PhD thesis

FACTORS OF PRODUCTIVITY OF SWEET CHERRY TREES

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1. The premise and main goals of the research

The Hungarian sweet cherry production has revived during the last few years. The number of newly planted sweet cherry orchards is increasing, just as is interest in Hungarian bred and new international cultivars, and thus also the results of the national rootstock trials. Currently there is enough information to make the change from the traditionally spacey, machine harvested orchards to high-density, hand-picked orchards with new cultivars and rootstocks (Szabó et al. 2011). Sweet cherry is basically a hand-harvested fruit genus, thus one way of lowering growing costs is to decrease the size of the trees. Using the right rootstock, cultivar and pruning technique are the tree main factors for achieving smaller trees. It is generally known how rootstocks influence the size of the tree, precocity, productivity, fruit size, resistance of pathogens and pests and also stress-tolerance, and through these, the profitability of the orchard. Since rootstocks are responsible for so many attributes it is essential to test them with several cultivars before growing them in great volume. The most important characteristics influenced by the rootstock are precocity and productivity (the number of branching shoots, flowers and fruits). According to the latest results of rootstock-breeding and evaluating researches, an assortment of rootstocks and the newest growing technologies are appropriate. However, there is still not enough information about how these new, promising rootstocks effect the cultivars, this is true despite that fact that it is very important to study the above mentioned factor before introducing new cultivars/rootstocks to growing practice.

Arid climate and the lack of precipitation, thus higher cost of irrigation is an increasing problem for Hungarian fruit production. For high quality fruit it is essential to irrigate. Although the importance of rootstocks is recognized, little is known about water usage of the different cultivar-rootstock combinations Hrotkó et al. 2008), about how rootstocks influence shoot-system, single leaf size and the distribution of leaves within the canopy. The above mentioned parameters play an important roll in photosynthesis, transpiration, thus water usage.

Preliminary research on different rootstocks is an emphasized issue, which result in better understanding of the complexity of cultivar-rootstock relationship, and contribute to an understanding of which rootstocks are best for the Hungarian site conditions.

During the trial we intended to find answer for the following questions:

- How different rootstocks influence the vegetative growth of the trees, the size of the canopy of 'Petrus', 'Rita', 'Vera' and 'Carmen' sweet cherry cultivars.

- How rootstocks influence several generative attributes, like the number of bearing-shoots, buds, flowering, cropping, productivity and precocity of the trees.

- How rootstocks define the total leaf population, the distribution of the leaves within the canopy, and the single leaf size.

- How different rootstocks influence the intensity of the photosynthesis, transpiration and water efficiency of the trees.

- Eventually we want to have a better understanding of which rootstocks are appropriate for high-density orchards in Hungary.

3. Materials and methods

3.1. **Site conditions of the research plot**

The orchard was planted in the spring of 2004 in the experimental farm of Corvinus University Budapest in Central Hungary, South-East of Budapest. The climate is typical to the central Hungarian flatland, yearly average temperature is 11.3 °C, and the total sunshine is 2079 hours per year. High radiation can often cause ground frost in spring and autumn. The precipitation is low, about 560 mm per year; the distribution of the rain during the year is not uniform. The rainiest months are May and June, and the most arid months are July and august.

The soil type is light sandy, lime content is around 2.5 %, soil organic matter is low (0.8 – 0.9 %), pH is 7.7 and the soil compactness index (KA) is 24 (low).

3.1. Table: The nutrition content of the soil (pH 7,7; soil compactness (KA) 24, $CaCO_3$ m/m % 2,8 – 3,0%, organic matter 0,8 – 0,9 %)

	2007			2010		
Soil layer (cm)	0-20	20-40	40-60	0-20	20-40	40-60
Organic matter %	0,94	0,88	0,81	1,08	0,94	0,81
NO_2+NO_3-N mg/kg	2,80	5,29	4,12	7,63	4,38	4,12
P_2O_5 mg/kg	424,67	339,00	309,33	462,2	403,8	345,8
K_2O mg/kg	206,44	137,87	99,40	200,2	167,6	140,5

Based on Table 3.1. the phosphorus and potassium content of the soil is sufficient, while the nitrogen content is low, as it is usually true for sandy soils with low organic matter (Szücs 2003).

