THESIS OF DOCTORAL (PhD) DISSERTATION

THE EXAMINATION OF SWEET CHERRIES VEGETATIVE AND GENERATIVE CHARACTERISTICS AND THE CULTIVATION SYSTEMS

Barbara Vaszily

Supervisor:
Dr. Istvan Gonda

UNIVERSITY OF DEBRECEN
Hankóczy Jenő Doctoral School of Plant Production, Horticulture and Food Science

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Introduction

The world sweet cherry production is continuously growing. Nowadays total sweet cherry production is about 2 million tons, while in Hungary the production is only 6000 tons.

Due to production growth marketing competition is also increase. Marketing requirements are increasing on fruit quality parameters, which can be fulfilled with adequate level of intensive production technology.

Out of fruit species sweet cherry is the most breaded species. Not only self fertile cultivars are widely speeded but cultivars are also able to undrawn maturity periods. Besides aim of the breeding and research activities is the production of excellent quality, above 26 mm fruit diameter and transportable cultivars providing year to year increasing yield. Hungary has great and recognized breeding past thankful to János Brózik and János Apostol.

Besides rootstock research is a key element due to sweet cherry growth features, which produced promising results worldwide. This is especially important for the great tree producing sweet cherry.

Practical experiences show that the use of dwarfing rootstock is not spreading in Hungary. Therefore production innovation is limited to elements of production technology.

More emphasis needs to be placed on technological issues in orchards planted with moderate and strong growth rootstock. Appropriate tree spacing and crown structure as well as cultivar selection is essential. As sweet cherry is a light demanding fruit species, aging process speed up due to inappropriate tree spacing and crown structure.

Among technological elements, role of cultivar is outstanding. Cultivars are largely different not only in fruit quality but in growth and production part features. These partly genetical features are influenced largely by technological elements in both negative and positive directions.

Thus, knowledge on growth and rejuvenation features of new and already produced cultivars are essential in domestic sweet cherry production due to marketing competitiveness and long-term profitability of production.

Therefore, vegetative and generative and regeneration features of 13 domestic and abroad sweet cherry cultivars including production value, technological features and pruning methods and crown structure were studied in Pallag Experimental Station, University of Debrecen.

Materials and methods

The study was carried out in Pallag Experimental Station University of Debrecen from 2008 to 2012. Soil type was sandy with below 1% humus. Results of low Arany's soil quality number (23) presented in **Table 1.**

Table 1. Soil parameters of experimetal orchard (Debrecen-Pallag, 2010)

	Sample dept (cm)	
	0-30 cm	**30-60 cm**
pH (KCl)	*5.6*	*5.7*
pH (water)	*6.5*	*6.5*
K_A	*23.5*	*22*
Water soulbe salt % (m/m)	*0.01*	*0.009*
$CaCO_3$ % (m/m)	*<0.1*	*0.2*
Humus % (m/m)	*0.9*	*0.8*
KCl-soluble NO_3-+NO_2--N (mg/kg)	*8.8*	*7.8*
AL- soluble P_2O_5 (mg/kg)	*169*	*148*
AL- soluble K_2O (mg/kg)	*771*	*615*
AL- soluble Na (mg/kg)	*15.8*	*11.1*
KCl- soluble Mg (mg/kg)	*207*	*79.2*
KCl- soluble SO_4 2--S (mg/kg)	*3.5*	*2.*
KCl-EDTA soluble Cu (mg/kg)	*3.1*	*2.9*
KCl-EDTA soluble Zn (mg/kg)	*4.5*	*4.6*
KCl-EDTA soluble Mn (mg/kg)	*239*	*227*

Alföld has the most extreme continental climate in Hungary. Király (2006) showed that the experimental area (Pallag Experimental Station, Risk Farm and regional research Institute, University of Debrecen) is suit to the ecological conditions of South-Nyírség and Alföld. East part of the experimental station is bordered by the Debrecen Great Forest. A weather feature of this region from 2009 to 2011 is shown in **Table 2.** compared to previous years means.

Table 2. Weather parameters in experimental years (precipitation, cumulative and mean temperature) compared to previous years means (%) (Debrecen-Pallag, 2012)

Precipitation (mm)								
			Previous years mean	%			Previous years mean	%
2009	Between bloom and maturity	**74,7**	**126,7**	**58,9**	Between 20 July and 1 November	**131,1**	**156,3**	**83,9**
2010	Between bloom and maturity	**241,7**	**143,0**	**169,0**	Between 20 July and 1 November	**247,9**	**156,3**	**158,6**
2011	Between bloom and maturity t	**69,7**	**127,0**	**54,9**	Between 20 July and 1 November	**167,5**	**156,3**	**107,1**
Cumulative temperature								
			Previous years mean	%-			Previous years mean	%
2009	Between bloom and maturity	**1077,3**	**950,0**	**113,4**	Between 20 July and 1 November	**1914,2**	**1624,1**	**117,9**
2010	Between bloom and maturity	**1180,8**	**1101,8**	**107,2**	Between 20 July and 1 November	**1490,8**	**1624,1**	**91,8**
2011	Between bloom and maturity t	**1042,2**	**967,8**	**107,7**	Between 20 July and 1 November	**1708,6**	**1624,1**	**105,2**
Mean temperature (°C)								
			Previous years mean	%			Previous years mean	%
2009	Between bloom and maturity	**16,8**	**14,8**	**113,5**	Between 20 July and 1 November	**18,4**	**15,6**	**117,9**
2010	Between bloom and maturity	**16,2**	**15,1**	**107,3**	Between 20 July and 1 November	**14,3**	**15,6**	**91,8**
2011	Between bloom and maturity t	**16,5**	**15,4**	**107,1**	Between 20 July and 1 November	**16,4**	**15,6**	**105,2**

Figure 1. Blooming super spindle (Vaszily) **Figure 2.** Blooming free spindle (Vaszily)

Most important data of experimental orchards presented in **Table 3.**

Table 3. Parameters of studies orchards

Crown structure	**Super spindle**	**Free spindle**
Plantation date	Spring of 2000	
Planting material	1 year old nursery material	
Distance between rows (m)	4 m	5 m
Distance between trees (m)	1 m	2 m
Row orientation	NW-SE	
Irrigation	Drip	
Rootstock	*Prunus mahaleb,*'CEMA CT-500'	
Studied sweet cherry cultivars	'Rita' 'Linda' 'Axel' 'Bigarreau Burlat' 'Germersdorfi 3' 'Anita' 'Stella' 'Celeste'	
	'Cristallina'	
	'Sunburst'	
	'Isabella'	
	'Katalin'	
	'Van'	

Altogether 13 sweet cherry cultivars were studied, out which 8 cultivars ('Rita', 'Linda', 'Axel', 'Bigarreau Burlat', 'Germersdorfi 3', 'Anita', 'Stella', 'Celeste') were both super spindle **(Figure 1.)** and free spindle **(Figure 2.).** Other 5 cultivars ('Cristallina, 'Sunburst', 'Isabella', 'Katalin' and 'Van') were studied only on super spindle crown structure.

Rain protection foil structure were created in 2005 above the super spindle orchard part, which is 25% of the total experimental areas. Parameters of foil structure **(Figure 3.):**

- Width: 8 m (3 rows covering),
- Length: 20 m (21 trees in each row),
- Height: 4,5 m.

