Impact of pruning time on tree vigour and productivity of three sweet cherry cultivars grown on two semi-dwarf rootstocks

J. Blažková, I. Drahošová

Research and Breeding Institute of Pomology Holovousy Ltd., Holovousy, Czech Republic

Abstract

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Tree pruning in two different terms (March and August) was applied in a sweet cherry orchard of Kordia, Těchlovan and Vanda cv. planted on Colt and P-HL-A rootstocks established in 1996 in the spacing 6 × 1.5 m. Tree vigour, yields and mean fruit weight were evaluated in this study in relation to the term of the pruning. The subject of this paper is the experimental orchard in the stage of full productivity and the study is a continuation of a previous publication focussed on its performance till 2005. The vigour of Kordia cv. trees on both rootstocks pruned in August was distinctly weaker. Trees of Těchlovan cv. on P-HL-A grew significantly stronger after pruning in August, whereas in the case of Vanda cv. this effect was found on the Colt rootstock. In comparison to the results from the first period of the study when specific productivity was mostly higher after tree pruning done in August, it is in the subsequent stage generally better to prune in the spring time. This change of tree response is evidently connected to a rate of tree ageing and the spring term of pruning probably compensates this development.

Keywords: tree-growth; time of pruning; yields; fruit weight

Trees in the range of modern growing systems of sweet cherries are kept on dense tree spacing in limited size of tree canopy thanks to regular strong pruning, despite being planted on vigorous rootstocks (Cordioli 2001; Tilkens 2001).

In the case of trees grafted on less vigorous rootstocks, pruning in the first years should be minimized; however, approximately from the fifth year of their age, stronger pruning is necessary for keeping the canopies in a restricted space as well as for preservation of sufficient fruit quality (Gutzwiler, Lang 2001).

Pruning of sweet cherries is most frequently practiced in two well-proven terms. The first one is during their dormancy, but regarding to its impact on the health status of trees, a short period just before tree budbreak is the best (Lang 2001). The second most frequently used term is a period after fruit harvest, usually taking place during August (Link 1992).

Effectiveness of summer pruning is significantly influenced by characteristics of cultivars. The effect on fruit production is positive when summer pruning is applied alone in alternate years (Roversi et al. 2008). According to Clements (2006) vigour and other performances of sweet cherry trees are mainly dependant on the rootstock used. Besides the dwarfing effect of the given rootstock, also planting density is important. This density affected growth reduction the most in trees planted in very small spacing because of the greater competition, mainly on the semi-dwarfing rootstocks (Santos et al. 2008).

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In the case of trees on semi dwarf rootstocks planted in higher densities, the tree training system is also important. In some studies, the slender spindle and the V systems had the best combination of high yield, fruit size and fruit quality (Robinson et al. 2008; Cantín et al. 2010). This system of tree training is very important especially for Kordia cv. (Gonkiewicz 2011).

The main aim of this study was a comparison of two terms of tree pruning regarding their influence on vigour and yields of the trees as well as on size of their fruits using three sweet cherry cultivars planted in a dense spacing on two rootstocks characterized by different tree vigour. This paper is a continuation of our preliminary study of the different terms of pruning applied during the first years of an experimental orchard (Blažková, Hlušičková 2005) and is focused on evaluating the effects of these treatments during the later stage of the orchard.

MATERIAL AND METHODS

Experimental orchards were established in Holovousy (altitude 280 m, mean year temperature 8.1°C, sum of annual rainfall 655 mm, loamy soil) in spring 1996. Two-year old tree cvs Kordia, Těchlovan and Vanda grafted on Colt and P-HL-A rootstocks were planted in the spacing of 6 × 1.5 m. The Colt rootstock in dry conditions induces tree vigour of about 20–30% weaker than on Mazzard (Webster et al. 1996). On the P-HL-A rootstock tree vigour is about 70–80% weaker (Kloutvor, Paprštein 1999). All cultivars belong to the Mazzard sweet cherry groups; weakly growing cv. Vanda ripens in the 4th sweet cherry week, cv. Těchlovan harvested in the 5th cherry week possesses a tree vigour from medium to strong and cv. Kordia ripens in the 6th cherry week and its trees are vigorous.