3.2. The structure of the trial

The methods of the trial are relevant to previous research in the topic. The following sweet cherry cultivars, ’Rita’, ’Vera’, ’Carmen’ and ’Petrus’ were grafted to 10 different rootstocks ’Cemany’, ’Egervár’, ’Érdi V.’, ‘GiSelA 6’, ’Korponay’, ’Magyar’, ’Bogdány’, ’SL 64’, ’SM 11/4’, ’Mazzard’ and ’Prob’. Spacing is 4x2 m (1250 trees ha -1). The trial was planted in randomized blocks; each plot consists of three trees, repeated four times. The applied canopy type is the so called Hungarian spindle (Hrotkó et al. 2007). Trees turned to bearing in 2006, and after they reached the final height (4.5-5 m) in summer 2009, they were headed at 3.5-4 m.

3.3. Attributes and calculated indexes of the trial

The trial started in 2005 and the measurements were carried out till 2010. Before the trees turned to bearing the measurement focused on vegetative attributes of the trees, thus every year during dormancy we measured the size of the trees. Parallel and perpendicularly to the row we measured the length and the width of the canopy. The height of the canopy was measured from the graft-union. Also every year we measured the trunk girth (circumference). Using these data we calculated trunk cross sectional area (cm^2), canopy area (cm^2) and canopy volume (cm^3) (Silbereisen és Scherr 1968).

Trunk cross sectional area *(cm^2)* = (trunk diameter *(cm)*/2)^{2}x π
Canopy area *(m^2)* = [(canopy width *(m)* + canopy length *(m)*)/4)]^2 x π.
Canopy volume (*m^3*) = (canopy area *(m^2)* x canopy height *(m)*)/2

In 2009 we counted the number of fruiting branches per tree in case of each cultivar-rootstock combinations. From these data we calculated fruiting branches per hectare, the total length of fruiting branches per tree, and the number of fruiting branches in one m^3 canopy.
We counted the number flowers per tree, the number of fruiting buds and flowers per fruiting branches; from these data we were able to conclude the productivity of the trees. Every year we measured the total yield per tree before the harvest with estimation and after the harvest with a digital scale. We calculated the cumulative yield for each cultivar-rootstock combinations.
Single fruit weight and water soluble dry material (in Brix°) was also measured in laboratory by using 50 sample fruits from each combination. We used ATAGO Palette PR-101 refractometer to analyze fruit juice (Codex Alimentarius 3-1-558/93).
To define how rootstocks effect the productivity of the trees we calculated the total yield per tree reflected to the trunk cross-section.

Total yield per tree reflected to the trunk cross-section = Cumulative yield (kg)/Trunk cross-sectional area (cm^2)

Specific yield reflected to the canopy area, volume and 1 hectare was calculated.

Total yield reflected to canopy area = Cumulative yield (kg)/ canopy area (m^2)

Total yield reflected to canopy volume = Cumulative yield (kg)/ Canopy volume (m3)

Leaf samples were collected in August, after the trees had been pruned so that the leaves would be fully developed (see guidelines of Hungarian Cherry Spindle, Hrotkó et al. 2007).Twenty leaves were collected from each tree; 10 from spurs and 10 from extension shoots. In 2009 the summer pruning included the heading (removal of the upper part of the canopy) at 4.5 m height. We measured the rough weight of collected leaves, then after drying them at 80 C° to invariable weight, we measured their dry-weight. This data helped us to calculate the specific leaf weight (SLW mg cm^{-2}, Jackson and Palmer 1977). We calculated the single leaf area (SLA) on dry leaves by using a special program developed by the Department of Applied Physics and Automatics CUB. The program takes photographs of the leaves, and by using a given sized control figure, the pixel number the single leaf area is easy to calculate with a simple equitation in Excel Microsoft. Counting of leaves separately on spurs and long extension shoots was carried out on one of the three trees in each plot. From the total number of leaves per tree and the single leaf area, we were able to calculate total leaf area (LAT) per each tree and shoot type. For comparison of leaf area distribution of trees on different rootstocks the leaf area total (LAT) was related to the trunk cross sectional area (TCSA, cm^2), the canopy volume (CV, m^3) and the area allotted to the trees at 1250 trees ha^{-1} orchard density.

In 2010 we measured the photosynthetic activity and transpiration of the trees with the portable LCi instrument, which measure the leaf area, H_2O and CO_2 content of the air, atmospheric pressure, leaf surface temperature, PAR (photosynthetic active radiation), CO_2 concentration between cells, transpiration and stoma conductivity. The instrument calculates the net CO_2 assimilation rate (BioScientific ltd. 2004.). In our research we mainly used the following data: vapor emission, stomata conductance and net CO_2 assimilation.

Statistic analysis was made by using single factor and multi factor analysis of variance with SPSS 15 statistic program. Our results are shown in tables and diagrams, where different letters mean significant variance among the statistic groups ('ab' – 'cd').