Foil coverage was partial in our case (**Figure 4.),** as only above part of the tress was covered and the lateral parts not. The same sweet cherry cultivars without rain protection foils were used as control. Rain protection foil was placed in mid-May and removed mid/end July (after harvest).

Figure 3. Rain protection foil structure (Vaszily)

Figure 4. Super spindle plantation under partial foil coverage (Vaszily)

Objects of the study and structure of the experiment

Different pruning methods on the studied sweet cherry cultivars and crown structure were carried out **(Table 4).**

Table 4. Degree, methods and timing of pruning in the experiments (Debrecen-Pallag, 2008-2011)

<table>
<tr><th colspan="3">Free spindle crown structure</th><th colspan="2">Super spindle crown structure</th></tr>
<tr><th colspan="2">Timing of pruning</th><th>Methods of pruning</th><th>Timing of pruning</th><th>Methods of pruning</th></tr>
<tr><td rowspan="2">2009 year</td><td></td><td rowspan="4">1-4 years old pruning of crown part and pruning back</td><td>V. 20.</td><td>Selection of shoots</td></tr>
<tr><td></td><td>VI. 21.</td><td>Pruning back of shoots</td></tr>
<tr><td></td><td>III. 13.</td><td>VII. 28.</td><td rowspan="3">Removal of abundant shoots, removal of 2-3 years old partially, top height limiting</td></tr>
<tr><td>2010 year</td><td>III. 20.</td><td>VII. 25.</td></tr>
<tr><td>2011 year</td><td>III. 25.</td><td>VII. 26.</td></tr>
</table>

Pruning was carried out in dormant bud stage in every year in trees with free spindle crown structure. Pruning of trees with super spindle crown structure was carried out in the vegetation period during summer (green) pruning with the following aims:

- due to abundant tree space,
- due to favorable light intensity and airy tree crown, and
- due to ability of technological work in the tree row space.

Older (4 years old) crown parts was removed in dormant bud stage from trees super spindle. In 2009, 3 summer pruning was carried out and the following years only ones after harvest

Studied features and calculated indexes

Table 5. contains the studied features.

Table 5. Object of the studies (Debrecen-Pallag, 2012)

Object of the studies	Years				
	2008	2009	2010	2011	2012
Trunk diameter (cm)	✓	✓	✓	✓	
Twig diameter (cm)	✓	✓	✓	✓	
Length of 1-5 years old crown parts (cm)	✓	✓	✓	✓	
Numbers of shoots (pc)		✓	✓	✓	
Length of shoots (cm)		✓	✓	✓	
Dynamics of shoot growth			✓		
Abudancy of solitary buds (pc)	✓	✓	✓	✓	
Abudancy of posy production plant parts (pc)	✓	✓	✓	✓	
Size of posy production plant parts (mm)	✓	✓			
Abudancy of opened flowers (pc)		✓	✓	✓	
Abundancy od set fruit (pc)		✓	✓	✓	
Floweinng time		✓	✓	✓	
Maturity time		✓	✓	✓	
Yield (kg/tree)		✓	✓	✓	
Fruit size /x, y, z (mm)		✓	✓	✓	
Length of pedicel (mm)		✓	✓	✓	
Weigth of fruit (g)		✓	✓	✓	
Wiegth of stone (g)		✓	✓	✓	
Inner content		✓	✓	✓	
Tensile strength of pedicel			✓		
Frost sensitvity %			✓	✓	✓
Flower content of solitary buds (pc)				✓	✓
Flower content of posy production plant parts (pc)				✓	✓
Blumeriella incidence			✓		
Regeneration feature		✓	✓		

Regeneration was studied in the lower third part of the tree crown, where the tree growth is lowest. The sweet cherry tree rejuvenation feature is probably the lowest in these parts of the tree due to polarity. In March of 2009, partial removal of 2-6 years old crown

parts was carried out. Length of the snag was 2-3 times longer than the cross-section of pruning surface area. Emergence of hided buds was observed after bud closing stage. Regeneration growth parts were sorted in categories (short and long). These as growth points were cumulated and cultivars and age of crown parts were sorted to regeneration capacity categories. In addition, vitality of previous years growth was also evaluated.

Results

Trunk area accession and the Zahn index of sweet cherry cultivars

Trunk area accession was only moderate on trees with free spindle crown form **(Figure 5.)**. Cultivar ’Stella’ was the weakest, while the strongest growth as well as trunk area accession was achieved on cultivars ’Rita’, ’Anita’, ’Celeste’ and ’Axel’.

Among trees of super spindle crown structure, cultivars ’Cristallina’ and ’Stella’ showed the smallest trunk cross-section. Largest growth was observed on cultivars Rita’, ’Celeste’ and ’Katalin’, all other cultivars showed middle strong growth.

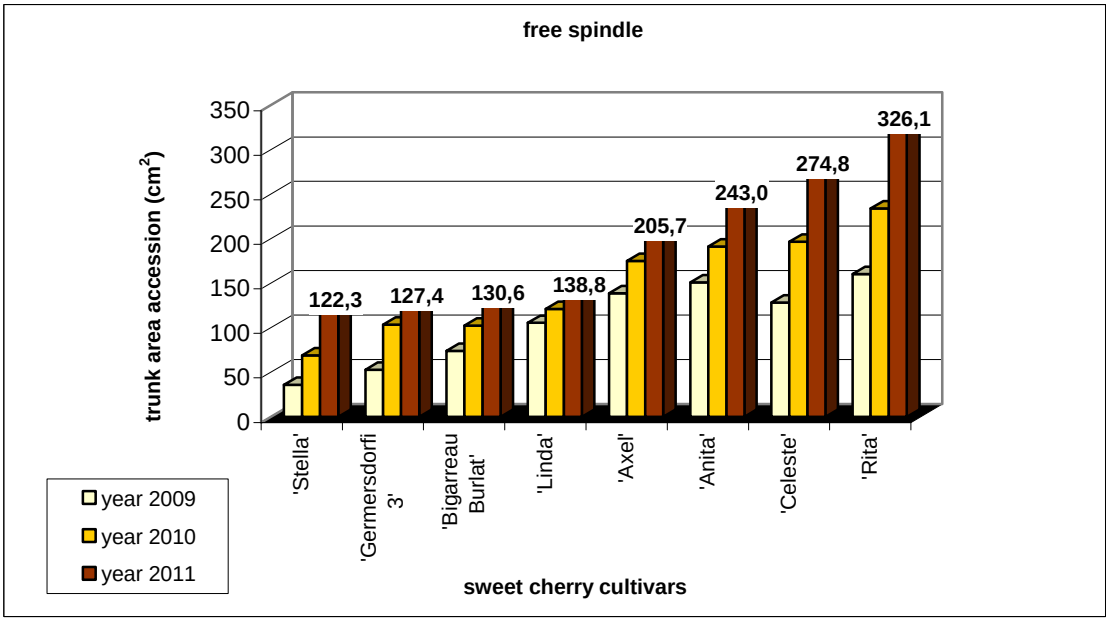

Figure 5. Changes of trunk area accession in free spindle crown structure from 2009 to 2011 (Debrecen-Pallag, 2012)

According to Zahn index, lateral twigs have to be removed on the central axis and all lateral twigs can not be thicker than half of the thickness of the central axis. Value of thickness index was not more than the Zahn index of 0.5 **(Table 6).** Differences among

cultivars were quite large (0.22-0.43). Crown structure had large effect on thickness of lateral twigs on cultivars ’Stella’, ’Germersdorfi 3’ and ’Rita’. These cultivars were welt adopted to higher density conditions too.

