Fruit Quality of Sweet Cherry Cultivars Grafted on Four Different Rootstocks

Simon G., Hrotkó K. and Magyar L.

BUESPA, Faculty of Horticultural Science, Department of Fruit Science, 1118 Budapest, Villányi út 29–43., Hungary

Summary: A rootstock trial planted at the Szigetcsép experimental station in 1989 involved the study of two cultivars- 'Germersdorfi FL 45' and 'Van' -grafted on four different rootstocks – 'Colt', 'MxM 14 – Brokforest', 'MxM 97 – Brokgrow' and 'Saint Lucie 64' as a control. The trees were trained to the "Modified Brunner-spindle" system and came into bearing in 1993. The yield per tree, fruit weight and fruit diameter have been measured each year since then. The refractivity, the acid content of the fruit juice, fruit cracking after four hours' dipping in water and stone weight ratio have also been measured since 1995. In 1997 and 1998 these parameters as well as fruit cracking after 24 hours' dipping were measured. Fruit firmness and fruit colour were also estimated. In almost every observed parameter significant differences were found between the scion cultivars. Yield efficiency was significantly higher on 'MxM 14' and 'Saint Lucie 64' than on the other two rootstocks. As regards fruit weight, in both cultivars and over an average of six years, it was found that trees on low yielding tree on 'Colt' rootstock had the highest fruit weight values and on heavy producing 'MxM 14' the smallest. Soluble solids content was higher on 'Colt' and 'MxM 97'. No significant differences between the rootstocks were found in acid content of the fruit juice. There were significant differences between the rootstocks in fruit cracking after 4 and 24 hours' dipping in water. Seemingly with respect to cultivars and rootstocks the year has a considerable effect on fruit cracking.

Key words: acid content, Colt, fruit cracking, fruit weight, fruit load, fruit firmness, Mahaleb SL 64, MxMa 14, MxM 97, refractivity, rootstock effect

Introduction

One of the most important factors determining the fruit quality of sweet cherry is fruit size, because most consumers prefer large fruits. Since pit size is relatively constant, mostly depending on the cultivar (*G. Tóth & Auer,* 1996), larger cherries have proportionally more flesh (*Looney* et al., 1996).

Fruit quality indicators such as size, colour, soluble solids and firmness are highly influenced the position of the fruit on the tree, because fruit inside the tree is less mature and its quality is poorer, when compared with fruits from trees with conventional canopies. Smaller tree canopies, together with pruning and training strategies that maximize light penetration into the canopy, should reduce within-tree variability in fruit ripening (*Looney* et al., 1996). Fruit quality is also influenced by crop load; fruit from heavily cropping trees is less firm than fruit from lightly cropping trees (*Spayd* et al., 1986). Suitable dwarfing rootstocks for sweet cherries have only been selected recently. Over the next few years it will be necessary to determine the effects of these new rootstocks on fruit quality (*Looney* et al., 1996). Recent research conducted in Norway (*Cline* et al., 1995) showed that rootstocks can influence the water and sugar content of the fruits of several varieties of sweet cherry. Perry (1985) found that semi-dwarf 'MxM 14' and 'MxM 97' rootstocks reduced fruit size. Edin (1996) reported that 'Edabriz' and 'MxM 14' rootstocks resulted in significantly higher yield efficiency compared to the traditional mazzard clonal rootstock, 'F 12/1'. Likewise, with a suitable canopy and pruning system and with good nutrition the decreasing fruit size observed on dwarfing rootstocks can be reduced or even eliminated.

Material and method

In 1989, 'Germersdorfi FL 45' and 'Van' cherry cultivars were planted on four different rootstocks at the "Szigetcsép Experimental Station" of Faculty of Horticulture, Budapest. The soil is sandy loam, with a high lime content (16.95%); humus is low (1.2%) and pH: 7.8–8.2. Average meteorological characteristics over the past 10 years (1991-2001) were: average yearly temperature: 11.39C, total sunshine: 2093 hours/year, and rainfall: 566 mm/year. Trees were irrigated with a total of about 100–120 mm water per year. Trees were grafted on the moderately-vigorous 'Colt', on the semi-dwarfing 'MxM 14' and 'MxM 97' rootstocks; a vigorous *Mahaleb* rootstock, 'SL 64', was used as a control. These trees were planted at a spacing of 7×4 m and were trained to the "Modified Brunner-spindle" (*Hrotkó* et al., 1997, 1998).

Data in this trial have been collected since 1993, when trees first began to bear fruits. To assess fruit weight, average fruit samples of 12 kg were collected from trees on the same rootstocks and, following the sampling procedure, 4×100 fruits were selected and the 100-fruit samples weighed. The largest diameter of the fruits was measured on 4×30 fruits, then after removing their pits the weights of pits (stones) were also measured.