4. Results and conclusions

4.1. Tree growth and vigor

Our results concerning rootstock vigor are in agreement with previous studies, thus we can conclude that sweet cherry trees grafted on ''Mahaleb'' rootstocks show faster vegetative growing at the beginning, and the final size of the trees will be also bigger comparing to other traditional rootstocks (Hrotkó 2003).

Rootstocks can be grouped in the same way for each of the four cultivars. Vigorous rootstocks are the followings: ’Egervár’, ’Érdi V.’,’CEMANY’, ’Korponay’, ’Bogdány’ ‘Mahaleb’ rootstocks. Semi-vigorous rootstocks are ’Magyar’, ’SL64’, ’SM 11/4’ clone ‘Mahaleb’ rootstocks and ’Mazzard’. Dwarfing rootstocks are ‘GiSelA 6’ and ’Prob’, both are interspecific hybrids. We observed that trees on ‘GiSelA 6’ rootstocks are rather small than vigorous, in contrary to foreign literature (Franken-Bembenek 1996). In both the 5th (2008) and 6th (2009) years the investigated trees produced significant differences in canopy size and in TCSA. Figure 4.1 shows the differences between how rootstocks affect the vigor of ‘Petrus’ sweet cherry trees. ‘CEMANY’ is a vigorous ‘Mahaleb’ seedling rootstock, and we took it as the 100 %, and we compared the other rootstocks to this.

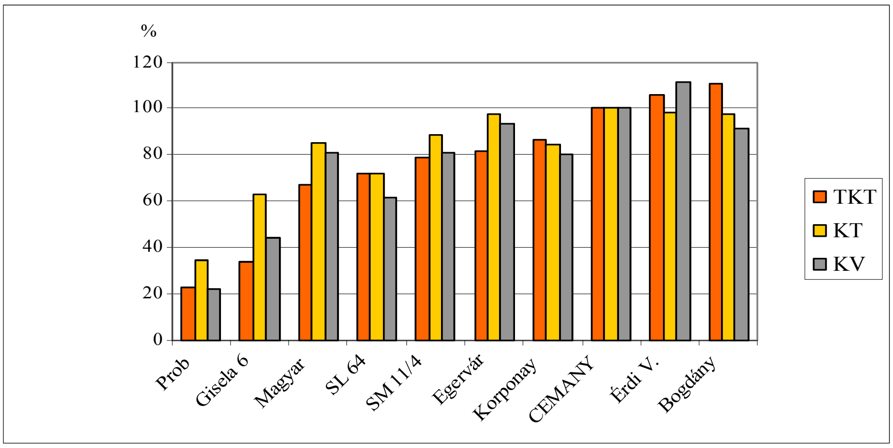
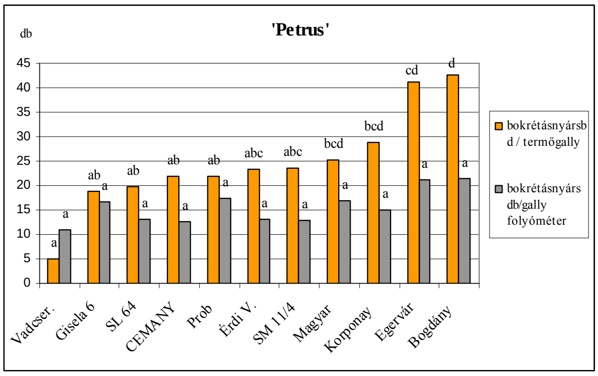


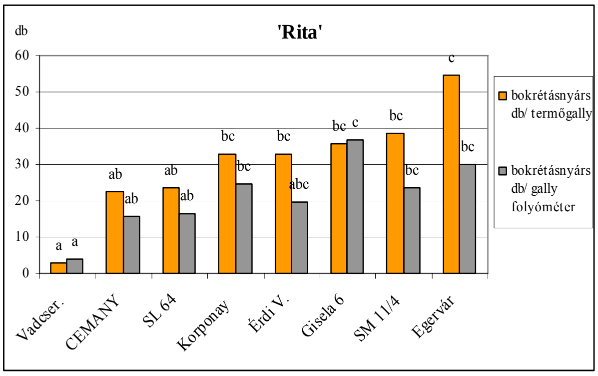
Figure 4.1. Rootstock affect on growth of 'Petrus' sweet cherry trees in2009 (CEMANY =100%)

