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GROWTH AND YIELDING OF FROSTBITTEN PEACH TREES AFTER REGENERATIVE PRUNING

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Abstract. In the years 2006–2008 in Przybroda near Poznań the objects of studies were peach trees 'Harbinger' on rootstocks Manchurian Peach, Sand Cherry and Rakoniewicka Seedling, formed as a spindle, severely damaged by frost in 2005/2006 winter. In May 2006, an intensive tree pruning was carried out. The objective of studies included the estimation of the pruning effect and rootstocks of frostbitten trees on the process of their regeneration and yielding. Pruning caused a decrease of tree height and crown width in relation to control. Trunks of the strongly pruned trees became thicker, as compared with control trees. In the third year after regenerative pruning, the trees decreased their yield by about 30% in relation to control. The best yielding trees were on rootstock Rakoniewicka Seedling, but the weakest on Sand Cherry.

Key words: growth, peach tree, regenerative pruning, rootstock, yielding

INTRODUCTION

In Poland, every several years, there appear severe winters with a temperature reaching -30°C and causing high damages in orchards, particularly in peach trees. Not only flower buds are destroyed, but also the cambium of branches and even the xylem get strongly frozen. Such situation took place in the winter of 2005/2006.

In spring 2006, in order to accelerate regeneration, an intensive tree pruning was carried out. According to many authors [Bielozierov 1972, Dudziński and Hołubowicz 1985, Radajewska 1989, Marini 2002], an intensive pruning of trees stimulates the regeneration processes as well as modifies the size of tree crowns and particularly lowers the excessive tree height.

The objective of the presented studies was the estimation of the effect of intensive pruning of the frozen 8-year old peach trees of 'Harbinger' cultivar on the regeneration processes, the reconstruction of the spindle-formed crowns and the yielding, as well as to assess the role of rootstocks played in these processes.

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MATERIAL AND METHODS

Studies were carried out in the years 2006–2008 in the experimental orchard in Przybroda belonging to the Pomicultural Department of Poznań University of Life Sciences. The object of studies consisted of 8-year old peach trees of an early 'Harbinger' cultivar with a spindle-form crown, cultivated on three types of rootstocks: Manchurian Peach (*Prunus mandschurica*/ Koehme), Sand Cherry (*Prunus besseyi*) and Rakoniewicka Seedling (*Prunus persica)*. The trees were severely damaged by frost during the winter in 2005/2006 showing disease symptoms of bark and xylem. The trees were grown in a spacing of 4×2 m in random block design and in 6 replications (trees). In the rows, herbicide fallow was maintained; while in the interrows, turf was grown. Every year, a homogeneous standard fertilization was applied and prophylactic treatments against diseases were carried out. In May, intensive tree pruning was performed according to the following combinations:

K1 – control combination, trees were not pruned at all,

K2 – all branches were shortened by 1/3 to 1/2,

K3 – the leader was pruned at the height of 1.5 m and the other branches were pruned as in K2.

After pruning, high fertilization with nitrogen and potassium was applied in the doses of 100 kg $N \cdot ha^{-1}$ and 150 kg $K_2O \cdot ha^{-1}$. Every year, in autumn, tree growth was estimated including: tree height, tree crown projection (quotient of 2 widths), number of one-year old long-shoots with diameter ≥0.5 cm and the mean and summaric long-shoot lengths on selected branches in the central part of tree crowns, as well as stem thickness expressed by the cross-section surface of stem (TCSA). There are presented only results of tree height measurements after 1 season after regenerative pruning (autumn 2006). Because sanitary pruning was carried out every year, this is why these results from next years are not presented. Fruit yield from each tree was estimated as well. Results were statistically elaborated using the STAT program of the analysis of variance for 2-factorial experiments. The significance of differences was estimated by Duncan's test on the significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

Estimation of tree growth carried out in autumn of the intensive tree pruning year showed that both the control trees (K1) and trees of K2 were higher by 0.5-0.6 m than the trees pruned at the height of 1.5 m (K3) and the growth of the three combinations was: 2.5 m; 2.6 m and 2.1 m, respectively (tab. 1). Intensive pruning together with an abundant fertilization evoked a compensating growth. Such reaction to a strong pruning in the spring period is known, many authors [Mika 1979, Marini 1984, Marini 2002, Norton 2002] reported that pruning in spring as well as high fertilization of trees with nitrogen enhances their growth. The trees were „trying" to reconstruct the lost parts of their crowns. A similar reaction of trees to intensive pruning was observed by Dudziński and Hołubowicz [1985] and by Radajewska [1989]. A higher growth in each year was shown by trees grown on Rakoniewicka Seedling and Manchurian Peach rootstocks than on the Sand cherry rootstock (tables 1, 2 and 3). Crown projection of trees differed in the first year after the regenerative tree pruning. The not pruned control trees showed a greater projection than the trees pruned at the height of 1.5 m. The projection after the first year was 6.6 m^2; 4.6 m^2 and 5.0 m^2, respectively (tab. 1).