The soluble solids content of the juice squeezed from the 4×30 fruit samples was measured with a MOM®-type refractometer, while total acidity was calculated by titrating with 0.1 N NaOH, and expressed as maleic-acid equivalent (gl^{-1}).

The cracking tendency was estimated by dipping the fruits, and 4×30 fruits were immersed in water for 4 hours, then cracked fruits were counted. In 1997 and 1998, the cracking ratios after 4 and 24 hours dipping were also calculated.

To measure firmness and skin strength a "QB-129" -type fruit examinator was used; 4×50 fruits from trees of the same rootstock were measured (data are in N/cm^2). 4×50 fruit samples were harvested from each rootstock to assess colour by visual ranking on a scale from one to five.

Cumulative yield efficiency (CYE) was evaluated through yield (kg)/canopy volume (m^3). In 1996 and 1997, the yield was hardly affected by the weather conditions: in 1996 it was cold and rainy during blooming time of 'Germersdorfi FL 45'; in 1997 yield was reduced by frost damage on both varieties.

Collected data and yield/canopy volume results were statistically analysed using a Statgraf Ver. 5.1. one way analysis of variance. The relationship between yield/canopy volume and fruit weight was examined using a regression analysis.

Results

Detailed data on fruit quality are included in *Tables 1* and *2*. The results show *(Table 1)* that yield efficiency per canopy volume was higher with 'Van', more than twice that recorded with 'Germersdorfi FL 45', but the weights and the diameters of the fruits were higher with 'Germersdorfi FL 45'. There were no differences between the observed cultivars in the stone weight ratio. Significant differences were found between the two cultivars in the soluble solids and acid content of the fruit juice and the cracking percentage after dipping. The soluble solids and acid content of the fruit juice was higher with 'Van'. The cracking percentage after 4 hours' dipping was higher with 'Germersdorfi'. The extraordinarily high cracking percentage (54.5%, three times higher than 'Germersdorfi') of 'Van' after 24 hours' dipping is worthy of note. No significant differences occurred with fruit colour. 'Germersdorfi' had significantly higher firmness in comparison with 'Van'.

When analysing the results of rootstocks by averaging the results from both cultivars *(Table 2)*, significant differences were shown in CYE by CV (kg/m^3), in the soluble solids content of the fruit juice and in the cracking percentage after dipping in water. Trees on 'SL-64' and 'MxM 14' had significantly higher CYE values than trees on the other rootstocks. The soluble solid content of the fruit juice was higher on 'Colt' and 'MxM 97' than on the other rootstocks. It was strange that, after 4 hours' dipping, fruits harvested from trees on 'MxM 97' had the highest cracking ratio and 'Colt' had the lowest value; however, after 24 hours' dipping the opposite trend was observed, 'Colt' had the highest and 'MaxMa 97' the lowest fruit cracking ratio. *(Table 2)*. There were no differences in the size and firmness of the fruits harvested from trees on the different rootstocks.

Differences between the data on fruit weight (*Table 3* – presented separately for cultivars and rootstocks) and yield (*Table 4* – presented separately for cultivars and rootstocks)

Table 1 Effect of cultivars on cherry fruit quality expressed as averages

Cultivar	Cumulative yield efficiency of CV (g/m^3)*	Fruit weight (g) *	Fruit diameter (mm) **	Stone/fruit weight ratio (%) **
Van	693 b	7.1 a	20.01 a	5.49 a
Germersdorfi óriás	534 a	8.8 b	23.33 b	6.34 a

Cultivar	Soluble solid content (%) **	Acid content (g/l) **	Fruit cracking after 4 hours (%) **	Fruit cracking after 24 hours (%) ***	Fruit colour (1–5) ***	Fruit firmness (N/cm^2) ***
Van	18.20 b	1.44 b	2.13 a	54.52 b	4.65 a	2.62 a
Germersd. óriás	17.58 a	1.13 a	7.11 b	17.48 a	4.95 a	3.14 b

*average of 6 years (1993–98)
**average of 4 years (1995–98)
***average of 2 years (1997–98)of all rootstocks

Table 2 Effect of rootstocks on cherry fruit quality expressed as averages of two scion cultivars

Rootstocks	Cumulative yield efficiency of CV (g/m^3)*	Fruit weight (g) *	Fruit diameter (mm) **	Stone/fruit weight ratio (%) **
SL64	704.24 b	7.79 a	22.57 a	5.58 a
Colt	518.84 a	8.04 a	22.98 a	6.34 a
MxM 97	547.01 a	7.74 a	23.58 a	5.91 a
MxM 14	683.88 b	7.65 a	22.55 a	6.04 a