4.2. Effect of rootstocks on the density of fruiting branches

The orchard productivity is determined by the number of fruiting branches. This parameter allows us to compare rootstocks in the experimental orchard (1250 tree/ha). Varying results among the four cultivars confirm Hrotkó’s results (2007, 2008, 2009/a), which say that each cultivar-rootstock combination is different. Sweet cherry is ’picky’ in rootstocks. It is remarkable how some of the ‘Mahaleb’ rootstocks (’Egervár, ’Magyar’, ’Bogdány, ’Korponay, ’ÉrdiV.’) grow as many fruiting branches as trees on the very productive ‘GiSelA 6’ and ’Prob’ rootstocks. The density of fruiting branches within the canopy indicates the ability of ’turning to bearing’ early. The number of burse shoots and flowers on the fruiting branches show similar results. Our results agree with Hrotkó’s statement (Hrotkó et al. 2009), that trees on some semi-vigorous and vigorous rootstocks can grow just as many burse shoots as trees with dwarfing rootstocks. Considering our results we can predict early yielding of ’Petrus’ sweet cherry trees with ’Prob’, ’GiSelA 6’ and ’Magyar’ rootstocks. ’Rita’ sweet cherry trees turn to bear early with ’GiSelA 6’, ’Korponay’ and ’Egervár’, while ’Vera’ sweet cherry trees have early yielding with ’GiSelA 6’ and ’Egervár’ rootstocks.



4.2.a



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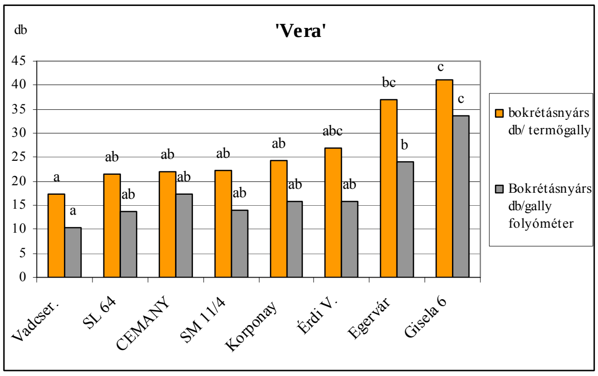

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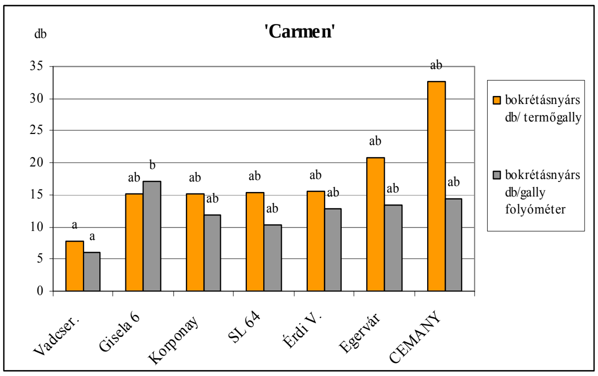


4.2 d

Figure 4.2.: Rootstock influence on the number of burse shoots per tree and the number of burse shoot per 1m of fruiting branch ’Petrus’ (a), ’Rita’ (b), ’Vera’ (c) and ’Carmen’ (d) sweet cherry trees

4.3. Effect of rootstocks on productivity

Our results agree with Bujdosó (2006), that trees grafted on dwarfing rootstocks produced greater number of flowers per tree, than those grafted on semi-vigorous and vigorous rootstocks. Trees on 'GiSelA 6' and 'Prob' dwarfing rootstocks turn to bearing earlier and the productivity of these trees in the first years is greater than of those grafted on 'Mahaleb' rootstocks. Interestingly, according to our results trees on 'Egervár' and 'Bogdány' 'Mahaleb' rootstocks showed similar results. These rootstocks can be classified as semi-early bearing types in agreement with Franken-Bembenek (2005, 2010) and Hrotkó et al. (2009).

We can conclude in agreement with the literature that trees on 'Mazzard' rootstocks turn to bearing relatively late, these trees are less productive and they show sensitivity to the high lime content of the soil (Hrotkó 2003). This and the less optimal irrigation both caused the poor results we experienced with these rootstocks.

Our results about productivity of the trees also agree with Franken-Bembenek 1995, 1996, Vogel 1994, Weber 2003, who say that dwarfing rootstocks indicate great productivity.

The cumulative yield of the last three years was the highest on trees grafted on 'Egervár', 'Érdi V.', 'Bogdány' and 'CEMANY' semi-vigorous 'Mahaleb' rootstocks (Table 4.3.).

Summarizing our result we can say that in a high-density sweet cherry orchard with less than optimal site conditions; 'Egervár', 'CEMANY' and 'Korponay' vigorous and semi-vigorous 'Mahaleb' rootstocks positively effect productivity of sweet cherry trees, fruit size, and optimal fruit-leaf proportion within the canopy compared to trees grafted onto dwarfing rootstocks.

