Growth reaction of young wild cherry (*Prunus avium* L.) trees to pruning

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ABSTRACT: A large crown is one of the most important prerequisites for the good growth of a tree and therefore the crown could be called an engine of increment. The care for a large crown brings a decrease in the bole value at the same time as it makes large branches and later knots on it. Pruning is a possible solution of these two contradictions. Young wild cherry trees were pruned in three different ways: (*i*) half of the crown left, (*ii*) one quarter of the crown left and (*iii*) control, i.e. no pruning. The results show that height growth was not influenced by pruning while diameter growth was significantly affected. The crown reduction to a half means 10% less in diameter growth within a 5-year period after pruning. The crown reduction to one quarter of the crown means only two thirds of 'full' diameter growth on the control plot. The data suggest that the pruning of young wild cherry trees should be done moderately (more than a half of the crown should be left) and pruning should be done when the bottom part of the crown is in the shadow zone of the crown layer, not earlier.

Keywords: young wild cherry tree; pruning; production; height; diameter; basal area; high quality tree

Scattered valuable broadleaves could significantly increase the value and biodiversity of our forests. The market in high-quality broadleaved logs is highly promising and develops quickly. The price of low-quality broadleaved veneer is 10 €/m^3 while the price of high-quality veneer varies between 200 and 1,000 €/m^3 (Oosterbaan et al. 2007).

The substitution of tropical wood products by European valuable broadleaves with nice wood structure and design is going on (Langbour, Gerard 2007; Rocha, de Assis 2007, etc.). The focus on scattered valuable broadleaves in Europe is also supported by scientific programs in European Cooperation in the Field of Scientific and Technical Research (COST) where one of the programs called *Growing Valuable Broadleaved Tree Species* under the label COST E42 is running in the years 2004 to 2008. The Faculty of Forestry and Wood Sciences of the Czech University of Life Sciences Prague is a member of the international research team and its research contributes to the program.

A large green crown is one of the most important prerequisites for the good growth of a tree (Spiecker 2002; Kupka 2004). One could call the crown an engine of increment. The crown volume filled with green leaves is a driving variable for the amount of photosynthesis assimilates and therefore it is a requirement for good growth (Kramer 1986). The maintenance of a large crown is essential for good production (Korpeľ 1991). On the other hand, a large crown is composed of thick branches which reduce the quality and value of the bole. Stem diameter and timber price per m^3 are increasing with decreasing crown base, i.e. increasing crown length (the larger the log, the better), but the volume of clean bole without any large knots is decreasing (Spiecker 2006). The situation is illustrated in Fig. 1.

Pruning could be a possible solution of these two contradictions when we remove the bottom part of the crown of young trees. In this way, we could produce a large knotless bole of four to six meters long producing the high-quality veneer log.

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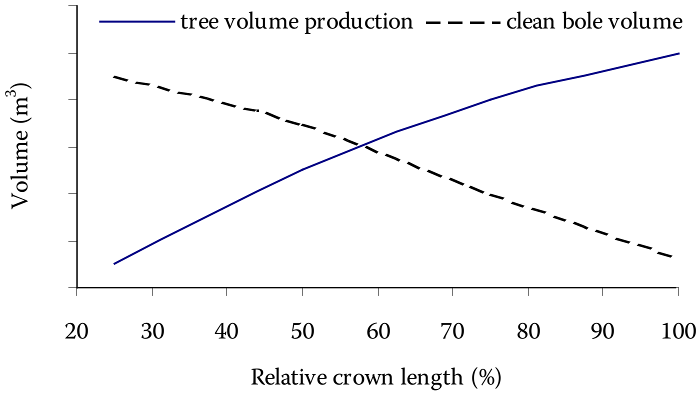

Fig. 1. An increase in crown length means an increase in tree volume production, but at the same time the clean bole volume is decreasing (adapted from Spiecker 2006)

There are not many publications which studied the relationship between crown diameter and stem diameter of trees. However, it is believed that the relationship between these two parameters is very close to a linear one with an r^2 value higher than 0.8 (Hemery et al. 2005). In fact, the true relationship between crown diameter and stem diameter may be sigmoid due to the distortion of the line at the lower end because tree diameter is measured at breast height and due to the possible depression of the upper end due to senility, but in a juvenile phase these irregularities could be neglected. Dawkins (1963) also suggested that for a common range of forest tree sizes, between 20 and 50 cm dbh, there would be a negligible distortion of the linear relationship. If this is true also for the crown volume, then the reduction of crown length will lead to a diameter increment loss. The verification of the relationship between crown size (volume) and stem diameter is one of the purposes of this article.

