstocks as well. The cultivars budded on P-HL-A and *Cerasus avium* L. C. 2493 produced the worst yields (Figs. 5–8).

The fruit diameter (fruit size) decreased with tree aging. Among the cultivars the Germersdorfi 3 produced the largest fruits, over 25 mm, on all the rootstocks. The cultivar Linda showed the best fruit size on Weiroot 72 (average of four years: 24.6 mm), while Katalin on Weiroot 158 and on P-HL-A (average of both rootstocks after four years: 25.4 mm). The largest fruits of Piramis were measured on trees on *Cerasus avium* L. C. 2493; however, this was connected with very low yields (Table 3).

The effects of the rootstock/scion combinations on fruit cracking varied (Table 4).

Comparing the relative frequency of the fruit diameters we obtained the following picture: the highest proportion of fruits larger than 26 mm was produced by the trees on Weiroot 72 (23%) and the lowest by the trees on GiSelA 5 (Table 5). This fact was combined with an unfavourable leaf/fruit ratio. Normal fruit development requires 8–9 leaves/fruit. In cultivars on GiSelA 5 there were many flowers, followed by an oversetting of fruits. Many bare branches were observed in the canopy, resulting in the lack of an adequate number of leaves to ensure

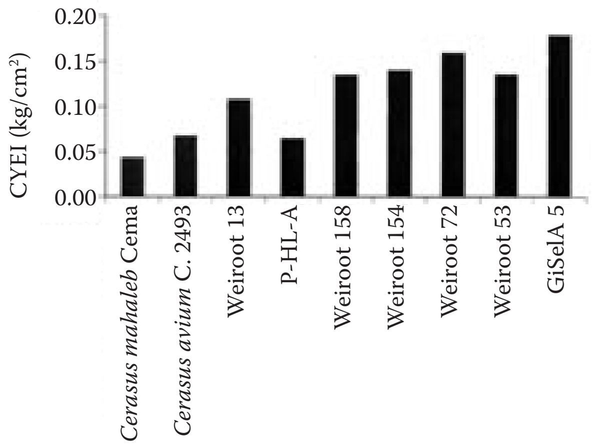

Fig. 9. Effect of the rootstock on the CYEI of sweet cherry cultivar Germersdorfi 3 (Érd-Elvira major, 2001–2004)

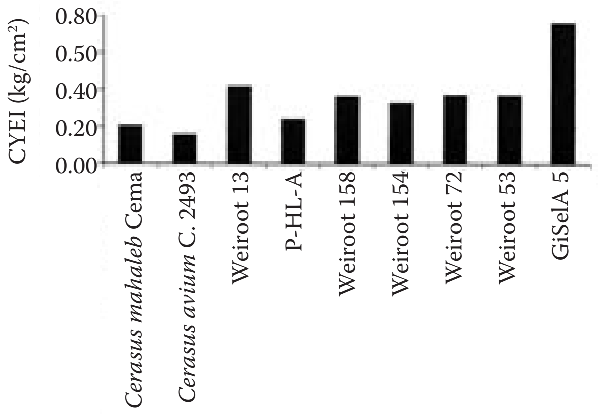

Fig. 10. Effect of the rootstock on the CYEI of sweet cherry cultivar Linda (Érd-Elvira major, 2001–2004)

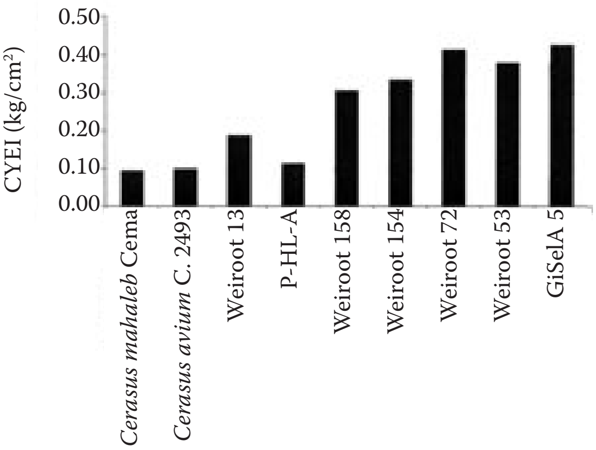

Fig. 11. Effect of the rootstock on the CYEI of sweet cherry cultivar Katalin (Érd-Elvira major, 2001–2004)

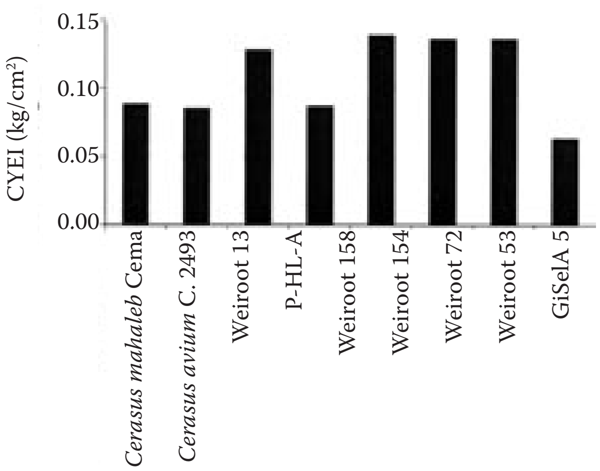

Fig. 12. Effect of the rootstock on the CYEI of sweet cherry cultivar Piramis (Érd-Elvira major, 2001–2004)

a good fruit size on GiSelA 5 combinations. In an intensive orchard careful management – including irrigation – is also very important to guarantee good fruit quality and size.

Cumulated yield efficiency index (CYEI)

CYEI showed the effects of the rootstocks on the scion cultivars. On the basis of this index, Weiroot 158, GiSelA 5 and Weiroot 72 had the highest effect on the budded cultivars (Figs. 9–12).

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Vlivy interakcí podnož – odrůda u zakrslých podnoží třešní v Maďarsku

ABSTRAKT: V roce 1997 byl ve Výzkumném ústavu pro pěstování ovoce a okrasných dřevin založen srovnávací podnožový pokus, jehož cílem bylo studium zahraničních zakrslých třešňových podnoží v klimatických podmínkách Maďarska. Na základě vlivu na růst kmene a koruny byly podnože roztříděny do tří skupin: velmi vzrůstné (*Cerasus mahaleb* L. Cema, *Cerasus avium* L. C. 2493 a Weiroot 13), středně vzrůstné (Weiroot 158, Weiroot 154 a P-HL-A) a zakrsle rostoucí (Weiroot 72, Weiroot 53 a GiSelA 5). Kromě toho byly u jednotlivých kombinací odrůdy a podnože pozorovány rozdíly v době kvetení a v době zrání. Nejvyšší kumulativní výnos byl zjištěn u odrůdy Linda, za kterou následovaly odrůdy Katalin, Germersdorfi 3 a Piramis. Z hodnocených odrůd třešní dosáhly největší velikosti podle svého příčného průměru plody odrůdy Germersdorfi 3. Pokud jde o podnože, nejvyšší podíl plodů s průměrem větším než 26 mm byl zjištěn u podnože Weiroot 72. Naproti tomu na podnoži GiSelA 5 byly plody nejmenší. U odrůdy višně Piramis byly největší plody na stromech rostoucích na podnoži *Cerasus avium* C. 2493.

Klíčová slova: třešně a višně; podnože; vzrůstnost; výnos; průřez plodu; kumulativní výnos

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