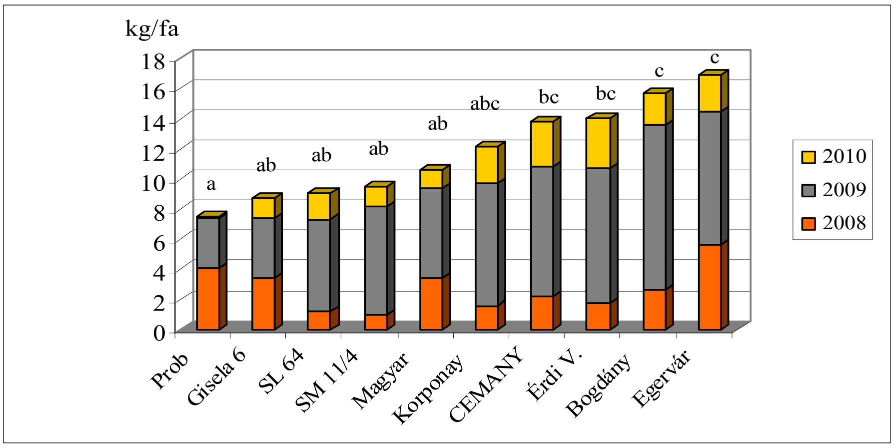


Figure 4.3.: Cumulative yield of Petrus' sweet cherry trees (2008-2010)

4.4. Fruit quality in the first three years

After the first three years of cropping, our results show that productivity of trees with ’Magyar’,’Korponay’, ’Egervár’ and ’Bogdány’ rootstocks is close to those with ’GiSelA 6’ rootstocks. In general dwarfing rootstocks have a positive impact on productivity, the number of flower buds per tree is higher, comparing to those trees on vigorous rootstocks (Franken-Bembenek 1995, 1996; Vogel 2000; Weber 2003). In our experiment none of the four sweet cherry cultivars with dwarfing rootstocks produced correctly sized fruit. Small fruits can result from the uneven Hungarian climate, and also from the fact that trees on ’GiSelA’ rootstocks mature too quickly; thus bud-less branches appear more often. The ideal four to one leaf-fruit ratio is not reached by those trees which mature too quickly. Finally, trees on ’GiSelA’ rootstocks often produce too many fruits. It is remarkable that for achieving the best productivity different sweet cherry cultivars require different rootstocks. These early years of our experiments are not enough to make final conclusion about how rootstocks affect the fruit quality and productivity of sweet cherry trees. Further researc is necessary in the topic.

4.5. Effect of rootstocks on leaf population and leaf distribution within the canopy of sweet cherry trees

The results of Santos (2006) prove that low light penetration into the canopy results in small specific leaf weight (SLW g/m^2), but bigger single leaf area (SLA). We also measured significantly larger single leaf size on vigorous trees with dense canopy. Shade leaves produce more effective assimilation to compensate the non-optimal light conditions (Pearcy és Sims 1994, Niinemets et al., 1998). The average leaf size (SLA) on both cultivars and in both years (2008-2009) was larger on long extension shoots compared to spurs, except for leaves on dwarf rootstocks in 2009. The average leaf size for both shoot types (long shoots and spurs) showed significant differences depending on the rootstocks. The largest leaves were found on ‘Petrus’ trees budded on vigorous *P. ‘Mahaleb’* ‘Bogdány’ (7,4-8,5 LAI), and on ‘Rita’ trees budded on ‘Korponay’ rootstock (3,7 LAI). Sweet cherry trees produced the smallest leaves for both shoot types when they were budded onto dwarfing ‘Prob’ or ‘Gisela 6’ rootstocks. The leaf size of trees on other *P. ‘Mahaleb’* rootstocks (‘Magyar’ and ‘Korponay’) and Mazzard showed intermediate values; further significant differences are shown in. The results of the two years prove that calculated LAI and the vigor of the trees are strongly correlated in 4 x 2 m spacing orchard. Supposing that for the right amount of fruits there is a required total leaf size; this means that trees on dwarfing rootstocks need to be planted 5-8 times denser to achieve the same orchard productivity. In our trial we measured 5-10 times larger leaf area per hectare, and 3,2-8,5 LAI on trees grafted into vigorous rootstocks. It is proved by our results that rootstocks not only determine the size of the sweet cherry trees, but thus the density of leaf population, light interception within the canopy, and light efficiency in the canopy (Goncalves 2008). Considering our results the optimal 3,2-3,5 LAI (Cittadini 2008, Hrotkó et al. 2010) can be achieved with 'Petrus' sweet cherry grafted into the semi-vigorous 'Magyar' 'Mahaleb' rootstocks, and with 'Rita' sweet cherry trees grafted into semi-vigorous 'Mahaleb' seedlings, or 'Korponay' and 'Érdi V.' vegetative propagated 'Mahaleb' rootstocks (Table 4.1.).