In the successive year, the differences between trees in the control combination and in the pruned trees were still maintained. Control trees had crowns with the greatest projection reach of 9.4 m^2, while the reach of the pruned trees showed values of 6.9 (K2) and 7.5 m^2 (K3) (tab. 2).

In the third year, the crown projection was smaller by about 2 m^2 in the intensively pruned trees than in the control trees (tab. 3).

In the first and in the second year, there was no visible effect exerted by the intensive pruning on the stem thickness measured by TCSA (tables 1 and 2). On the other hand, from the first year after pruning, the rootstock showed a differentiating influence on the tree stem thickness. The greatest area of trunk cross-section was shown by trees on Rakoniewicka Seedling rootstock, and then, on Manchurian Peach rootstock (tab. 1 and 2). In the third year, the stimulating effect of Manchurian Peach was decreased and on that rootstock, similarly as on Sand cherry rootstock, trees showed a smaller surface area of trunk cross-section than trees on Rakoniewicka Seedling rootstock (tab. 3). Thus, the observation of Radajewska and Andrzejewski [2004], who found that Sand cherry rootstock exerted a weakening effect on the growth, has been confirmed.

Both the tree pruning and the rootstocks, in the first year after pruning did not significantly differentiate the number of shooting up strong one-year old long-shoots on selected branches. Their number always included about 5 long-shoots (tab. 4). However, the pruning significantly differentiated the mean length of shooting up long-shoots, as well as their summaric length. In the first year, on the not pruned control trees, the long-shoots were shorter than on the pruned trees, both in K2 and in K3, where the trees were additionally pruned at the height of 1.5 m (tab. 4). As reported by McIntyre [1964], the removal of the competition of the main axis top caused an inflow to the buds of an increased amount of nutrition and hormons from the roots and this fact is one of the factors favoring the shooting up of new buds after pruning. Furthermore, the shooting up buds lying in the closest neighborhood of the pruning place require the production of auxin which stimulates their development improving still more their provision with nutrition and hormons. There was also a negative effect of the Sand cherry rootstock which decreased the growth of long-shoots in contrast to the Rakoniewicka Seedling and Manchurian Peach rootstocks.

In the second year after pruning, there was a small number of shooting up long-shoots, but still their number was greater on the most intensively pruned trees (K3 – tab. 3). In the second year, there also appeared differences resulting from the influence exerted by the rootstock. There was a greater number of the more valuable long-shoots after the pruning of trees grown on Manchurian Peach and Rakoniewicka Seedling rootstocks than on Sand cherry rootstock (tab. 5). Similar differences were also found in reference to the mean length of long-shoots and regarding the pruning levels (tab. 5). Thus, the weakening effect of Sand cherry rootstock, as reported by Radajewska and Andrzejewski [2004], was here confirmed as well.

Table 1. Growth of peach trees on different rootstocks after regeneration pruning, 1 year after pruning, autumn 2006
Tabela 1. Wzrost drzew brzoskwini na różnych podkładkach po cięciu regeneracyjnym, 1 rok po cięciu, jesień 2006