Table 6. Zahn index of sweet cherry cultivars on various crown structure (Debrecen-Pallag, 2008-2011)

Zahn index (mm/mm)		
Cherry cultivars	***Free spindle***	***Super spindle***
’Anita’	***0,25***	***0,22***
’Linda’	***0,26***	***0,24***
’Axel’	***0,27***	***0,31***
’Celeste’	***0,31***	***0,30***
’Rita’	***0,32***	***0,25***
’Germersdorfi 3’	***0,38***	***0,25***
’Bigarreau Burlat’	***0,40***	***0,37***
’Stella’	***0,43***	***0,33***
’Katalin’		***0,27***
’Isabella’		***0,35***
’Van’		***0,37***
’Cristallina’		***0,37***
’Sunburst’		***0,38***

Specific indicators of shoot growth

Shoot producing ability shows considerable differences among cultivars. And of course it is affected by crown structure too. Large and long number of shoot produced by cultivars of ’Katalin’, ’Linda’, ’Germersdorfi 3’ and ’Rita’. Short and slight number of shoot produced by: ’Axel’, ’Stella’, ’Isabella’, ’Anita’, ’Cristallina’, ’Bigarreau Burlat’, ’Van’, and ’Sunburst’ **(Table 7).** Years has little or no effect in these specific indicators.

Maturity time and top bud closure date showed no connection as dynamics of shoot growth is genetically determined for cultivars.

Table 7. Shoot numbers and length of sweet cherry cultivars on trees with super spindle crown structure (Debrecen-Pallag, 2009-2011)

	Total shoot pc/branches cm^2			**Total shoot cm/branches cm^2**		
	2009	**2010**	**2011**	**2009**	**2010**	**2011**
'Bigarreau Burlat'	0,8	0,4	2,1	11,2	4,0	79,8
'Van'	1,4	0,7	1,3	21,0	22,4	50,7
'Germersdorfi3'	1,9	0,9	3,1	50,3	23,9	88,7
'Rita'	2,5	1,7	2,4	58,3	52,8	77,5
'Linda'	3,1	0,9	3,7	77,2	11,5	89,5
'Stella'	0,6	0,9	1,3	14,3	34,8	34,3
'Axel'	2,2	0,8	1,0	78,5	38,7	23,9
'Anita'		1,1	1,8		17,1	38,3
'Katalin'		1,8	1,5		76,7	41,7

'Isabella'		0,7	1,1		22,5	14,2
'Cristallina'		0,8	1,4		28,7	43,7
'Sunburst'		1,1	1,2		37,6	32,0
mean	**1,8**	**1,0**	**1,8**	**44,4**	**30,9**	**51,2**

Empty cell: no data

A Duncan test **(Table 8)** produced 5 groups of the cultivars according to their shoot length. The test showed clear significant differences among cultivars.

Table 8. Grouping of sweet cherry cultivars according to their shoot length (Duncan-test, Debrecen-Pallag, 2009-2011)

Duncan [a,b,c]	Isabella	12	19,0000				
	Linda	46	22,6739	22,6739			
	Axel	18	24,9444	24,9444	24,9444		
	Katalin	14		30,0000	30,0000	30,0000	
	Anita	17		31,8824	31,8824	31,8824	
	Sunburst	23			34,2609	34,2609	34,2609
	Stella	32			34,9688	34,9688	34,9688
	Rita	54				36,9815	36,9815
	Germersdorfi 3	25				37,0400	37,0400
	Bigarreau B.	16				37,3750	37,3750
	Cristallina	12				37,5833	37,5833
	Van	32					43,5938
	Sig.		,245	,080	,062	,185	,095

Means for groups in homogeneous subsets are displayed

On the sampled shoots, increasing shoot number results in longer shoots in both crown structure types **(Figure 6).** Thus sweet cherry cultivars with abundant branching capacity have longer shoots while with less abundant branching capacity has shorter shoots.

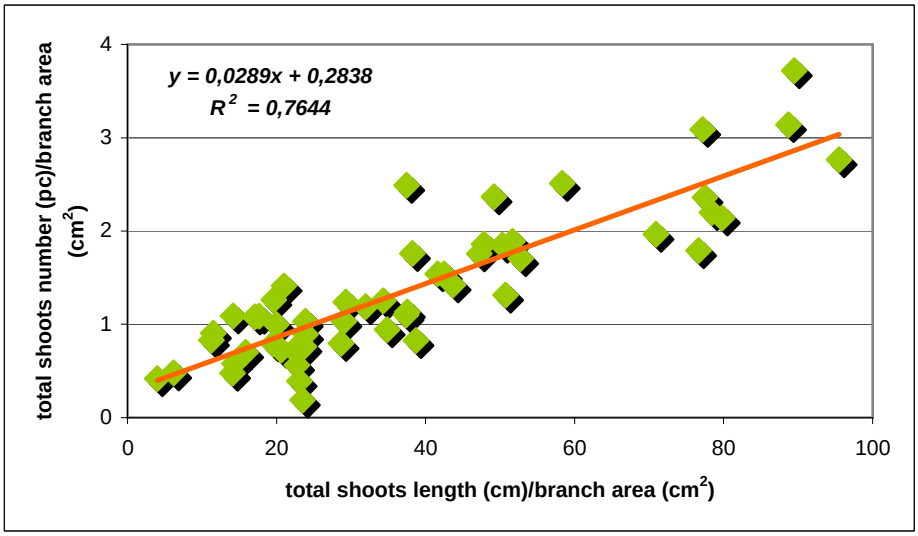

Figure 6. Connection between shoot number and shoot length (Debrecen-Pallag, 2012)

Vegetation activity of different aging of crown parts of sweet cherry cultivars

Incidence and number of short (posy producing part) and long (shoot) plant parts are various in different aging of crown parts **(Figure 7).** These are characterizing well their activity and rejuvenation capacities.