Regarding specific leaf weight (SLW), the results from 2008 show significant differences only in 'Petrus', while in 2009 we found significant differences among both cultivars and shoot types (Table 4.1.). Leaves collected from trees on dwarfing rootstocks on average showed larger SLW, while on vigorous rootstocks the SLW on both shoot type was smaller. On the other hand, there is a tendency that spur-leaves show lower SLW compared to long extension shoots. In both years (2008-2009) we measured the largest specific leaf weight in case of 'Petrus' sweet cherry trees with 'Prob' és 'GiSelA 6' rootstocks on both shoot types. The smallest SLW was measured on trees with 'Bogdány' semi-vigorous 'Mahaleb' rootstocks. Although the tendency was the same in case of 'Rita' sweet cherry trees, there were no significant differences between the rootstocks. We measured the largest SLW on 'GiSelA 6' rootstocks. The smallest SLW was found on trees grafted on 'Mazzard' rootstocks.

Summarizing our first results on rootstock-leaf population relationship we can conclude that specific leaf weight is bigger in case of dwarfing rootstock. This holds independently of the shoot type and the cultivar. The proportion of leaves growing on long shoots within the canopy is higher than that of those growing on spurs. LAI projected to the trunk cross sectional area, and leaf distribution based on the canopy area also depend on rootstock in our trial orchard (with 1250 tree/ha). Total leaf area of the trees is correlated to vigor, but it is also affected by the cultivar and the weather conditions. Pruning back the top of the trees in 2009 drastically changed the total leaf area of the trees. We have to admit that in an intensive orchard the growing of the canopy is limited by space constraints, while the trunk of the trees can grow independently (Hrotkó 2002, Hrotkó et al. 2007).

Table 4.1.: The distribution of leaf population, and LAI of ‘Petrus’ and ‘Rita’ sweet cherry trees (in a 1250 tree/ha orchard)

Rootstocks	*2008* *LA / CV m² /m ³*		*LA /TCSA m²/cm²*		*LAI*		*2009* *LA / CV m² /m ³*		*LA / TCSA m²/cm²*		*LAI*	
					’Petrus’							
‘Prob’	-	-	-	-	-	-	1.44	a	0,17	a	0.4	a
‘GiSelA 6’	3.40	a	0,51	a	1,1	a	1.87	a	0,26	a	0.6	a
’Magyar’	3.13	a	0,65	b	3.6	b	5.50	b	0.76	b	5.7	b
’Bogdány’	3.59	a	0,68	b	7.4	c	6.51	b	0.64	b	8.5	c
					’Rita’							
‘GiSelA 6’	1.97	a	0,40	a	1.1	a	1.67	a	0,26	a	0.8	a
’Korponay’	2.61	b	0,60	b	3.7	b	2.41	b	0.28	a	2.3	b
’Vadcseresznye’	1.60	a	0,42	a	1.7	a	1.64	a	0.18	a	1.0	a
‘Érdi V.’	2.05	ab	0,48	ab	3.2	b	-	-	-	-	-	-

LA: leaf area
CV: canopy volume
TCSA: trunk cross-sectional area

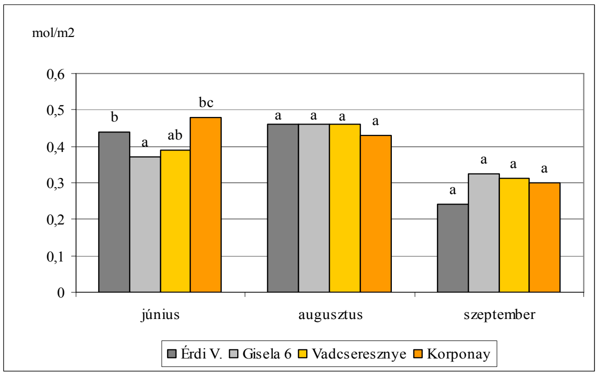
Table 4.2. : Effect of rootstocks on SLW of ’Péter’ and ’Rita’ sweet cherry trees (SLT, mg cm -2)