The soil surface in the orchard was kept clean by initial cultivation and since that time onwards clean herbicide strips were kept under trees and by cutting grass between them. The orchard was not irrigated.

Trees were cut back about two-thirds after planting and competitive shoots were removed if necessary. Later on, no pruning or training was applied till 2000. In that time only tree growth variability induced by different rootstocks and cultivars were evaluated (Blažková 2001).

Since the year 2001 two different terms of tree pruning were applied. The first variant was tree pruning done just before the start of the vegetation season at the end of March to the beginning of April. The second variant was pruning done after fruit harvest in August during the first decade. Trees were pruned by hand always in the same intensity based on principles of Zahn's system of tree pruning (Zahn 1988, 1991).

Every combination of cultivar, rootstock and time of pruning was replicated on 10 trees. The initial results from the period till 2005 were published (Blažková, Hlušičková 2005). In 2005 all trees were pruned in August. Therefore, in 2006 values on canopy size in March before pruning are missing. Since 2006 onward trees again were pruned in 2 terms. In this period, however, the number of replicated trees in each experimental combination was diminished to 5 because some trees had to be removed from the orchards due to infection by Prune dwarf virus (PDV).

Every year in the experimental orchard trunk cross-sectional area of trees at a marked place about 0.5 m above soil level was measured towards the end of September. Dimensions of tree canopy were measured always twice – before and after pruning. Values of fruit weight are based on weighing 25 fruits reaped from every evaluated tree and weight of tree harvest from all harvested fruits of the tree.

Significance of differences between assessed variants was assessed by the *t*-test.

RESUTS AND DISCUSSION

Tree vigour

This characteristic was evaluated in the five-year period based on the trunk cross-sectional area, and was in the mean significantly higher on the Colt rootstock. Upon this rootstock trees grew about 54% more vigorously than on the P-HL-A rootstock. Tree size in the total mean of cultivars was most significantly influenced by the term of pruning. This characteristic was nevertheless evidently influenced by climatic conditions of the given year. Trunk cross-sectional area in the year 2007 was ascertained higher after summer pruning in comparison with the year 2006 (Fig.1). This could have been caused as a response of the trees to strong damage of flowers by frost and subsequent low set of fruits. Similarly, in the year 2008 this influence invoked weak yields of Těchlovan on both rootstocks and cultivar Kordia on the Colt rootstock. In April of

Fig. 1. Trees of Kordia cv. on the rootstock Colt in 2006

Table 1. Influence of the rootstock and term of pruning on trunk cross-sectional area

Rootstock	Year	Time of pruning	
		August	March
		trunk cross-sectional area (cm^2)	
Colt	2006	114.1	122.6
	2007	132.9	124.4
	2008	149.2	144.9
	2009	158.1	155.6
	2010	171.0	178.2
	mean	145.1	145.1
P-HL-A	2006	74.5	78.4
	2007	86.8	84.6
	2008	96.2	92.8
	2009	103.3	97.8
	2010	109.3	120.3
	mean	94.0	94.8

the year 2009 it was extremely dry (precipitation amount 2 mm), but during the next three months a high level of precipitation increased average tree vigour (Table 1).

The response of trees to summer pruning was significantly affected by cultivars (Table 2). Kordia cv. on the Colt rootstock grew the most vigorously. Trees of Těchlovan cv. in the variant of March pruning and Vanda cv. pruned in August, both on P-HL-A rootstock, grew the weakest. In the case of Kordia cv., the trunk cross-sectional area was in all years smaller in both rootstocks after pruning in August. On the P-HL-A rootstock, a statistically significant difference in this characteristic was recorded in all the assessed years. A positive response of Kordia to tree training and summer pruning is reported also from Slovenia and Canada (Usenik et al. 2008, Gonkiewicz 2011).