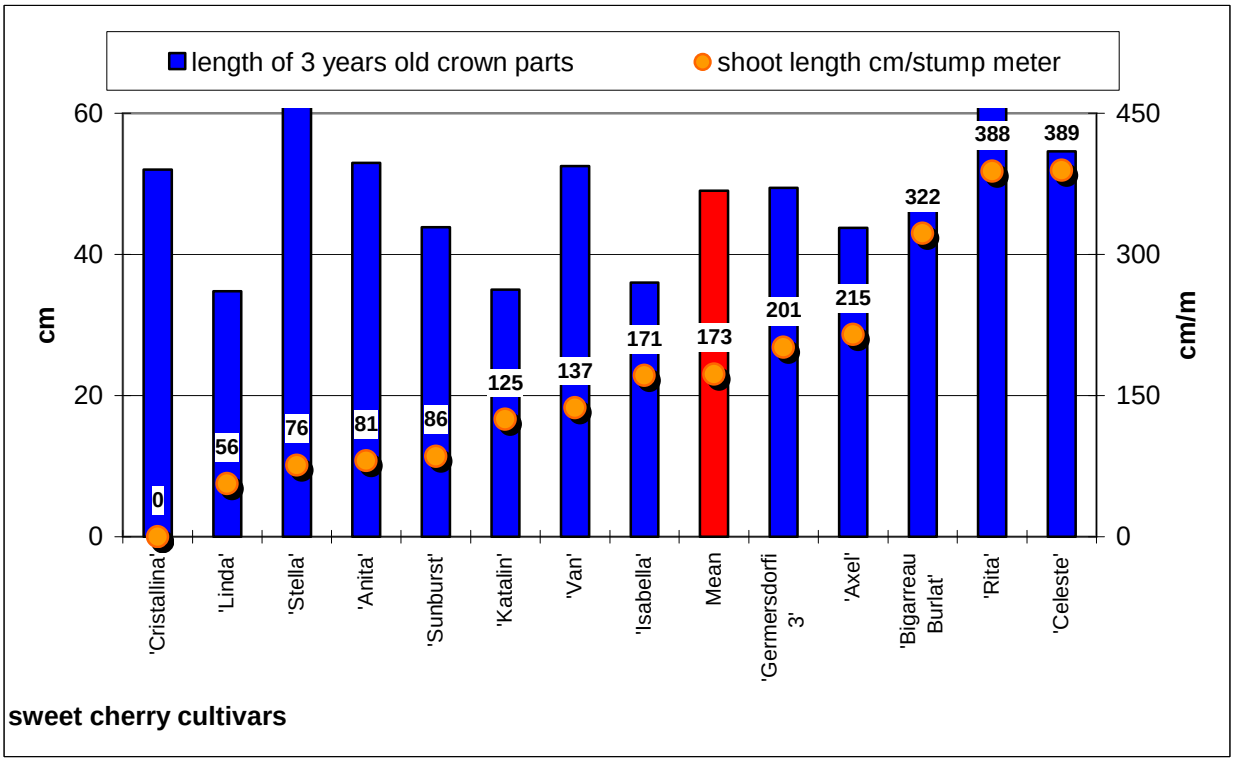

Figure 7. Shoot length and branching length of three years old crown parts of sweet cherry cultivar (Debrecen-Pallag, 2008-2011)

Considering 2-4 years old plant parts, large numbers of shoot are produced by cultivars ’Katalin’, ’Celeste’, ’Linda’ and ’Rita’, while long shoot was produced by cultivars ’Celeste’, ’Rita’ and ’Cristallina’. On 2-4 years old plant parts, low numbers and short shoots are produced by cultivars ’Anita’ and ’Stella’. Various vegetation activity of different aging of crown parts was observed on other cultivars.

Regeneration features of sweet cherry cultivars on various aging of crown parts

Not only growth characteristics but bolding activity and rejuvenation ability are also different among cultivars. In intensive production we have to take into consideration the

utilization of the tree area and we have to replace the old nonproductive plant parts. In **Figure 8.**, the second year effect of the pruning to snag is shown (see materials and methods). These long regenerative growth parts are more valuable as they are able to replace the old nonproductive plant parts.

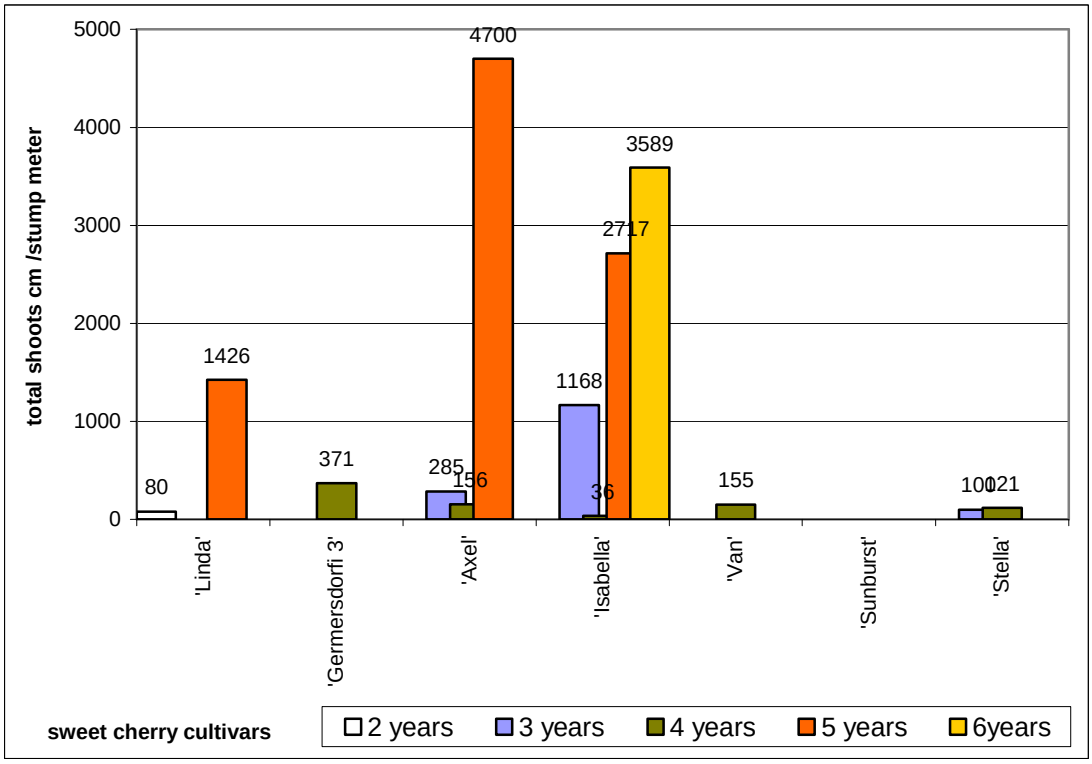

Figure 8. Rejuvenation of various aging plant parts of sweet cherry cultivars according to total length of shoots in 2010 (Debrecen-Pallag, 2010)

According to our study, 3-5 and 6 years old crown parts of cultivars ’Axel’ and ’Isabella’ **(Figure 9.),** while the 4 years old crown parts of cultivars ’Van’ and ’Germersdorfi 3’ were able to rejuvenate. All other cultivars produced only short shoots **(Figure 10.).**

Figure 9. Cultivar ’Isabella’ is nonviable on 3-6 years old plant parts (Vaszily)

Figure 10. Cultivar ’Sunburst’ is able to rejuvenate (Vaszily)

Numbers of solitary buds on various aging crown parts

Increasing numbers of laterals will increase the number of buds too. However, there are large differences among cultivars in these features **(Figure 11.)**