Rootstocks	*2008* *Mean SLW (mg/cm^2) on long shoots*		*Mean SLW (mg/cm^2) on spurs*		*2009* *Mean SLW (mg/cm^2) on long shoots*		*Mean SLW (mg/cm^2) on spurs*	
				’Petrus’				
’Prob’	10,97	b	7,71	ab	14,05	b	10,33	b
’Gisela 6’	9,40	ab	7,85	b	9,29	a	9,04	ab
’Magyar’	8,80	ab	6,23	ab	9,23	a	9,15	ab
’Bogdány’	7,20	a	5,99	a	8,23	a	6,15	a
				’Rita’				
’Gisela 6’	8,64	a	7,71	a	11,08	c	8,72	c
’Korponay’	9,08	a	7,01	a	9,12	b	6,17	ab
‘Sajmeggy mag’	7,46	a	6,92	a	8,34	ab	6,59	b
‘Vadcseresznye’	8,12	a	7,34	a	7,62	a	5,88	a

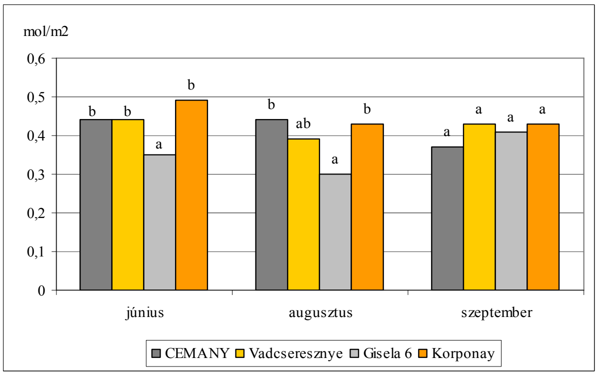
SLW: single leaf weight

4.6. Effect of rootstocks on transpiration, photosynthesis and water usage of sweet cherry trees

Leaf anatomy, CO_2 assimilation, gas exchange, photosynthesis, transpiration are highlighted research topics in fruit growing. The above mentioned attributes are all correlated to SLW, leaf size and leaf distribution (Goncalves 2008). Drought stress has a complex affect on plant metabolism, especially on leaf gas exchange (Hsiao 1976). In case of water deficiency (soil or atmospheric drought) plants can control transpiration by closing stomata (Sousa et al., 2006).

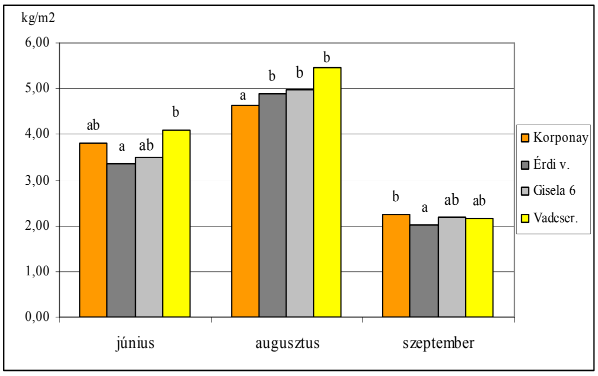


’Rita’

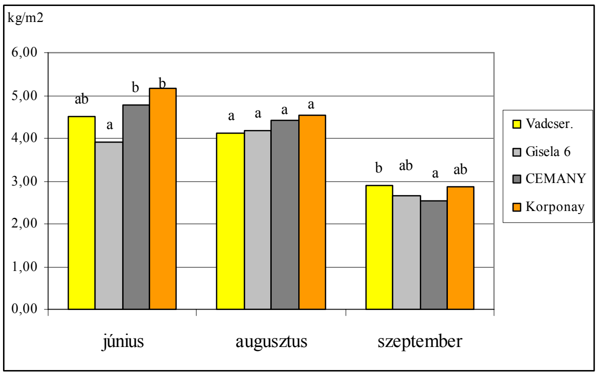


’Vera’

Figure 4.4.: Daily photosynthetic activity of ’Rita’ and ’Vera’ sweet cherry trees in June-August-September



’Rita’



’Vera’

Figure: 4.5: Daily transpiration of ’Rita’ and ’Vera’ sweet cherry trees in June-August-September