	Rootstock Podkładka	Method of trees pruning – Sposób cięcia drzew			Mean for rootstock Średnia dla podkładki
		Control Kontrola K1	Shortening branches Skracanie gałęzi K2	Trees pruned at 1.5 m and shortening branches Cięcie drzew na 1.5 m i skracanie gałęzi K3	
Tree crown height, m Wysokość koron drzew, m	Manchurian Peach – Brzoskwinia Mandżurska	2.9 d*	2.6 c	2.0 a	2.5 b
	Sand Cherry – Wisienka stepowa	2.1 ab	2.3 b	2.0 a	2.2 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	2,6 c	2.8 cd	2.2 ab	2.6 b
	Mean for pruning method Średnia dla sposobu cięcia	2.5 b	2.6 b	2.1 a	
Tree crown projection, m^2 Projekcja koron drzew, m^2	Manchurian Peach – Brzoskwinia Mandżurska	5.6 bc	4.7 ab	5.7 bc	5.3 a
	Sand Cherry – Wisienka stepowa	7.5 d	4.5 ab	3.8 a	5.3 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	6.8 cd	4.8 ab	5.5 bc	5.7 a
	Mean for pruning method Średnia dla sposobu cięcia	6.6 b	4.6 a	5.0 a	
TCSA, cm^2 PPPP, cm^2**	Manchurian Peach – Brzoskwinia Mandżurska	56.3 ab	55.3 ab	69.0 b	60.2 b
	Sand Cherry – Wisienka stepowa	39.6 a	58.3 b	52.1 ab	50.0 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	62.5 b	64.6 b	65.2 b	64.1 b
	Mean for pruning method Średnia dla sposobu cięcia	52.8 a	59.4 a	62.1 a	

*Means indicate by the same letter do not differ significantly at $P \leq 0.05$ – Statistical analysis was made separately for each characteristic
*Średnie oznaczone tą samą literą nie różnią się istotnie przy $P \leq 0,05$ – Analiza statystyczna została wykonana oddzielnie dla każdej cechy
**TCSA – trunk cross sectional area, cm^2
** PPPP – powierzchnia przekroju poprzecznego pnia, cm^2

Table 2. Growth of peach trees on different rootstocks after regeneration pruning, 2 year after pruning, autumn 2007
Tabela 2. Wzrost drzew brzoskwini na różnych podkładkach po cięciu regeneracyjnym, 2 rok po cięciu, jesień 2007

	Rootstock Podkładka	Method of trees pruning – Sposób cięcia drzew Control Kontrola K1	Shortening branches Skracanie gałęzi K2	Trees pruned at 1.5 m and shortening branches Cięcie drzew na 1,5 m i skracanie gałęzi K3	Mean for rootstock Średnia dla podkładki
Tree crown projection, m^2 Projekcja koron drzew, m^2	Manchurian Peach – Brzoskwinia Mandżurska	8.4 a*	6.6 a	7.7 a	7.6 a
	Sand Cherry – Wisienka stepowa	8.6 a	6.8 a	7.5 a	7.7 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	11.3 b	7.2 a	7.4 a	8.6 a
	Mean for pruning method Średnia dla sposobu cięcia	9.4 b	6.9 a	7.5 a	
TCSA, cm^2 PPPP, cm^2 **	Manchurian Peach – Brzoskwinia Mandżurska	71.0 b	65.2 ab	79.2 b	71.8 ab
	Sand Cherry – Wisienka stepowa	49.0 a	71.5 b	64.1 ab	61.5 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	76.2 b	82.8 a	78.3 b	79.1 b
	Mean for pruning method Średnia dla sposobu cięcia	65.4 a	73.1 a	73.9 a	

* and ** Explanations, see Table 1.

Table 3. Growth of peach trees on different rootstocks after regeneration pruning, 3 year after pruning, autumn 2008
Tabela 3. Wzrost drzew brzoskwini na różnych podkładkach po cięciu regeneracyjnym, 3 rok po cięciu, jesień 2008

	Rootstock Podkładka	Method of trees pruning – Sposób cięcia drzew			Mean for rootstock Średnia dla podkładki
		Control Kontrola K1	Shortening branches Skracanie gałęzi K2	Trees pruned at 1.5 m and shortening branches Cięcie drzew na 1,5 m i skracanie gałęzi K3	
Tree crown projection, m^2 Projekcja koron drzew, m^2	Manchurian Peach – Brzoskwinia Mandżurska	10.4 abc*	8.7 ab	9.6 abc	9.6 a
	Sand Cherry – Wisienka stepowa	10.9 bc	8.2 a	8.3 a	9.1 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	11.9 c	10.5 abc	10.3 abc	10.9 b
	Mean for pruning method Średnia dla sposobu cięcia	11.1 b	9.1 a	9.4 a	
TCSA, cm^2 PPPP, cm^2 **	Manchurian Peach – Brzoskwinia Mandżurska	75.5 b	71.8 b	81.6 bc	76.3 a
	Sand Cherry – Wisienka stepowa	58.1 a	81.0 bc	75.9 b	71.7 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	83.5 bc	85.9 bc	91.3 c	86.9 b
	Mean for pruning method Średnia dla sposobu cięcia	72.4 a	79.6 ab	82.9 b	

* and ** Explanations, see Table 1.