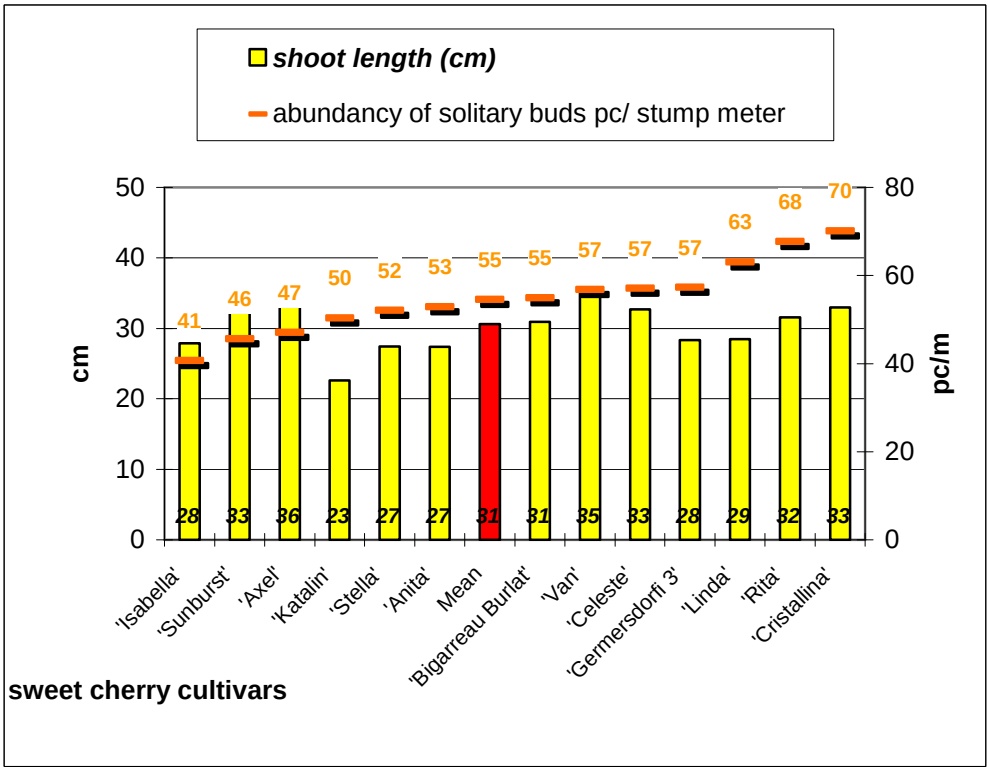

Figure 11. Density of solitary buds on sweet cherry shoots (Debrecen-Pallag, 2008-2011)

Apart from shoots, on the two years old parts cultivars ’Rita’, ’Celeste’, ’Bigarreau Burlat’ and ’Cristallina’, while on the three years old parts cultivars ’Stella’, ’Bigarreau Burlat’ and ’Celeste’ produce low number of buds. Density of solitary buds is more a cultivar characteristics that is slightly influenced by crown structure. Summer pruning has an effect on super spindle crown structure when the bases of these features are removed.

Specific plant part production on various aging crown parts of sweet cherry cultivars

On 2-3 years old crown parts, abundancy of posy production plant parts are significantly different.

Table 9. Specific density of 2 years old crown parts of sweet cherry cultivars (Debrecen-Pallag, 2009-2011)

Duncan[a,b,c]

		Subset							
fajta	N	1	2	3	4	5	6	7	8
Katalin	27	7,8209							
Linda	130	9,8717	9,8717						
Rita	67		12,0937	12,0937					
Cristallina	47		12,6325	12,6325	12,6325				
Stella	38		13,0207	13,0207	13,0207	13,0207			
Sunburst	59		13,1860	13,1860	13,1860	13,1860	13,1860		
Isabella	43		13,4765	13,4765	13,4765	13,4765	13,4765	13,4765	
Germersdorfi 3	121			14,5855	14,5855	14,5855	14,5855	14,5855	
Axel	124				16,2502	16,2502	16,2502	16,2502	16,2502
Van	75					16,8581	16,8581	16,8581	16,8581
B Burlat	51						17,2317	17,2317	17,2317
Anita	48							17,3650	17,3650
Celeste	39								18,8100
Sig.		,262	,085	,241	,084	,065	,051	,062	,218

Table 10. Specific density of 3 years old crown parts of sweet cherry cultivars (Debrecen-Pallag, 2009-2011)

Duncan[a,b,c]

		Subset		
fajta	N	1	2	3
Linda	48	3,4379		
Isabella	16	4,1445		
Katalin	14	5,5857	5,5857	
Rita	26	6,9116	6,9116	6,9116
Anita	14	7,6102	7,6102	7,6102
Germersdorfi 3	60	8,0941	8,0941	8,0941
Stella	20		9,2850	9,2850
Sunburst	22		9,3675	9,3675
B Burlat	25		9,7288	9,7288
Axel	50		9,8178	9,8178
Cristallina	19		9,8583	9,8583
Van	25		10,5421	10,5421
Celeste	23			11,2046
Sig.		,059	,055	,100

Abundancy of posy production parts specified to laterals **(Figure 12.)** shows the 'activity' of solitary buds, i.e. the ability to create short production plant parts.

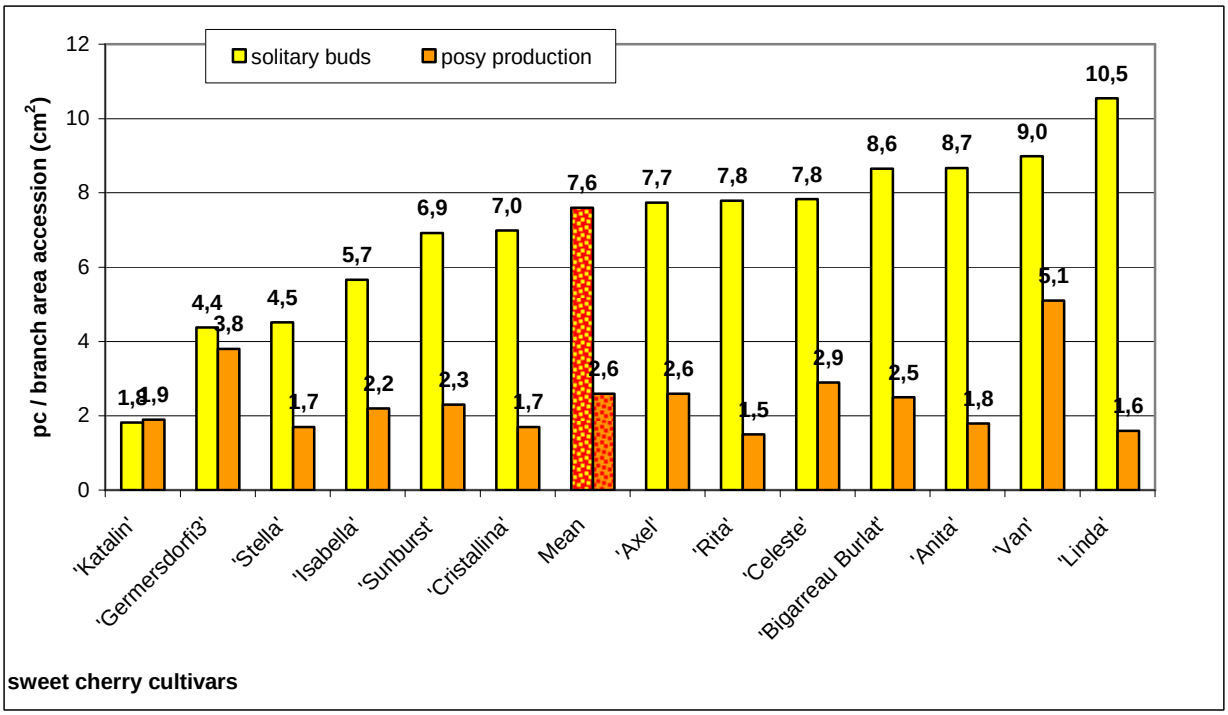

Figure 12. Specific production part capacity in the mean of crown structure and years for sweet cherry cultivars (Debrecen-Pallag, 2008-2011)

Many solitary buds and little posy production parts, i.e fast aging tendency, week regeneration features can be seen on cultivars ’Linda’, ’Anita’, ’Rita’, ’Cristallina’, and ’Bigarreau Burlat’. Many solitary buds and many posy production parts, i.e optimal balance can be seen on cultivars ’Van’, ’Celeste’ and ’Axel’. Little solitary buds and many posy production parts, i.e. optimal balance can be seen on cultivar ’Germersdorfi 3’. Little soltary buds and little posy production parts, i.e. fast aging tendency can be seen on cultivar ‘Stella’, ’Katalin’, ’Isabella’, ’Sunburst’.

