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Effect of trunk cutting, root pruning, and double-trunk on the growth and yields of apple trees

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ABSTRACT

In 2000 – 2002 the investigations were carried out on trees of 'Melrose' apple, grown on M.26 rootstock, planted in 1991. The trunk cutting with a chain saw, root pruning, and double-trunk trees were compared. As an additional trunk a 10-cm long piece of M.9 shoot was used. The treatments were performed in June 2000. All the treatments decreased a cumulative increase (2001 – 2002) in the trunk cross-section area. The length of limb leaders decreased only as a result of trunk cutting. However, the canopy volume decreased in trees with a double trunk and a bark grafting in inverted position on the main trunk. Cumulative yields from two years after all treatments increased by 30-35%. The ratio of the cumulative yield to a trunk cross-section increase (2001 – 2002) was several times higher than

in the control, but it was significant only when the double trunk with a 5-cm inverted ring of the bark on the main trunk was used. The mean weight of fruit did not change. The colour of fruit was better when the trunk cutting and double trunk with an inverted 5-cm bark ring on the main trunk were used.

INTRODUCTION

Breaking the flow of assimilates and bioregulators in the phloem of the tree trunk induces flower bud setting. This event occurs irrespective of whether the break is caused by grafting a bark ring from a dwarf rootstock (Poniedziałek et al. 2000) or by girdling (Wilton 2000). In both cases the effect of treatments carried out at earlier dates was poorer than the later ones.

Hoying and Robinson (1992) compared the trunk cutting and root pruning in 'Mutsu' apple trees. Both treatments reduced the cross-section area of the trunk and the mean length and mean number of shoots. In comparison with girdling and the control the cutting of roots significantly decreased the yields chiefly owing to a decrease in the mean weight of fruit. The girdling reduced the growth to a smaller degree than the root prunning, although it increased the yield irrespective of the date of treatment. Samad et al. (1999) used the interstock bridge grafting in vigorously growing trees in an orchard. The investigation was conducted on four cultivars ('Granny Smith', 'Cox's Orange Pippin', 'Gala', and 'Oregon Red Delicious') on three rootstocks (MM.106, M.793, and Northern Spy). Apart from shoots on the M.9 rootstock, shoots of various commercial cultivars were used as bridge interstocks. The applied grafting resulted in a decrease in the growth of shoots by 20%, an increase in the concentration of carbohydrates, an increase in the number of flower buds, and a 30% increase in yields. The authors of the present paper estimated this method of growth and yield enhancement as highly promising. In China the method was implemented on a large scale. Three thousand trees of 'Nagano Fuji' apple trees grown on *Malus micromalus* were bridge-grafted using four grafts 25 cm in length sampled from the M.9 rootstock. After the girdling the main trunk of trees stopped growing for three years. The yield of treated trees increased by 45.5% and the quality of apples and their colour were improved (Jiang Shou Fu et al. 2000).

The purpose of the present study was to investigate the effect of various modifications of trunk or root treatments on the control of tree growth vigour and basic yield and fruit parameters.

MATERIAL AND METHODS

In an apple orchard with 'Melrose' apple trees grown on M.26 rootstock, planted in 1991, the effect of various treatments on the growth and yield of trees was investigated. The experiment was started in June 2000 in a randomized block design in four replications, three trees on each plot. The following treatments were compared:

- Control,
- Trunk cutting, i.e. tree trunks were cut with a chain saw to a depth of ½ of their diameter, on two opposite sides of the trunk 40 cm apart,
- Root pruning, i.e. roots were pruned to a depth of 40 cm, which was done along the tree rows at a distance of 1 m from the trunks,
- Double-trunk + bark grafting, i.e. an additional auxiliary trunk from M.9 rootstock was introduced together with grafting a 5 cm wide ring of bark in inverted position on the main trunk,
- Double-trunk + bark girdling, i.e. an additional auxiliary trunk from M.9 rootstock was introduced together with an every-year removal of a 1 cm wide ring of bark from the main trunk.