Table 4. Longshoots characteristic after regeneration pruning, 1 year after pruning, autumn 2006
Tabela 4. Charakterystyka długopędów po cięciu regeneracyjnym, 1 rok po cięciu, jesień 2006

	Rootstock Podkładka	Method of trees pruning – Sposób cięcia drzew			Mean for rootstock Średnia dla podkładki
		Control Kontrola K1	Shortening branches Skracanie gałęzi K2	Trees pruned at 1.5 m and shortening branches Cięcie drzew na 1,5 m i skracanie gałęzi K3	
Number of shoots with diameter ≥0.5 cm Liczba długopędów o średnicy ≥0.5 cm	Manchurian Peach – Brzoskwinia Mandżurska	5.3 ab*	6.0 b	5.8 ab	5.7 a
	Sand Cherry – Wisienka stepowa	6.0 b	4.2 a	5.2 ab	5.1 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	5.3 ab	5.0 ab	5.7 ab	5.3 a
	Mean for pruning method Średnia dla sposobu cięcia	5.6 a	5.1 a	5.6 a	
Mean length of shoots with diameter ≥0.5 cm, cm Średnia długość długopędów o średnicy ≥0,5 cm, cm	Manchurian Peach – Brzoskwinia Mandżurska	42.0 a	50.7 abc	57.3 bc	50.0 ab
	Sand Cherry – Wisienka stepowa	38.0 a	51.0 abc	44.3 ab	44.4 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	43.3 ab	56.8 bc	60.7 c	53.6 b
	Mean for pruning method Średnia dla sposobu cięcia	41.1 a	52.8 b	54.1 b	
Summaric length of shoots with diameter ≥0.5 cm, m Sumaryczna długość długopędów o średnicy ≥0,5 cm, m	Manchurian Peach – Brzoskwinia Mandżurska	232.7 ab	309.2 ab	325.5 b	289.1 a
	Sand Cherry – Wisienka stepowa	229.0 ab	209.7 a	270.0 ab	236.2 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	230.0 ab	285.8 ab	322.0 b	279.3 a
	Mean for pruning method Średnia dla sposobu cięcia	230.6 a	268.2 ab	305.8 b	

* Explanations, see Table 1.

Table 5. Longshoots characteristic after regeneration pruning, 2 year after pruning, autumn 2007
Tabela 5. Charakterystyka długopędów po cięciu regeneracyjnym, 2 rok po cięciu, jesień 2007

	Rootstock Podkładka	Method of trees pruning – Sposób cięcia drzew			Mean for rootstock Średnia dla podkładki
		Control Kontrola K1	Shortening branches Skracanie gałęzi K2	Trees pruned at 1.5 m and shortening branches Cięcie drzew na 1,5 m i skracanie gałęzi K3	
Number of shoots with diameter ≥0.5 cm Liczba długopędów o średnicy ≥0.5 cm	Manchurian Peach – Brzoskwinia Mandżurska	5.0 d*	2.8 b	4.3 cd	4.06 b
	Sand Cherry – Wisienka stepowa	2.0 a	2.8 b	4.2 c	3.00 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	4.2 c	3.3 b	4.3 cd	3.94 b
	Mean for pruning method Średnia dla sposobu cięcia	3.72 b	3.00 a	4.28 c	
Mean length of shoots with diameter ≥0.5 cm, cm Średnia długość długopędów o średnicy ≥0,5 cm, cm	Manchurian Peach – Brzoskwinia Mandżurska	33.3 bcd	29.8 abc	36.7 de	33.3 b
	Sand Cherry – Wisienka stepowa	26.0 a	29.0 ab	33.5 bcd	29.5 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	36.2 cde	34.3 bcde	40.2 e	36.9 c
	Mean for pruning method Średnia dla sposobu cięcia	31.8 a	31.0 a	36.8 b	
Summaric length of shoots with diameter ≥0.5 cm, m Sumaryczna długość długopędów o średnicy ≥0,5 cm, m	Manchurian Peach – Brzoskwinia Mandżurska	170.0 cd	84.5 ab	159.5 cd	138.0 b
	Sand Cherry – Wisienka stepowa	52.0 a	83.0 ab	141.5 cd	92.2 a
	Rakoniewicka Seedling – Siewka Rakoniewicka	160.8 cd	124.3 bc	177.2 d	154.1 b
	Mean for pruning method Średnia dla sposobu cięcia	127.6 b	97.3 a	159.4 c	

* Explanations, see Table 1.