In such years, those cultivars are excellent or weak which are genetically determined. Thus years have little effect on the genetically determined features of production plant parts

According to above, two categories can be made. One is less or not sensible to years: ’Celeste’, ’Cristallina’, ’Linda’, ’Rita’, ’Germersdorfi3’, ’Anita’, and ’Katalin’. And those which are influenced by years such as cultivars ’Stella’, ’Isabella’, ’Van’, ’Bigarreau Burlat’, ’Axel’, ’Sunburst’. There were no differences among crown structure.

Flower formation and fruit set of sweet cherry cultivars on different aging crown parts

High fruit set can be observed on 1-4 years old plant parts on cultivars ’Axel’, ’Cristallina’, ’Stella’ and ’Isabella’, while fruit set is low on cultivars ’Sunburst’ and ’Rita’. Fruit set is more cultivar specific which are not influenced by crown structure but the years are.

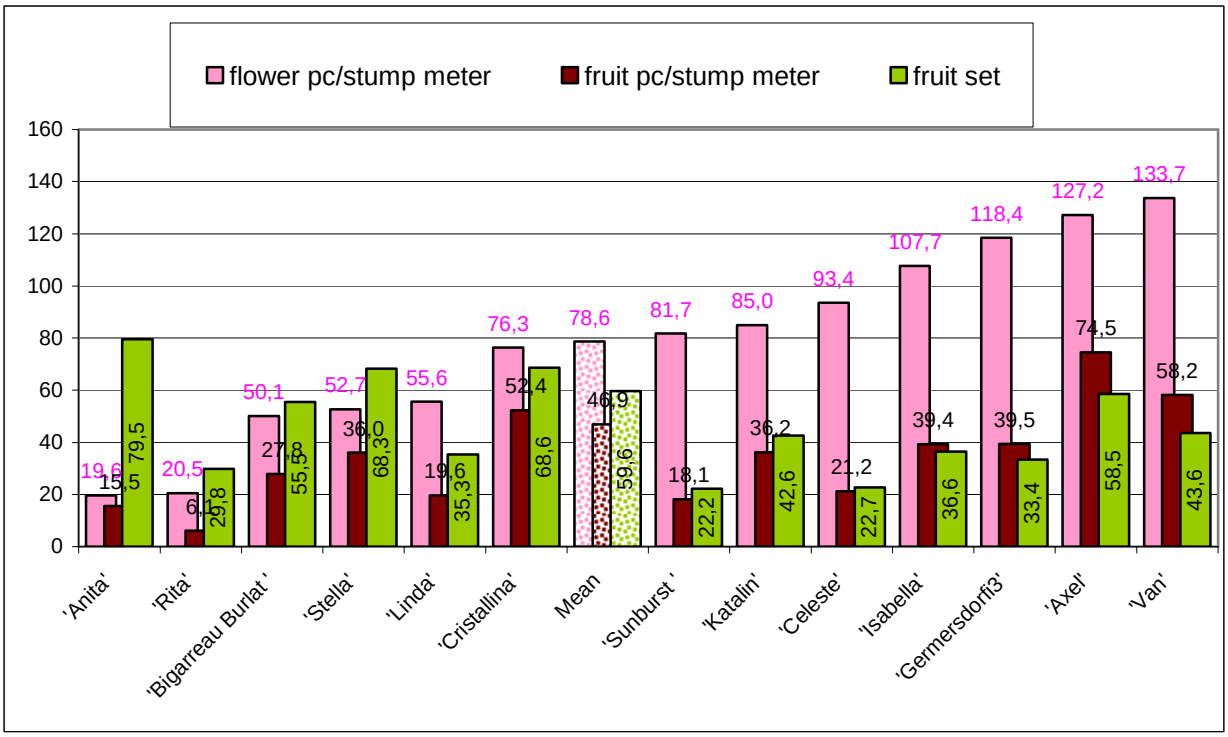

Figure 13. Numbers of flower and fruit set on three years old crown parts of sweet cherry cultivars depending on crown structure and years (Debrecen-Pallag, 2009-2011)

Flower content of flower buds of sweet cherry cultivars

Cultivars can be sorted to the following group: 4 flower initials in each of the flower buds such as cultivars ’Rita’ and ’Germersdorfi 3’. 3 flower initials in each of the flower buds such as cultivars ’Anita’, ’Cristallina’, ’Isabella’, ’Van’, ’Axel’, ’Katalin’, ’Stella’ and ’Linda’. 2 flower initials in each of the flower buds such as cultivars ’Celeste’, ’Bigarreau Burlat’ and ’Sunburst’. Thus flower content of flower buds of sweet cherry cultivars are genetically determined.

On posy production parts, cultivars can be sorted into three groups. **Above 5:** ’Germersdorfi 3’, ’Rita’, **between 4 and 5** ’Anita’, ’Cristallina’, ’Van’, ’Linda’, ’Isabella’, ’Axel’, and **between 3 and 4** ’Celeste’, ’Katalin’, ’Stella’, ’Sunburst’, ’Bigarreau Burlat’.

Posy production parts for each flower bud can also be sorted into three groups. **Above 3:** ’Germersdorfi 3’, ’Rita’, ’Anita’, ’Cristallina’, ’Isabella’, ’Van’, **3**: Axel’, ’Linda’, **2**: ’Stella’, ’Katalin’, ’Celeste’, ’Bigarreau Burlat’, ’Sunburst’.

Due to larger space, free spindle crown form receives more light than super spindle, therefore larger flower numbers can be seen within the buds.

2009 and 2011 were favorable to flower production (lot of sunshine, little precipitation) while 2010 was not (cold spring, lot of rain), therefore in this year the number of flowers were lower.

In **Table 11**., cultivars significant differences can be seen on numbers of open flowers on posy production plant parts by Duncan test (5 categories).