In June the daily transpiration per 1 m^2 leaf area was less than four kilograms in case of all cultivar-rootstock combinations. In our measurements, daily transpiration was less intensive on trees with ‘GiSelA 6’ rootstocks. CO_2 assimilation per unit area was most intensive on trees with ‘GiSelA 6’, ’Érdi V.’ and ’CEMANY’ rootstocks. In August the transpiration of ’Rita’ trees was the lowest on ’Korponay’ and ’Egervár’ rootstocks, and we measured the most (5 liter/ m^2) intensive daily transpiration on trees with ’Mazzard’ rootstocks. The transpiration of ’Vera’ trees was the most intensive on ’Egervár’, and the least on ’GiSelA 6’ rootstocks in August. Daily CO_2 assimilation of ’Vera’ trees was the most intensive on ’Mahaleb’ rootstocks. Daily transpiration decreased in September, the daily transpiration per 1 m^2 leaf area was two or three liters in case of all cultivar-rootstock combinations. The most efficient CO_2 assimilation and also the most intensive transpiration of ‘Rita’ trees were with ‘Korponay’ and ’GiSelA 6’ rootstocks. ’Vera’ trees had more intensive transpiration than ’Rita’ trees in September. We did not find any significant difference in the daily CO_2 assimilation rates for the different trees in September, but the most efficient trees were grafted on ‘Mazzard’ and ‘Korponay’ rootstocks. Our results confirm Teszlák (2008) although he did his research on grapes. Specifically the opening of the stoma decreases as transpiration and photosynthesis decrease. Teszlák also observed that some of the cultivars produced high CO_2 assimilation even though stoma conductivity was low. We observed similar phenomena with trees on ‘GiSelA 6’ rootstocks independent of the month and the time of day; the stoma conductivity was always lowest even though the daily CO_2 assimilation rates were not significantly lower. Similar to the CO_2 assimilation , transpiration rate shows positive correlation with stoma conductivity. Daily transpiration of trees on ‘Korponay’ rootstocks agrees with Juhász et al. (2008) who measured the water usage of ‘Rita’ sweet cherry trees in June with Flow32 (dynamax) to be between 25 and 50 kilograms.

Water use efficiency (WUE) in June and August was greater with ‘Korponay’ nd ‘Érdi V:’ mahaleb rootstocks, while in September trees grafted on ’GiSelA 6’ rootstocks seemed to be the most efficient. High leaf temperature, low stoma conductivity and low transpiration during the summer heat prevent trees on ’GiSelA 6’ rootstocks from adapting to the heat, and thus the trees show signs of heat stress during this time. In September however, trees on ’GiSelA 6’ rootstocks have relatively better WUE than those on other rootstocks. Our results from September agree with those from Goncalves (2008), Wayne and Bazzaz 1993, Niinemets and Tenhunen 1997, Genard et al. 2000, and Frak et al.2002). Leaves from ’GiSelA 6’ trees use less water to produce the same amount of dry material, which means that less water flows through the leaf zone. This together with the relatively smaller leaves on this rootstocks lowers the chance of producing fruit of optimal size.

5. New scientific results

1. We show that trees on ’Bogdány’ and ’Egervár’ mahaleb rootstocks can be classified as vigorous. The trees on ’Korponay’ and ’Magyar’ rootstocks are semi-vigorous, and under Hungarian climate conditions, trees on ‘GiSelA 6’rootstocks are rather dwarfing than semi dwarfing.

2. Precocity, productivity flower density and fruit yield as almost as high on trees with ’Egervár’ rootstocks as on those with ‘GiSelA 6’in high-density orchard. Trees on ’Bogdány’, ’Korponay’ and ’Magyar’ semi-vigorous rootstocks exhibit moderate precocity.

3. We conclude that rootstocks effect single leaf size and specific leaf weight (g/cm^2). These parameters together with tree vigor influence orchard LAI. Leaf population is mostly found

on spurs of dwarfing rootstocks, which causes the leaf-fruit ratio to be the worst for those trees. According to the literatiure leaves on long shoots are important in determining the fruit size. The total leaf area on semi-vigorous and vigorous rootstocks have a higher proportion of leaves on long shoots.

4. The daily trend of leaf temperature, stoma conductivity, transpiration and CO_2 assimilation during the vegetative stage is different for different rootstocks. On most rootstocks transpiration correlates with stoma conductivity and CO_2 assimilation. WUE (g CO_2 /kg water transpiration) of trees on ‘GiSelA 6’ rootstocks is greater that those on ’Mahaleb’ rootstocks.

5. We reccomend the following sweet cherry cultivar-rootstock combination for high-density orchards in arid conditions:

’Petrus’ sweet cherry trees with ’Bogdány’, ’Egervár’ rootstocks
’Rita’, ’Vera’ sweet cherry trees with ’Egervár’, ’Érdi V.’, ’Korponay’ rootstocks
’Carmen’ sweet cherry trees with ’Egervár’,’Korponay’ rootstocks

6. Selected papers of the author related to the research topic

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