The main purpose of this article is to evaluate how much the crown of wild cherry trees could be reduced and how early it could be done, i.e. what could be a good timing of the operation in terms of minimizing the production lost.

MATERIAL AND METHODS

The research plot was established in 1998 in a demonstration forest near Kostelec nad Černými lesy at the Truba location. The geographical coordinates are latitude 50°0´´N and longitude 14°50´´E. The area belongs to provenance region No. 17 Polabí at an altitude of 370 m above sea level. The region belongs to a moderately warm area with average temperature of 10.1°C and average precipitation of 650 mm per year.

Seven-years-old plants of wild cherry were used at a spacing of 1 m by 2 m. The plants of the same provenance origin, i.e. No. 17 Polabí, were bare-root plants. The planting technology was a pit-planting system. The area is 0.15 ha and it is fenced. The moderate forest soils belong to forest type 2K1, i.e. slightly acid soil with no severe deficiency of nutrient contents.

The basic data were recorded in 2002, when a pruning trial started. The research plot was divided into three parts on which different pruning systems were applied in the same year. The third "system" was a control, i.e. no pruning at all. The basic data are given in Table 1.

Data collected on the plots were:
- diameter at breast height taken twice in perpendicular directions (mm),
- total height of the tree (cm),
- length (height) of the bole up to the first living whorl (at least two living branches make the whorl – cm),
- crown projection diameters in two perpendicular directions (cm).

The remarks on the crown and stem qualities were also recorded. The crown length was calculated as the difference between total height and length of the stem without branches. The simplified crown volume was also calculated supposing the pyramid form of the crown where crown projection diameters in two

Table 1. Basic characteristics of used pruning systems

Used symbol	Type of pruning	Year of pruning	Number of trees in 2002
H	upper half of the crown left	2002	205
Q	upper quarter of the crown left	2002	210
C	whole crown left	–	220

Table 2. Total height growth of wild cherry trees in 2002–2007 (cm) after pruning in 2002

	2002	2003	2004	2005	2006	2007
H	249.9 ± 10.2[a]	282.5 ± 11.5[a]	309.8 ± 12.9[a]	325.4 ± 13.3[a]	340.9 ± 15.2[a]	372 ± 19.8[a]
Q	257.8 ± 7.9[a]	294.7 ± 9.6[a]	313 ± 9.8[a]	319.9 ± 10.1[a]	346.5 ± 13.9[a]	380.1 ± 21.9[a]
C	261.5 ± 8.1[b]	289.8 ± 9.9[a]	315.2 ± 11.5[a]	334.6 ± 11.9[b]	353.6 ± 14.4[a]	401.9 ± 20.3[a]

The same letter in the upper index indicates no significant differences between the values

Table 3. Diameter growth of wild cherry trees in 2002–2007 (mm) after pruning in 2002

	2002	2003	2004	2005	2006	2007
H	17.6 ± 1.5[a]	21.4 ± 1.7[b]	25.4 ± 1.6[b]	27.1 ± 1.9[b]	28.5 ± 1.9[b]	32.6 ± 2.0[b]
Q	17.8 ± 1.2[a]	21.2 ± 1.1[b]	23.0 ± 1.2[b]	24.3 ± 2.1[c]	25.5 ± 2.0[c]	28.2 ± 1.8[c]
C	19.3 ± 1.4[a]	25.8 ± 1.8[a]	29.7 ± 2.1[a]	32.1 ± 2.3[a]	34.2 ± 1.8[a]	37.5 ± 1.9[a]

The same letter in the upper index indicates no significant differences between the values

perpendicular directions were taken for the base of the pyramid. Crown volume is used also for the calculation of "crown efficiency" which is the ratio of basal area increment to crown volume. It indicates how much of diameter increment is produced by one volume unit of the green crown.

The calculations were done using Microsoft (c) Office Excel 2003 software including statistical "plug-ins".

Three "pruning systems" – radical labelled Q, no pruning labelled C and the average between these two extremes labelled H – could suggest the answer to the first question while the time series registered on the research plots for the time period from 2002 to 2007 should help to answer the second question.