Table 11. Numbers of open flowers on posy production plant parts of various sweet cherry cultivars (Debrecen-Pallag, 2009-2011)

Duncan

Fajta	N	Subset				
		1	2	3	4	5
Rita	82	4,17				
BBurlat	253	4,57	4,57			
Anita	101	5,59	5,59			
Sunburst	202	5,66	5,66			
Van	407		6,08	6,08		
Cristallina	125			7,32	7,32	
Celeste	67			7,51	7,51	
Stella	96				7,88	
Katalin	78				8,24	
Isabella	88					10,74
Linda	129					10,74
Germersdorfi 3	467					10,96
Axel	331					11,90
Sig.		,069	,066	,071	,267	,160

Frost damage on various crown structure of sweet cherry cultivars

Super spindle showed less winter frost damage compared to free spindle trees as these trees are more protected due to density of trees **(Figure 14).**

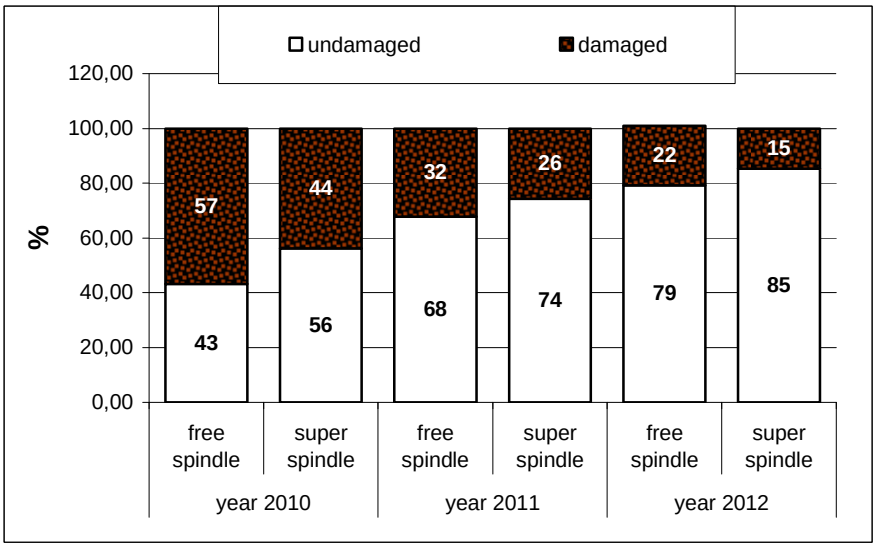

Figure 14. Degree of winter frost damage depending on crown structure and years (Debrecen-Pallag, 2012)

Winter frost damage was the most serious in 2010 and the other two years was more slight. The larger frost damage in 2010 was probably due to stronger summer pruning. This gives the advice that weaker summer pruning are advised and it is recommended to perform during flower-bud differentiating period. 3 summer pruning in 2009 was to intensive activity on super spindle crown format.

Frost sensitivity of cultivars can sorted into four groups **(Table 12.).**

Table 12. Winter frost sensitivity of sweet cherry cultivars (Debrecen-Pallag, 2009-2012)

Degree of winter frost damage (%)			
Below 10 %	**10-30 %**	**31-50 %**	**Above 51 %**
’Celeste’	’Axel’ ’Isabella’ ’Linda’ ’Stella’ ’Sunburst’ ’Van’	’Anita’ ’Cristallina’ ’Germersdorfi 3’ ’Katalin’	’Bigarreau Burlat’ ’Rita’

Fruit quality comparison of sweet cherry cultivars

Shape and regularity index

Figure 15. Shows the strong connection between fruit width (diameter) and weight of 13 sweet cherry cultivars SOLTÉSZ (1997).

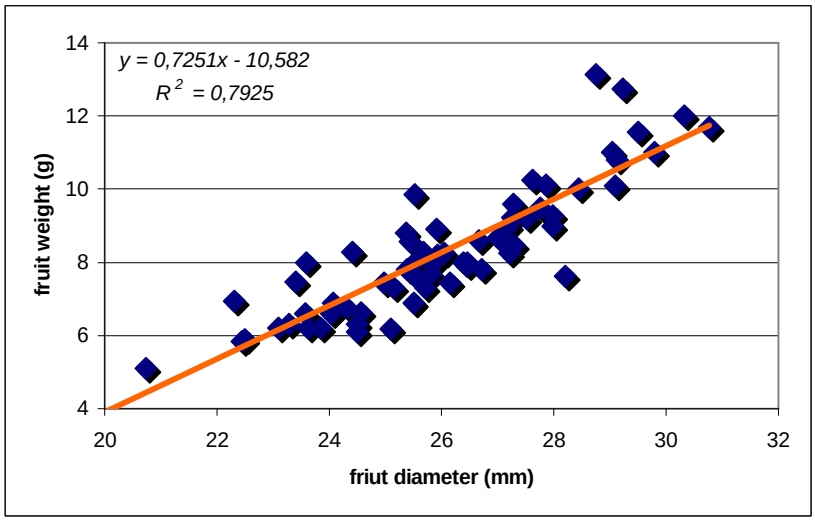

Figure 15. Connection between fruit width (diameter) and weight of 13 sweet cherry cultivars (Debrecen-Pallag, 2012)

Shape index of ’Van’ and ’Rita’ is depressed while all other cultivars were spherical. Regularity index of all cultivars was laterally flattered.

Cultivar, crown structure, years and fruit quality connections

Cultivars ’Van’, ’Celeste’, ’Rita’ and ’Linda’ produced larger fruit while cultivar ’Sunburst’ lower fruit size on the studied crown structure and years compared to literature data. Fruit size and weight were not considerably affected by crown structure. ’Celeste’ was the most sensitive to this feature.

Years had also less influence on fruit size and weight as these features are genetically determined.

Connection among fruit quality, fruit quantity and rain protective foil covering

Partial foil covering has positively influenced fruit size and fruit inner content **(Figure 16).**

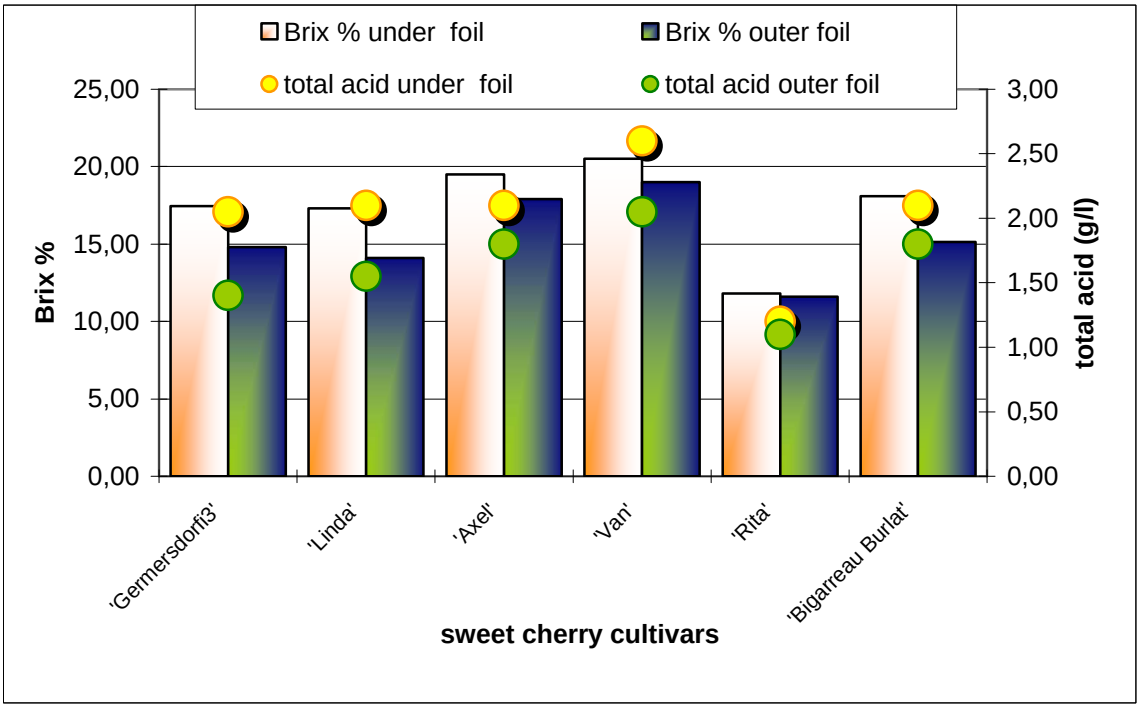

Figure 16. Inner content of sweet cherry cultivars under and outer rain protective foil coverage (Debrecen-Pallag, 2010-2011)

