ASSESSMENT OF AMOUNT OF WOOD FROM PRUNED APPLE ORCHARDS AS A SOURCE OF RENEWABLE ENERGY

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A B S T R A C T

The aim of the studies was to assess the amount of wood to be gained during the pruning of apple orchards. The trials were carried out on the following cultivars of apple: 'Jonagold', 'Elstar', 'Idared', 'Jonica', and 'Rubinstar'. The chosen orchards in which the estimations took place had different interrow widths, tree distances and tree ages. The widths of interrows were from 3.5 m to 4.4 m. The distances between trees were from 1.5 m to 2.5 m. The ages of the trees were from 4 to 17 years. Pruned branches were manually collected from interrows along 20 grown trees. The mass of branches cut from a single tree, and the total mass of wood gathered on 1 hectare of orchard were calculated. The obtained results showed significant variability from 21% to 77%, between replications. This variability depended on cultivar and tree age. According to expectations, the highest amount of cut wood was achieved from the oldest, 17-year-old trees of the 'Elstar' cultivar. The mass of the branches cut from one 'Elstar' tree was from 1.92 kg to 2.43 kg, which means 3.7-4.6 tons of wood from 1 ha of the orchard. Of the 4-6-year-old trees of three cultivars: 'Rubinstar', 'Jonica' and 'Jonagold', grafted on M.26 rootstock,, less wood was achieved from 'Jonica' tree – 1.59 kg, on average. The highest wood mass gave 'Rubinstar' – 2.27 kg per tree, on average. Significant differences were observed in different years of the studies when young trees became older. The most wood came from 'Rubinstar' – 960, 1700 and 2050 kg per hectare, in the 4th, 5th and 6th year of the study, respectively. In the same years 'Jonica' gave 780, 630 and 1450 kg/ha, respectively. In middle-aged orchards with 'Jonagold' and 'Idared', significantly more wood was obtained after cutting 'Jonagold' trees: 2100, 2000 and 2550 kg/ha, than after cutting 'Idared' trees: 780, 1440 and 1350 kg/ha in the 8th, 9th and 10th year of cultivation, respectively.

Key words: apple orchard, pruning, energy resources, wood from orchard

INTRODUCTION

Calorific value of dry wood is 13.6-14.6 MJ/kg and is similar to calorific value of brown coal, which is 7.5-18.8 MJ/kg (Kaleta and Wojdalski, 1995). Because of its low price, wood is an important source of energy in many households all over the world. It is also valuable because it emits fumes that are less harmful to the environment, and a relatively small amount of ashes remains after burning wood. These are the reasons why wood is considered to be one of the most valuable biofuels. The role of wood in the environment-friendly economy will continue to grow. National forests are the most important sources of acquired wood. Plantations with fast growing trees (willow, poplar) are also set up, but running them requires expensive agrotechnological treatment and protection.

A great amount of wood which annually remains in orchards and fruit plantations after pruning and as an effect of plantation renewal, can be used for an energy purpose. Now in Poland, the orchard area under cultivation is 336 thousand hectares (GUS, 2007), 258 thousand hectares are fruit trees, including 172 thousand hectares of apple trees. The amount of wood gained during pruning from apple orchards can be assessed as 1-5 tons per ha of cultivated area annually. Jagielski et al. (1988) estimated that depending on the cultivar, type of rootstock and age of apple trees, the mass of brunches cut from a single tree is 3-20 kg. Such a range is due to the different age of trees, growth vigour depending on the rootstock used, the nutrient contents in the soil and climatic conditions. Now, in most orchards, wood obtained from pruned trees is ground down and mulched in interrows or burnt in bonfires within the orchards. As a source of energy, it is used on a local scale, mainly in individual households or for a few buildings (schools, district buildings), which specialize in using renewable fuel. A new technology must be developed and expensive specialistic equipment must be purchased to arouse more interest in such a way of gaining fuel. The effectiveness of such undertakings will depend on the amount of wood that can be acquired. Up till now, there have been no in-depth data showing how much wood can be gained during pruning in productive orchards. Because of a growing interest in renewable energy, studies aimed at assessing the amount of wood from pruned apple orchards were undertaken. The practical aim of the study was to provide the data for calculating the economical efficiency of this renewable source of energy, on the individual orchard scale or regional scale.

MATERIAL AND METHODS

The studies were conducted in the years 2005-2007 during winter pruning in apple orchards located near Skierniewice, Poland. Three plots in orchards were chosen depending on the age of trees: young orchard (5-years-old), middle-aged

orchard (10-years-old) and old orchard (15-years-old). In the youngest orchard, planted with 'Jonica', 'Rubinstar' and 'Jonagold' grafted on M.26, the tree spacing was 4.4 x 2.5 m. In the older orchard, planted with 'Idared' and 'Jonagold', also grafted on M.26, the tree spacing was 4.0 x 2.5 m. In the oldest plot with 'Elstar' and 'Šampion' cultivars (both grafted on M.26), the tree spacing was 3.5 x 1.5 m and 4.0 x 1.8 m, respectively. Every season pruning was conducted by the same group of workers. Pruned branches were collected manually from interrows along 20 grown trees. The cut branches were weighed on electronic scales to an accuracy of 0.10 kg. The medium mass of wood cut from a single tree and the total mass of wood gathered on 1 ha of an orchard were calculated. The obtained results were elaborated statistically using the analysis of variance. The significance of differences between means were assessed with the Duncan Multiple Range Test at $p = 0.05$.