The growth of trees was estimated in 2001 and 2002. Every year the trunk diameter of the investigated trees was measured 10 cm above the upper place of the treatment, the cross-section area and increases in this area being calculated on the basis of the measurements. On each plot 10 limb leaders were also measured. After the experiment was finished in autumn of 2002 the diameter and height of tree canopy was measured, the volume of tree crowns being calculated. The yield was determined every year. A random sample of 100 fruit was taken for mean weight determinations. The colour of fruits was estimated in a 1-5 scale based on % of blush area (1– 0-20%, 2 – 20-40%, and respectively up to 5 – 80-100%). Since the experiment was carried out in a 10-year old orchard, it was not possible to calculate a bearing index of the trees by the standard method. Instead of that the total yield from the years 2001 and 2002 was divided by total increases in cross-section areas in these years in order to determine a dependence between the growth and yielding of trees.

All cultivation practices were conducted according to the recommendations for production orchards. The results were statistically elaborated with the use analysis of variance, the means being evaluated using the Duncan test at $p = 0.05$.

RESULTS AND DISCUSSION

All the applied combinations of treatments inhibited the increases in trunk circumference (Table 1). The inhibition was already observed in the first year after the treatments. In the second year the difference between the treated trees and the control was diminished owing to the poorer growth in the latter. In both years a tendency was shown to a stronger inhibition of increases in the cross-section area of the trunk owing to the use of a double-trunk combined with an inverted 5-cm bark ring on the main trunk. This significant effect of the applied treatments was confirmed both by statistical analysis of total increases in the cross-section area from the years 2001 and 2002 and of the final cross-section area in autumn 2002. There were no significant differences in the total length of limb leaders in spite of smaller increases in their length, both in the second and the third year after the treatments. During 3 years of the experiment a significant decrease in the mean length of limb leaders was noted only when trunk cutting with a chain saw was applied. The volume of tree canopy was slightly changed, its reduction only occurred in the combination with a double-trunk with an inverted bark ring on the main trunk.

In the first year after the treatment a yield increase was induced by the trunk cutting and root pruning. In the next year the yield increase was significant only in the combination with the double-trunk combined with an inverted bark ring on the main trunk (Table 2). All the applied treatments caused an increase in the total yield from years 2001 and 2002. For assessing a dependence between the yield and increases in cross-section area of the trunk the ratio of total yield from 2001 and 2002 to the total increase in cross-section area in the same period was calculated. The results showed that a several-fold increase in the value of this ratio followed all the applied treatments. However, owing to a pronounced variability of trees, which affected the estimation of this index, it was only significant with respect to the treatment with double-trunk combined with an inverted bark ring. The mean weight of a fruit did not change in spite of significant yield increases. The improvement of fruit coloration (expressed in scale based on % of fruit surface covered by red colour) was observed when a double-trunk was applied, and to a lesser degree, after trunk cutting with a chain saw.

The investigations conducted so far showed that double trunk method (Poniedzialek et al. 2001), also called the interstock bridge grafting (Samad et al. 1999, Jiang Shou Fu et al. 2000), allowed the grower to dwarf efficiently the trees grown on vigorous or semi-dwarf rootstocks in the orchard. The favourably weakened growth and increases in yields resulted from the above treatments. In the present experiment the total yields from two years increased by 30-35% in comparison with the control. Samad et al. (1999) recorded a yield increase by 30% and Jiang Shou Fu et al. (2000) by 45%.

Table 1. Effect of trunk cutting, root pruning, and double-trunk on the growth of 'Melrose' apple trees

Treatments	Increases in trunk cross-section area [cm^2]		Trunk cross-section area 2002 [cm^2]	Total length of 10 limb leaders [cm]			Mean length of 10 limb leaders 2000 – 2002 [cm]	Mean volume of tree canopy 2000 – 2002 [m^3]
	2001	2002		2000	2001	2002		
Control	25.8 c	13.5 b	77.7 b	376.5 a	728.5 f	555.5 bc	553.5 b	2.3 b
Trunk cutting	7.8 ab	10.0 ab	65.4 a	359.5 a	648.0 ef	473.0 b	493.5 a	2.1 ab
Root pruning	7.7 ab	7.0 ab	68.1 a	350.3 a	639.0 def	527.8 bc	505.7 ab	2.0 ab
Double-trunk + bark grafting	5.3 a	3.4 a	65.4 a	376.5 a	666.0 ef	534.8 bc	525.8 ab	1.9 a
Double-trunk + girdling	10.1 ab	8.0 ab	82.5 b	363.3 a	690.0 f	590.0 cde	547.8 b	2.3 b

Table 2. Effect of trunk cutting, root pruning, and double-trunk on yields of 'Melrose' apple trees