Partial foil covering increased yield of cultivars ’Germersdorfi 3’, ’Linda’ and ’Rita’ **(Table 13).** However larger cumulative temperature reduced the size of cultivars ’Axel’, ’Van’ and ’Bigarreau Burlat’. In rainy years (2010), foil covering had a significantly better effect on yield. Large amount of rain cause frit cracking and brown rot of fruit.

Table 13. Yield of sweet cherry cultivar on super spindle crown structure under and outer rain protective foil coverage (Debrecen-Pallag, 2012)

Sweet cherry cultivars	2009		2010		2011	
	Under foil	Outer foil	Under foil	Outer foil	Under foil	Outer foil
	t/ha					
'Linda'	*23,0*	*25,5*	*23,2*	*9,0*	*32,5*	*18,0*
'Axel'	*26,5*	*31,5*	*15,0*	*monilia*	*17,3*	*23,6*
'Rita'	*Bird damage*	*Bird damage*	*Bird damage*	*Bird damage*	*16,9*	*13,3*
'Van'	*20,5*	*16,3*	*17,0*	*18,9*	*11,8*	*19,8*
'Germersdorfi 3'	*18,0*	*15,5*	*22,1*	*13,8*	*16,0*	*14,5*
'Bigarreau Burlat'	*8,8*	*4,0*	*5,3*	*7,2*	*6,3*	*8,9*

Yield performance of sweet cherry cultivars

Various groups can be made for the yield data on the two crown structure format **(Tables 14 and 15).**

Table 14. Yield grouping super spindle crown structure in the mean of three years results (Debrecen-Pallag, 2012)

cultivar	Fruit size	yield	
	diameter (mm)	kg/tree	t/ha
'Bigarreau Burlat'	25,5	**< 3**	**<7,5**
'Celeste'	25,3		
'Anita'	23,0	**3-5**	**7,5-12,5**
'Sunburst'	25,8		
'Isabella'	24,9	**5-8**	**12,5-20**
'Germersdorfi 3'	**28,7**		
'Katalin'	**27,8**		
'Cristallina'	**26,5**		
'Rita'	**26,5**		
'Van'	25,7		
'Linda'	**27,0**	**8-10**	**>20**
'Axel'	24,3		
'Stella'	23,1		

Table 15. Yield grouping free spindle crown structure in the mean of three years results (Debrecen-Pallag, 2012)

cultivar	Fruit size	yield	
	diameter (mm)	kg/tree	t/ha
'Celeste'	**30,8**	**<10**	**<10**
'Germersdorfi 3'	**29,0**	**10-20**	**10-20**
'Linda'	25,8		
'Rita'	25,2		
'Anita'	25,1	**20 <**	**>20**
'Axel'	23,4		

Great yield but small fruit size are characterized for cultivars ’Axel’ and ’Stella. Small yield but great fruit size are characterized for cultivars ’Celeste’ and ’Bigarreau Burlat’. Middle yield and great fruit size are characterized for cultivars ’Germersdorfi 3’, ’Katalin’ and ’Rita’.

On super spindle trees, great yield and great fruit size are characterized for cultivar ’Linda’, middle yield for ’Germersdorfi 3’, ’Cristallina’ and ’Rita’, while small yield for ’Sunburst’, ’Celeste’ and ’Bigarreau Burlat’.

On free spindle trees, great yield and great fruit size are characterized for cultivars ’Rita’, ’Linda’ and ’Germersdorfi 3’, while small yield for ’Celeste’.

New scientific results

- **Cultivars were sorted into four categories according to their degree of frost damage. The most frost resistant cultivar was ’Celeste’.**

- **Pistils are more damaged after dry and hot years compared to other flower parts.**

- **Increasing number of shoots on lateral twigs will increase the length of the soot too. Thus cherry cultivars with larger number of lateral shoots will produce longer shoots too.**

- **Timing of top bud closure for sweet cherry is not connected to the fruit maturity which feature is different forms other fruit species.**

- **Number of buds on production plant parts are not connected with shoot length as it can be considered as a genetically determined feature.**

- **Thick later twig (compared to central axis – Zahn index is high) such as ’Bigarreau Burlat’, ’Celeste’, ’Sunburst’ results in lower amounts of flowers in flower buds compared to those twigs which are thinner.**

- **Rejuvenation of older plant parts results in emergence of hided buds compared to rejuvenation of younger plant parts.**

Patent scientific results

- **Annually 2-3 times summer pruning increased frost sensitivity of cultivars.**

- **Super spindle crown type produces more and longer shoots than free spindle one. This can be explained by the different pruning methods of the two crown structure types.**

- **Abundancy of specific production plant parts on 2-3 years old crown parts are different on the cultivars, which suggest cultivar specific pruning methods.**

Practical usable results

- **Rain protective foil coverage resulted in positive fruit quality parameters.**

- **Cultivar ’Bigarreau Burlat’ on *Prunus mahaleb* rootstock was sensitive to high soil water and winter frost. Therefore plantation site is especially important for this cultivar-rootstock combination.**

- **Cultivar specific pruning strategy was developed based on features of 2-4 years old plant parts of sweet cherry cultivars.**

- **For high density production on super spindle crown structure on *Prunus mahaleb* rootstock the following cultivars are advised: ’Rita’, ’Linda’, ’Katalin’, ’Anita’, ’Stella’, ’Cristallina’, ’Germersdorfi 3’, ’Axel’.**

- **According to our results, on free spindle crown structured on *Prunus mahaleb* rootstock the following cultivars are advised: ’Bigarreau Burlat’, ’Celeste’, ’Sunburst’, ’Rita’, ’Linda’, ’Isabella’, ’Katalin’, ’Van’, ’Anita’, ’Stella’, ’Cristallina’, ’Germersdorfi 3’, ’Axel’.**

- **According to growth characteristics, continuous summer pruning advised for cultivars ’Rita’, ’Isabella’, ’Katalin’, ’Cristallina’,**

- **According to growth characteristics, summer pruning are slightly advised for cultivar: ’Linda’, ’Van’, ’Anita’, ’Stella’.**

- **According to growth characteristics, annually two (three) winter pruning are advised for cultivars ‘Bigarreau Burlat’, ’Katalin’, ’Sunburst’, ’Celeste’, ’Germersdorfi 3’.**

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