Trees of Těchlovan cv. on the P-HL-A rootstock pruned in August grew more strongly, a statistically

Table 2. Tree vigour expressed by trunk cross-sectional area in cm^2

Cultivar	Rootstock	Time of pruning	Year					
			2006	2007	2008	2009	2010	Mean
Kordia	Colt	March	140.8	142.8	166.0	173.4	197.9	164.2
		August	122.1*	140.1	155.2	168.3	177.6*	152.6*
	P-HL-A	March	89.8	91.1	106.8	114.1	134.0	107.2
		August	70.1*	81.1*	89.2*	98.6*	101.6*	88.1*
Těchlovan	Colt	March	110.0	111.6	128.8	142.1	160.0	130.5
		August	104.0*	121.9*	135.1	139.1	150.7	131.2
	P-HL-A	March	74.9	76.0	84.5	92.0	112.0	87.9
		August	83.9*	96.9*	111.4*	115.6*	123.0	106.2*
Vanda	Colt	March	117.1	118.7	139.8	151.3	176.6	140.7
		August	119.9	136.8*	157.3*	167*	184.7	153.1
	P-HL-A	March	70.5	86.7	87.1	87.5	114.9	89.3
		August	69.6	82.5	88.2	95.6	103.2	87.9
Mean	Colt	March	122.6	124.4	144.9	155.6	178.2	145.1
		August	114.1	132.9	149.2	158.1	171.0	145.1
	P-HL-A	March	78.4	84.6	92.8	97.8	120.3	94.8
		August	74.6	86.8	96.2	103.3	109.3	94.0

*statistically significant difference at $P \leq 0.05$

Table 3. Values of canopy volumes (m^3) according to cultivars, rootstocks and time of pruning

Cultivar	Rootstock	Year	Time of pruning			
			March		August	
			before pruning	after pruning	before pruning	after pruning
Kordia	Colt	2007	17.1	16.6	13.6	11.4
		2008	22.8	12.6	20.8	10.8
		2009	19.0	11.7	17.5	11.5
		mean	19.7	13.6	17.3	11.3
	P-HL-A	2007	10.6	9.4	8.0	6.8
		2008	15.0	9.2	12.7	5.8
		2009	13.9	12.0	9.5	6.5
		mean	13.2	10.2	10.1	6.4
Těchlovan	Colt	2007	14.6	9.9	14.1	10.3
		2008	20.7	10.7	15.7	8.0
		2009	17.7	10.8	17.5	8.6
		mean	17.6	10.4	15.8	8.9
	P-HL-A	2007	10.1	9.3	11.2	9.1
		2008	14.0	10.4	17.2	8.1
		2009	13.0	10.5	12.3	8.8
		mean	12.4	10.1	13.6	8.7
Vanda	Colt	2007	11.9	10.5	12.7	10.3
		2008	17.9	11.8	19.6	12.6
		2009	18.2	13.9	20.9	11.4
		mean	16.0	12.1	17.7	11.4
	P-HL-A	2007	9.2	6.9	9.1	7.6
		2008	12.8	8.4	12.4	7.7
		2009	12.2	9.3	9.6	7.3
		mean	11.4	8.2	10.3	7.5

significant difference was not detected only in the year 2010. On the other hand, in the case of this cultivar tree vigour on the Colt rootstock was not affected by the term of pruning.

The Vanda cv. on the Colt rootstock displayed strong tree growth in the term of pruning, however, after pruning in August tree vigour was statistically higher in most years. On the other hand, in the case of trees of the cultivar on P-HL-A rootstock, this difference was insignificant.

Tree growth expressed by the mean size of canopy volume before pruning was not significantly different from results obtained by measuring of the trunk cross-sectional area (Table 3). Kordia cv. on the Colt rootstock had the greatest values of canopy volume. On the contrary, the smallest size of tree canopy was observed in the cvs Kordia and Vanda on the P-HL-A rootstock. The high importance of using dwarf rootstocks for Kordia was reported by Sitarek and Grzyb (2010).