Rootstocks	Soluble solid content (%) **	Acid content (g/l) **	Fruit cracking after 4 hours (%) **	Fruit cracking after 24 hours (%) ***	Fruit colour (1–5) ***	Fruit firmness (N/cm^2) ***
SL64	17.67 a	1.17 a	4.18 ab	37.66 ab	4.80 a	2.62 a
Colt	18.29 b	1.39 a	2.85 a	40.85 b	4.72 a	2.82 a
MxM 97	18.02 b	1.36 a	6.30 b	27.81 a	4.84 a	2.96 a
MxM 14	17.60 a	1.23 a	5.20 ab	37.68 ab	4.82 a	2.78 a

* average of 6 years (1993–98)
** average of 4 years (1995–98)
*** average of 2 years (1997–98)

Table 3 Annual variations in mean individual fruit weight (Szigetcsép, 1993–1998)

Rootstocks	Fruit weight (g) Year 1993		1994		1995		1996		1997		1998		Average of six bearing years	
Van														
SL 64	6.80	a	7.88	a	7.44	a	5.19	ab	8.01	b	7.11	c	7.07	ab
Colt	7.25	c	8.98	b	8.41	b	5.01	a	7.84	b	7.06	c	7.42	b
MxM 14	7.05	b	7.88	a	7.66	ab	5.58	b	7.22	a	6.66	b	6.89	a
MxM 97	6.95	ab	8.10	a	7.85	ab	5.10	a	6.92	a	5.73	a	6.85	a
Germersdorfi óriás														
SL 64	8.25	a	10.83	d	7.92	a	8.90	b	7.66	a	7.42	c	8.49	b
Colt	9.07	b	10.08	c	8.46	a	8.43	b	8.21	a	7.61	c	8.64	b
MxM 14	8.5	a	8.53	a	8.28	a	8.48	b	7.72	a	6.87	b	8.06	a
MxM 97	8.5	a	9.38	b	9.36	b	7.25	a	7.73	a	6.29	a	8.08	a

Table 4 Yields of cherry trees at Szigetcsép. (Yield, kg/tree; Cumulative yield per tree in 1998, kg/tree. Cumulative yield efficiency per unit TCSA, g/cm^2)

Rootstocks	Yield (kg/tree) Year 1993		1994		1995		1996		1997		1998		Cumulative yield (kg/tree)		Cumulative yield efficiency per TCSA (g/cm^2)	
Van																
SL 64	4.84	c	20.02	c	21.00	d	23.57	b	9.18	b	11.30	b	90.09	c	560	c
Colt	2.01	a	7.97	a	10.88	b	13.10	a	7.80	b	10.40	ab	52.25	ab	348	a
MxM 14	3.80	bc	14.27	b	15.27	c	12.96	a	4.60	a	7.90	a	45.48	a	496	b
MxM 97	3.11	ab	11.70	b	5.89	a	12.37	a	4.51	a	850	ab	59.48	b	626	d
Germersdorfi óriás																
SL 64	0.68	b	10.94	b	11.50	c	0.17	a	8.23	b	15.00	bc	46.52	b	295	a
Colt	0.08	a	6.66	a	6.36	ab	2.33	a	4.86	ab	17.00	c	37.29	b	425	c
MxM 14	0.46	ab	5.71	a	8.99	bc	2.38	a	6.13	ab	10.50	a	20.09	a	342	b
MxM 97	0.25	ab	2.31	a	4.57	a	0.10	a	2.36	a	11.90	ab	35.57	ab	284	a

per tree varied each year. On average there were significant differences between fruit weight of trees on different rootstocks over six producing years. The tendency was the same on both cultivars, but with a different degree of difference in the absolute values. Fruits harvested from trees on 'Sl-64' and 'Colt' were larger in size than fruits on the 'MxM' rootstocks.

Discussion

Regular high yields were produced by the 'Van' sweet cherry cultivar: on an average of five producing years the yield efficiency was significantly higher for 'Van' than for the cv. 'Germersdorfi FL 45'. Average fruit weights and diameters were larger than those published by *Brózik* (1982) on both varieties, which may partly be explained by the young bearing branches present in this type of canopy. Fruit weights and diameters were significantly higher with 'Germersdorfi', which is a characteristic of the cultivar, but the usually low yield of the cultivar may be a contributary factor with this cultivar. According to our measurements the soluble solids content and total acidity of the fruit juice of the 'Van' cultivar was significantly higher than that of 'Germersdorfi'. Total acidity of fruits of the 'Van' cultivar was lower than that found by *Dolenc & Stampar (*1998), possibly because of differences in site conditions. Flesh and skin firmness were lower with 'Van' fruits compared to 'Germersdorfi óriás FL 45', which may be the result of Van's weaker skin (*Proebsting & Murphey* 1987), but with our equipment ("QB-129"-type fruit examinator) this cannot be measured separately.