Treatments	Total yield [kg per tree]		Totaly ield 2001 – 2002 [kg per tree]	Ratio of total yield to total increases in cross-section area 2001-2002	Mean fruit weight 2001 – 2002 [g]	Fruit coloration 2001 –2002 [1-5 scale]
	2001	2002				
Control	10.0 a	15.4 bc	25.4 a	0.67 a	208.0 ab	3.1 a
Trunk cutting	18.3 cd	14.6 abc	32.9 b	1.90 a	203.7 a	3.6 bc
Root pruning	18.7 cd	13.4 bc	32.1 b	2.32 a	210.8 ab	3.4 ab
Double-trunk + bark grafting	13.1 ab	21.0 d	34.1 b	4.64 b	218.6 b	4.0 c
Double-trunk + girdling	14.4 abc	18.6 cd	33.0 b	2.40 a	213.1 ab	3.4 ab

The present results were in conformity with those data. In this method the application of grafting an inverted bark ring seemed less risky than the removal of a wide ring used by Jiang Shou Fu et al. (2000) which could induce a decline of the main trunk. The effects of the main trunk decline could last much longer, though. The root pruning requires a powerful tractor and suitable tools. Its effect on fruit bearing was similar to that of other treatments, though its yield reducing effect had been frequently reported (Hoying and Robinson 1992). The last authors noted also an increase in fruit yield resulting from trunk cutting with a chain saw, which was confirmed by the present results. However, the trunk cutting with a chain saw presents a danger of serious damage to trees or even their decline. Such trees may be broken by strong wind and the protection of wounds induced by breaking against fungal diseases and other noxious agents is difficult. The currently recommended protection of cutting wounds by emulsion paint with an addition of fungicides or such preparations as Funaben 3 is not proper in orchards where herbicides of the Roundup type (glifosat) are used. The herbicides freely permeate through the protective coatings of this type, inhibiting the healing of wounds and leading even to the tree death (unpublished data). In this case the only proper protection of wounds on the tree trunk seems to be the use of plastic sheeting.

The experiment was established in a ten-year-old orchard in which the variability among the trees was already considerable. Although the selection of trees was random, the differences between them could not be excluded. The trees with the lowest cross-section area were included into control combination unintentionally. For healthy trees, growing in the same conditions and subjected the same treatments, physiological processes proceeded similarly. There was no evidence that weather conditions could affect the particular experimental treatment differently. This allowed the conclusion that the applied treatments affected favourably the growth and yield of ‘Melrose’ apple trees.

CONCLUSIONS

1. Applied treatments decreased the tree growth habit of apple trees expressed by the increase of trunk cross-section area and the increase in the length of limb leaders.
2. All treatments increased the yield of fruit but did not affect the mean weight of fruit.

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WPŁYW NACINANIA PNI, CIĘCIA KORZENI ORAZ PODWÓJNEGO PNIA NA WZROST I PLONOWANIE JABŁONI

Streszczenie: W latach 2000 – 2002 na drzewach jabłoni 'Melrose', rosnących na podkładce M.26 posadzonych w 1991 roku, prowadzono badania nad wpływem nacinania pni piłą łańcuchową, cięcia korzeni oraz zmodyfikowanego podwójnego pnia. Jako dodatkowy pień stosowano pędy z podkładki M.9. Wszystkie zastosowane zabiegi zmniejszyły sumę przyrostów pola przekroju poprzecznego pnia. Suma długości przewodników konarów zmniejszyła się jedynie pod wpływem nacinania pni drzew piłą łańcuchową. Natomiast objętość korony zmalała w wyniku zastosowania zmodyfikowanego podwójnego pnia współdziałającego z przeszczepionym odwrotnie pierścieniem kory na pniu głównym. Suma plonu z dwóch lat po wykonaniu zabiegów wzrosła o 30-35%. Stosunek tej sumy do sumy przyrostów pola przekroju poprzecznego pnia z tego samego okresu był kilkakrotnie wyższy we wszystkich kombinacjach w porównaniu z kontrolą, jednak pod względem statystycznym udowodniono tylko różnicę powstałą w wyniku zastosowania zmodyfikowanego podwójnego pnia w połączeniu z przeszczepionym odwrotnie pierścieniem kory na pniu głównym. Średnia masa owocu nie uległa zmianie. Wybarwienie owoców poprawiło się pod wpływem nacinania pni piłą łańcuchową oraz zmodyfikowanego podwójnego pnia połączonego z odwróconym pierścieniem kory na pniu głównym.

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