Fig. 2. Trees of Vanda cv. on the rootstock P-HL-A in 2006

Table 4. Mean yields per tree according to cultivars, rootstocks and time of pruning

Cultivar	Rootstock	Time of pruning	Weight of harvest (kg)					
			2006	2007	2008	2009	2010	mean
Kordia	Colt	March	2.0	0.4	3.4	5.6	4.2	3.1
		August	0.6*	0*	4.5*	7.0*	3.0*	3.0
	P-HL-A	March	14.2	2.1	13.2	14.0	10.4	10.9
		August	6.6*	0.7*	9*	10.4*	8.2*	7.0*
Těchlovan	Colt	March	2.6	0.1	3.0	6.0	4.4	3.2
		August	1.2*	0.1	3.0	7.0	4.0	3.1
	P-HL-A	March	4.4	1.4	2.8	8.2	8.0	5.0
		August	5.4*	1.3	3.2*	8.8	4*	4.5
Vanda	Colt	March	2.8	1.6	8.8	10.4	11.0	6.9
		August	3.0	0.5*	8.0	8.2*	13*	8.0
	P-HL-A	March	7.8	9.0	12.3	11.0	9.8	10.0
		August	7.8	4.6*	11.9	13*	11.4*	11.4
Mean	Colt	March	2.5	0.7	5.1	7.3	6.5	4.4
		August	1.6*	0.2*	5.5	7.4	6.7	3.9
	P-HL-A	March	8.8	4.2	9.4	11.1	9.4	8.5
		August	6.6	2.2	8.0	10.7	11.4	6.8

*statistically significant difference at $P \leq 0.05$

Trees of Těchlovan cv. on the P-HL-A rootstock after pruning done in August had larger canopy volumes in comparison to the variant of pruning done in March. The same was the case of cv. Vanda on the Colt rootstock. A more remarkable influence of the term of pruning on size of canopy volume was recorded only on trees of Kordia cv. on the P-HL-A rootstock.

Table 5. Values of specific yields calculated for 100 cm^2 of trunk cross-sectional area

Cultivar	Rootstock	Time of pruning	Specific yields calculated for 100 cm^2					
			2006	2007	2008	2009	2010	mean
Kordia	Colt	March	1.6	0.3	2.2	3.4	2.1	1.9
		August	0.5*	0.0*	3.0	4.3	1.7*	1.9
	P-HL-A	March	17.5	2.4	12.1	12.6	7.9	10.5
		August	9.9*	0.8*	10.8	12.2	8.4	8.4
Těchlovan	Colt	March	2.6	0.1	2.3	4.2	2.7	2.4
		August	1.1*	0.1	2.2	5.3	2.8	2.3
	P-HL-A	March	6.5	2.0	3.5	9.2	7.5	5.7
		August	7.0	1.3*	3.0	7.8*	3.3*	4.5
Vanda	Colt	March	2.8	1.4	6.3	7.1	8.2	5.1
		August	2.6	0.3*	5.1	4.9	7.2	4.0
	P-HL-A	March	10.3	10.6	13.0	11.2	8.7	10.8
		August	9.8	5.8*	14.2	14.3*	11.7*	11.1
Mean	Colt	March	2.3	0.6	3.6	4.9	4.3	3.1
		August	1.4*	0.2*	3.4	4.8	3.9	2.7
	P-HL-A	March	11.4	5.0	9.5	11.0	8.0	9.0
		August	8.9*	2.6*	9.3	11.4	7.8	8.0