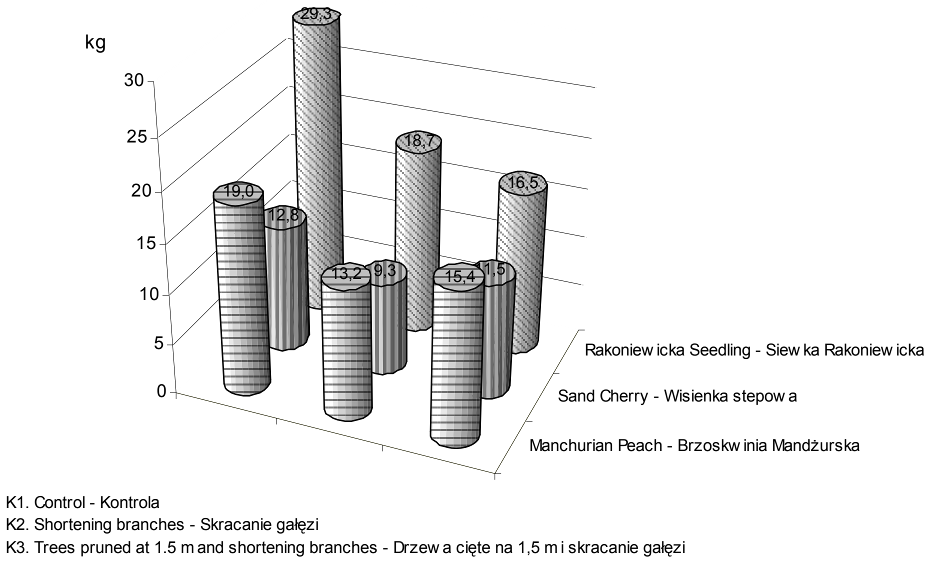


Fig. 1. Effect of pruning method and rootstock on yielding of peach 'Harbinger' in 2008 (kg·tree^{-1})
Rys. 1. Wpływ sposobu cięcia i podkładki na plonowanie brzoskwini 'Harbinger' w 2008 (kg·drzewo^{-1})

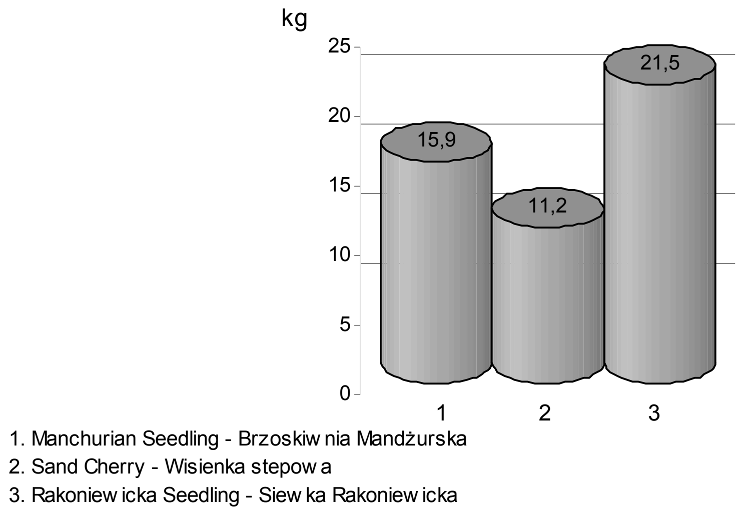
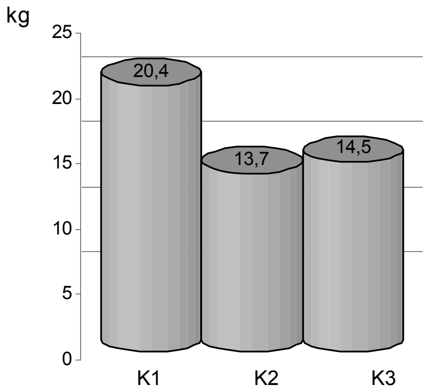


Fig. 2. Effect of rootstock on yielding of peach 'Harbinger' in 2008 (kg·tree^{-1})
Rys. 2. Wpływ podkładki na plonowanie brzoskwini 'Harbinger' w 2008 (kg·drzewo^{-1})

Measurement of stem thickness has shown differences, both for the particular pruning combinations and for the rootstocks in the successive years of studies. The thickest trunks were found every year in the trees which were intensively pruned and lowered to the height of 1.5 m (K3), as well as in trees grown on Rakoniewicka Seedling rootstock (tables 1, 2 and 3).