RESULTS AND DISCUSSION

The influence of pruning on height growth was evaluated in the first step. The data in centimetres are given in Table 2.

In spite of small differences in some years, the average heights of two "pruning systems" are not significantly different from the control within five years after pruning. This finding confirms the hypothesis given by many authors (e.g. Assmann 1968; Korf et al. 1972; Šebík, Polák 1990; Hao 2002, etc.) that no silvicultural treatment influences growth significantly. The data suggest that even the drastically reduced crown of young wild cherry trees – used in the case of "Q pruning system" – did not decrease the height growth significantly.

A totally different picture was observed in diameter growth. The data are given in Table 3.

One could see immediate reactions of wild cherry trees to the reduction in their crowns in diameter increment next year (2003). The differences between trees with reduced crowns and those with "full" crowns increased each year. Later on (about three years after pruning) significant differences were also recorded between half crown reduction (H) and radical crown reduction (Q).

A clearer picture of the development of diameter and basal area can be seen in Fig. 2. The basal area of unpruned wild cherry trees is nearly twice as large as the basal area of trees pruned by Q system

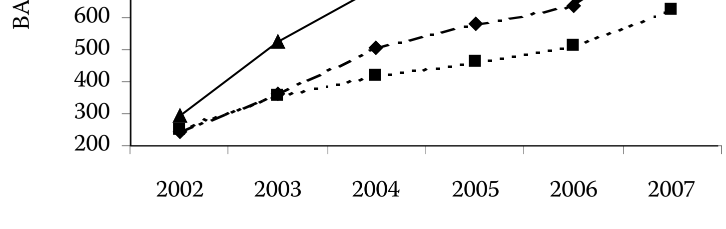

Fig. 2. Basal area development of pruned wild cherry trees in 2002–2007

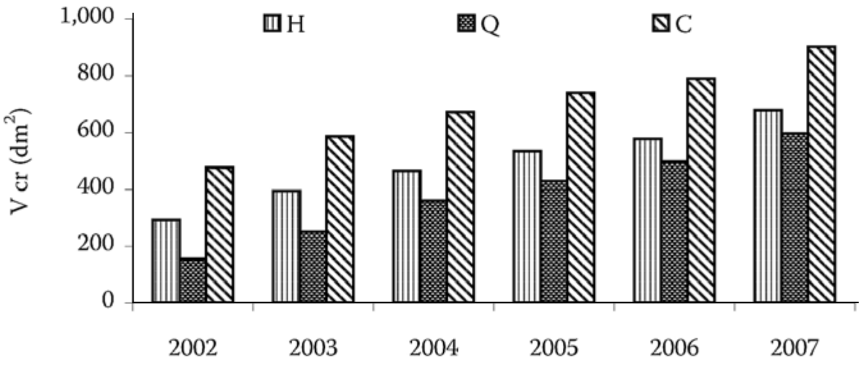

Fig. 3. Crown volume and its growth after pruning in 2002

Table 4. Crown efficiency of trees under different "pruning systems" (cm^2/dm^3)

Part of the crown left after pruning –"pruning system"	Crown efficiency
Half of the crown left (H)	0.29 ± 0.03[a]
Quarter of the crown left (Q)	0.19 ± 0.04[b]
Whole crown left (C)	0.20 ± 0.02[b]

The same letter in the upper index indicates no significant differences between the values

nowadays. Trees which lost halves of their crowns in 2002 had better diameter growth as compared with Q system but they lost nearly one third of the basal area compared to the trees without pruning so far.

The crown development after pruning in 2002 can be seen in Fig. 3. The loss of the crown made in the pruning year 2002 has not been compensated yet, i.e. five years after crown reduction. On the other hand, trees with drastically reduced crowns (Q) are approaching the crown volume of trees with moderately reduced crowns step by step.

The bottom parts of crowns in canopy-closed stands end up in shadow and their contribution to the assimilation processes becomes very modest. This means a decrease in the crown apparatus efficiency in terms of diameter or basal area growth. The ratio of basal area increment to crown volume is used to evaluate the "crown efficiency".