*statistically significant difference at $P \leq 0.05$

Table 6. Values of mean fruit weight

Cultivar	Rootstock	Time of pruning	Weight of 1 fruit (g)				
			2006	2007	2008	2009	mean
Kordia	Colt	March	9.1	10.7	10.5	10.9	10.3
		August	9.9	10.9	10.4	10.4	10.4
	P-HL-A	March	9.9	10.2	10.3	10.4	10.2
		August	10.2	10.8	10.7	9.5	10.3
Těchlovan	Colt	March	10.9	11.5	10.4	10.9	10.9
		August	10.5	9.9	10.8	10.5	10.4
	P-HL-A	March	10.9	11.1	12.5	10.3	11.2
		August	10.2	11.6	12.3	10.1	11.0
Vanda	Colt	March	8.0	9.4	8.3	8.0	8.4
		August	8.5	9.3	8.3	8.4	8.6
	P-HL-A	March	8.7	8.7	8.1	7.0	8.1
		August	8.4	9.5	7.3	6.6	8.0
Mean	Colt	March	8.5	10.5	9.7	9.5	9.6
		August	9.6	9.6	9.8	9.8	9.7
	P-HL-A	March	9.8	10.0	11.4	9.2	10.1
		August	9.6	10.6	9.8	8.7	9.7

Productivity of trees and size of fruits

Mean yield per tree in the term of pruning was evaluated in the period on the Colt rootstock in all cultivars inferior to the P-HL-A rootstock. On this rootstock no significant difference in yields between both terms of pruning was found. cv. Vanda (Fig. 2) was the most productive on this rootstock but mainly because of its tolerance to late spring frosts. Trees of this cultivar on the P-HL-A rootstock pruned in August reached higher average yields in comparison to trees pruned in March. In the case of Kordia cv. trees on P-HL-A, higher yields were recorded after their pruning in March (Table 4).

Also on average all cultivars grown on the P-HL-A rootstock had somewhat higher yields from trees pruned in March. On the contrary, cultivars grown on the Colt rootstock in two years had a statistically significant difference, however, in other years the differences were insignificant. The specific productivity of trees calculated for 100 cm^2 of trunk cross-sectional area was the highest on the P-HL-A rootstock in both variants of pruning Vanda cv., and the lowest in both variants of pruning on the Colt rootstock. The specific productivity was always slightly higher in the March term of pruning on average among all cultivars on Colt rootstock. The same response was also found on trees on the P-HL-A rootstock with the exception of the year 2009 (Table 5).

In comparison to the results from the first period of the study (Blažková, Hlušičková 2005), when specific productivity was generally higher after pruning done in August, this characteristic was evaluated as mainly better in the subsequent period after using the Spring term of pruning. This change of tree response is evidently connected to the rate of tree ageing and the spring term of pruning probably compensated for this development.

The largest fruits in this trial were observed in the Těchlovan cv. on the P-HL-A rootstock (Table 6). The smallest fruits were observed in the Vanda cv. on P-HL-A rootstock. This finding is also confirmed by recent results from Poland (Grzyb, Rozpara 2009). The size of fruits was not within the evaluated cultivars influenced by the term of pruning.

CONCLUSIONS

– The tree vigour on average of all the assessed cultivars was about 54% stronger on the Colt rootstock than on P-HL-A.
– The effect of the time of pruning was different according to the cultivar and rootstock used.
– It was also significantly influenced by climatic conditions in the year.
– The vigour of Kordia cv. trees on both rootstocks pruned in August was distinctly weaker.

– Trees of Těchlovan cv. on P-HL-A grew significantly stronger after pruning in August, whereas in the case of Vanda cv., this effect was found on the Colt rootstock.
– Pruning of trees in August reduced growth in the majority of experimental variants.
– Yields of Vanda cv. on P-HL-A were the highest when the trees were pruned in August. On the contrary, trees of Kordia cv. had higher yields after spring pruning.
– The size of fruits within the assessed cultivars was not influenced by the term of the pruning.

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Corresponding author:

Ing. Jitka Blažková, Research and Breeding Institute of Pomology Holovousy Ltd., Holovousy 1, 508 01 Hořice, Czech Republic
phone: + 420 493 692 821, fax: + 420 493 692 833, e-mail: blazkova@vsuo.cz