K1. Control - Kontrola
K2. Shortening branches - Skracanie gałęzi
K3. Trees pruned at 1.5 m and shortening branches - Drzewa cięte na 1,5 m i skracanie gałęzi

Fig. 3. Effect of pruning method on yielding of peach 'Harbinger' in 2008 (kg·tree^{-1})
Rys. 3. Wpływ sposobu cięcia na plonowanie brzoskwini 'Harbinger' w 2008 (kg·drzewo^{-1})

In 2007, because of the severe ground frost in spring, the trees did not yield. The year 2008 was the first yielding year after the radical pruning. The yield was differentiated by the levels of pruning and by the rootstocks. From the not pruned control trees, the amount of fruits was significantly greater (on the average over 20 kg from one tree) (fig. 1). The greatest number of fruits was harvested from the not pruned trees grown on Rakoniewicka Seedling rootstock. In each pruning combination, the best yield was obtained on this particular rootstock. The next good rootstock was the Manchurian Peach (fig. 2). The poorest yields were obtained in each pruning combination from trees on Sand cherry rootstock. Intensive pruning of frozen trees caused in the third year after treatment a yield decrease by about 30% in relation to control combination (fig. 3). In another experiment conducted in years 2006–2008 on trees 'Harbinger' cultivar with crown vase form and intensively pruned on height 1.5 and 1.0 m obtained similar results. The best yielding were control trees, not pruned. Trees pruned the most intensively gave yield 40% lower, but respectively trees pruned on 1.5 m gave yield 30% lower than control trees [Radajewska and Szklarz 2008]. Intensive tree pruning, particularly in K3 (where also the tree height was decreased) limited the fruit-bearing zone in spite of an intensive reconstruction of that part of tree crown with the long-shoots (more than 30 cm long) being the most valuable ones for fruiting [Marini 2002]. The long--shoots were also more than 0.5 cm thick. Therefore, intensive pruning of frostbitten trees should always be previously individually exactly analysed for each orchard, taking into consideration the degree of damages caused by frost and the losses and advantages following from such intensive treatment. However, one must expect that the tree height will be restored after a few years and the more advantageous tree dimensions as well as the associated with it easier fruit harvest will compensate the losses caused by decreased tree height in the first year after pruning.

CONCLUSIONS

1. Intensive regenerative pruning of frostbitten trees causes a very strong compensating growth of trees directly after pruning.
2. Decreased crown reach of the pruned trees remain for several years after the treatment.
3. Decreased tree crowns during pruning deprive the trees of some part of the fruit-bearing zone and decrease thereby the yield by about 30%, as compared with the not pruned control trees.
4. Decision about intensive pruning of frostbitten trees should be taken carefully considering the individual conditions of each orchard and analysing the advantages and losses resulting from such treatment.

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WZROST I PLONOWANIE DRZEW BRZOSKWINI PO CIĘCIU REGENERACYJNYM

Streszczenie. W latach 2006–2008 w Przybrodzie koło Poznania badano drzewa brzoskwini ‘Harbinger’ na podkładkach: Siewka Mandżurska, Wisienka stepowa i Siewka Rakoniewicka o koronie wrzecionowej, silnie uszkodzone przez mróz zimą 2005/2006. W maju 2006 r. przeprowadzono intensywne cięcie drzew. Celem badań była ocena wpływu cięcia i podkładek na proces regeneracji i plonowanie przemarzniętych drzew. Cięcie spowodowało obniżenie wysokości drzew oraz zasięgu koron w stosunku do kontroli. Grubsze były pnie drzew silnie ciętych od kontrolnych. Cięcie drzew spowodowało obniżenie plonu w 3 roku po cięciu o około 30% w stosunku do kontroli. Najlepiej plonowały drzewa na podkładce Siewka Rakoniewicka, a najsłabiej na Wisience stepowej.

Słowa kluczowe: wzrost, brzoskwinia, cięcie regeneracyjne, podkładka, plonowanie

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