Note the quite different cracking percentages of the two varieties after dipping for various periods of time in water; more detailed studies on these data should be carried out in the future. With respect to cultivars, the fruit cracking percentages of cultivar 'Germersdorfi' was much lower than that found by *G. Tóth & Auer* (1996). They also proved that the year has a considerable effect on fruit cracking.

Cumulative yield (kg/tree) was significantly higher on 'SL 64' and 'MaxMa 14' rootstocks but the cumulative yield efficiency (kg/m^3) shown the same tendency only on 'Van' trees. Fruit size changed each year due to the effects of the rootstocks – *Perry* (1985) reported the same results. On an average of 6 years, fruit size was significantly larger on rootstocks with stronger growth vigour but the difference was not very large, a maximum of 0.5 g. No significant differences were observed one year previously, in our analysis of the average of 5-year's data. This is presumably the effect of the training system and pruning, which confirms *Edin's* (1996) opinion in this respect. Tree size reducing rootstocks usually produce high yields per tree ('MxM 14', 'MxM 97') and decrease the size of the fruits, but this effect is often the reverse in certain years, thus year effects hide and compensate for this decrease. This also means that this trend can be overcome or decreased with implementation of a suitable training system, and optimum fertilization and irrigation.

Our results proved that the ratio of total fruit to stone fresh weight is a stable characteristic of the cultivar (*Looney* et al. 1996), and that rootstocks do not influence this index.

The rootstocks affected the fruit flesh firmness in different ways on different cultivars. The firmest fruits of 'Van' were found on 'Colt' and the highly productive rootstock, 'MxM 14' (productivity similar to 'SL 64'). Fruits from 'Germersdorfi' trees were firmer on "MxM" rootstocks. With these results concerning the fruit load on trees on different rootstocks we can conclude that the findings of *Spayd* et al. (1996) concerning the relationship between heavy fruit load and decreased firmness of the fruit flesh are only partly true.

Our results confirm Loony's opinion that smaller tree canopies and pruning and training strategies that maximize light penetration into the canopy should reduce within-tree variability in fruit ripening (*Looney* et al., 1996).

Conclusion

Our results are in agreement with literature data and confirm the fruit quality characters of the tested cultivars 'Van' and 'Germersdorfi óriás' under conditions of modified Bruner-Spindle. Mean fruit weight varied from year to year with significant differences between the tested rootstocks, early changes are often in contrary direction. In average of six years the mean fruit weight is slightly larger on vigorous rootstock. The effect of rootstocks doesn't seem to be larger than other factors influencing fruit quality. Possible negative rootstock effect should be compensated by nutrition, irrigation, training and pruning.

To summarize, the final conclusion is that 'MxM' rootstocks, which decrease the growth of the trees, do not have statistically proven adverse affects on fruit quality based on the studies of six productive years.

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References

Brózik S. (1982): Cseresznyefajtáink. in Poór J.–Faluba Z. (szerk.) Cseresznye és meggy. Mezőgazdasági Kiadó, Budapest, 61–74.

Cline, J. A., Sekse, L., Meland, M. & Webster, A. D. (1995): Rain-induced fruit cracking of sweet cherries. I. Influence of cultivar and rootstock on fruit water absorption. Acta Agriculturae Scandinavica Series B 45, 213–223.

Dolenc, K. & Štampar, F. (1998): Determining the quality of different cherry cultivars using the HPLC method. Acta Hort. 468: 705–712.

Edin, M., Garcin, A., Lichou, J. & Jourdain, J. M. (1996): Influence of dwarfing cherry rootstocks on fruit production. Acta Hort. 410: 239–243.

G.Tóth, M. & Auer F. (1996): Pomological features of sweet cherry cultivars adapted from abroad. Acta Hort. 410: 25–33.

Hrotkó, K., Simon, G., Magyar, L. & Hanusz, B. (1997): Experiences with sweet Cherry Spindle Trees. Acta Hort. 451. 637–642.

Hrotkó, K., Simon, G. & Magyar, L. (1998): Modified Brunner-spindle as a training system for semi-intensive sweet cherry orchards. Acta Hort. 468. (2): 459–464.

Looney, N. E., Webster, A. D. & Kupferman, E. M. (1996): Harvest and handling sweet cherries for fresh market. Cherries: Crop Physiology, Production and Uses (Eds. Webster, A.D.& Looney, N.E.) Cab International, Wallingford, 411–442.

Perry, R. L. (1985): Progress with cherry rootstocks. Compact Fruit Tree 8: 107–108.

Proebsting, E. L. Jr & Murphey, A. S. (1987): Variability of fruit quality characteristics within sweet cherry trees in central Washington. HortScience 22: 227–230.

Spayd, S. E., Proebsting, E. L. & Hayrynen, L. D. (1986): Influence of crop load and maturity on quality and susceptibility to bruising of 'Bing' sweet cherries. Journal of the American Society for Holticultural Science 111: 678–682.