The results are given in Table 4. While the crown efficiency is nearly the same for unpruned trees (control) and drastically reduced crown (Q), the crown reduction to a half done five years ago seems to be the most effective measure. Data suggest that the loss of the bottom part of the crown does not influence the efficiency negatively. But one has to bear in mind that even though the crown efficiency is not touched, the basal area increment is negatively influenced (comp. Fig. 2). The slope for a relationship between crown volume and basal area (see Fig. 4) is the same for all three pruning systems, which confirms the hypothesis of Hemery et al. (2005). But pruning has shifted pruned trees to the left on the horizontal axis, i.e. to a younger stage. The shift represents a 'net loss' in the time of production period.

Data also confirm a strong relationship between crown volume and basal area (coefficient of determination $r^2 = 0.91$). As the basal area is calculated from diameter at breast height, the same is true of the relationship between crown volume and diameter. Fig. 4 illustrates a strong correlation between crown volume and basal area growth and it gives a warning

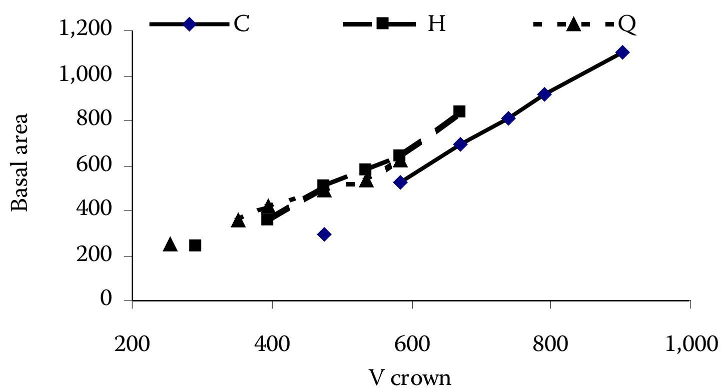

Fig. 4. The relationship between crown volume (dm^3) and basal area (cm^2)

against the drastic pruning system in young stages of wild cherry trees.

CONCLUSIONS

Valuable broadleaves which are scattered in our forests would bring an important financial effect for forest management in case that they had boles of high quality. The large crown guarantees the large bole but at the same time it means many thick branches which decrease the bole quality. Pruning which will increase the length of the bottom part of knotless bole could be a possible solution of these two contradictions.

This article searches for probable answers to two questions:

– how much could the crown of young wild cherry trees be reduced when pruned?
– when could pruning be done, i.e. a good timing of this operation.

Our data based on two "pruning systems" suggest that the radical reduction of crown (more than a half of the crown taken away) produces a serious loss in diameter increment while height growth is not practically affected.

The second conclusion as the answer to the second proposed question is that pruning could and should be done when the bottom part of the crown is in shadow which means a decrease in the efficiency of the crown apparatus. The right time when it happens cannot be exactly determined as it is strongly influenced by initial spacing and also by the species, i.e. its growth rhythm.

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Vliv vyvětvení na růst třešně ptačí (*Prunus avium* L.) v počáteční fázi jejího vývoje

ABSTRAKT: Velká koruna je jednou z nejdůležitějších podmínek pro dobrý růst stromu, a proto můžeme korunu stromu označit za „motor" objemového přírůstu. Pěstování velkých korun však zároveň znamená snížení kvality a hodnoty oddenkové části kmene. Možným řešením tohoto rozporu je umělé vyvětvování. Mladé třešně ptačí byly v roce 2002 jednorázově vyvětveny třemi různými způsoby: (*i*) ponecháním poloviny koruny, (*ii*) ponecháním jen čtvrtiny koruny a (*iii*) kontrola, tzn. nedošlo k žádné redukci koruny. Dosavadní výsledky ukazují, že vyvětvení nemělo významný vliv na výškový přírůst mladé třešně ptačí, ale mělo významný vliv na tloušťkový přírůst. Třešně, kterým byla ponechána jen polovina koruny, mají po pěti letech v průměru o 10 % nižší výčetní tloušťku a třešně s korunou redukovanou na jednu čtvrtinu mají výčetní tloušťku, která dosahuje jen dvou třetin tlouštěk kontroly. Ze získaných výsledků lze konstatovat, že drastická redukce koruny mladých třešní (více než polovina původní koruny) vede ke značnému zpomalení tloušťkového růstu. Vhodný termín k provedení vyvětvení je doba, kdy se spodní část koruny ocitá ve stínu a její příspěvek k růstu stromu je minimalizován.

Klíčová slova: mladá třešeň ptačí; vyvětvení; produkce; výška; tloušťka; kruhová výčetní základna; kvalitní strom

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