RESULTS AND DISCUSSION

In young plots of a 4-6-year-old apple orchard, the amount of wood gained in separate years of the studies differed significantly for all three cultivars (Tab. 1). As the trees grew older, the mass of pruned branches was 2-3 times higher. The lowest amount of branches from a single tree grown on young plots, was obtained during the pruning of 'Jonica' (0.97 kg per tree on average in the years 2005-2007), and the highest amount was obtained during pruning of 'Rubinstar' (1.73 kg on average in the years 2005-2007). Significant differences were observed in the mass of branches from 1 ha, of young plots, in different years of the studies. The highest amount of cut wood on the young plots was achieved from the 'Rubinstar' cultivar. The mass of branches in 'Jonica' was half the amount until the 5th year of cultivation. 'Rubinstar' and 'Jonagold' reached an amount of around 2 tons of branches per hectare in the 6th year.

In 10-year-old plots of 'Jonagold' and 'Idared', it was 'Jonagold' which gave twice as much cut wood (2100, 2000 and 2550 kg) (Tab. 2). No significant differences were observed between the amounts of wood achieved in a 9- and 10-year-old orchard with 'Idared'. A similar mass of cut wood was also achieved from 8- and 9-year-old plots with 'Jonagold'. Taking into account the fact that the same cultivar in a different 6-year-old orchards gave about 2 tons of wood per ha (Tab. 1), can be assumed that the average amount of branches after winter pruning of trees on M.26 rootstock with a tree spacing of 4 x 2.5 m, will remain at the same level from the 6th year of cultivation.

The highest mass of branches was obtained during pruning 15-17-year-old orchards. A single tree gave 1.4-3.2 kg of wood (Tab. 3). Noticeable and statistically significant differences were observed in different years of the studies. In the 16th year of cultivation 'Šampion' cultivar gave twice as much cut wood than

Table 1. Mass of wood obtained from pruning a young 4-6-year-old apple orchard for 3 successive seasons

Cultivar	Tree spacing [m]	Mass of wood according to the age of trees					
		per tree [kg]			per hectare [kg ha^{-1}]		
		4 years	5 years	6 years	4 years	5 years	6 years
Jonica	4.4 x 2.5	0.53 a*	0.69 a	1.59 c	483 a	628 a	1445 c
Rubinstar	4.4 x 2.5	1.06 b	1.88 d	2.27 e	959 b	1708 d	2059 e
Jonagold	4.4 x 2.5	0.76 a	1.16 b	2.11 de	690 a	1055 b	1918 de

*Means followed by the same letter are not significantly different (ANOVA, Duncan Multiple Range Test, p = 0.05)

Table 2. Mass of wood obtained while pruning of 8-10-year-old apple orchard during 3 successive seasons

Cultivar	Tree spacing [m]	Mass of wood according to the age of trees					
		per tree [kg]			per hectare [kg ha^{-1}]		
		8 years	9 years	10 years	8 years	9 years	10 years
Idared	4.0 x 2.5	0.78 a*	1.44 b	1.35 b	780 a	1439 b	1348 b
Jonagold	4.0 x 2.5	2.11 c	2.00 c	2.55 d	2108 c	2003 c	2549 d

*Explanations: see Table 1

Table 3. Mass of wood obtained while pruning of a 15-17-year-old apple orchard during 3 successive seasons

Cultivar	Tree spacing [m]	Mass of wood according to the age of trees					
		per tree [kg]			per hectare [kg ha^{-1}]		
		15 years	16 years	17 years	15 years	16 years	17 years
Elstar	3.5 x 1.5	1.73 a*	3.04 c	2.22 b	3300 b	5787 d	4225 c
Šampion	4.0 x 1.8	1.36 a	3.16 c	1.80 ab	1883 a	4387 c	2495 a

*Explanations: see Table 1

the year before. Many more (75% more) branches were also pruned in the plot with 'Elstar'. The observed differences were caused by different conditions of growth in successive years and different intensity of pruning. Bigger crown growth requires more intensive pruning, which causes the growth of the mass of cut elements of the crown.

The results of this study do not confirm the results of previous studies according to which the mass of wood gathered during pruning apple

orchards was 20 kg per tree (Jagielski et al., 1988). The highest amount of wood that can be obtained from intensive orchards is less than 3 kg per tree annually. It is possible, however, to obtain more in older orchards of between ten and twenty years with trees grafted on M.26. A total mass of branches gained from such orchards was from 2 t/ha to more than 5 t/ha, on average 3.0-4.4 t/ha annually. In younger orchards, the amount of cut wood depended on the cultivar and the age of trees. Before the 4th year of cultivation 1 ton of wood per ha is the highest amount that can be expected, and for poorer growing cultivars ('Jonica') even half of that amount.

'Jonagold' and 'Rubinstar' did not reach the level of 2 tons per hectare until the 6th year of cultivation. 'Jonagold' gave a similar mass of cut wood (2.05 t/ha on average) in a different orchard with 8-9-year-old trees. In the same plot, 'Idared' gave only 40-70% of this amount. It might be expected, that in average conditions, the amount of cut wood from 10 year old plots would be around 2 tons per hectare annually.

Assuming that all wood remaining in the apple orchards in Poland might be collected – the total quota will reach over 300 000 tons of an ecological energy resource. It is a large amount, especially when Poland has to reach (by the year 2020) a level in which 20% of its total energy is obtained from renewable resources. It should be emphasized that wood is an ecological source of energy. Wood smoke is not as dangerous for the environment, and the amount of ashes is relatively small and could be used as natural fertilizer.

CONCLUSIONS

The mass of wood gained during pruning from apple orchards depends on the age of trees and growth vigour of individual cultivars. In young orchards, for strong growing cultivars ('Rubinstar' and 'Jonagold' grafted on M.26), it is possible to obtain 2 t/ha but not before the 6th year of cultivation. Only 37-72% of this mass is gained from 'Jonica' and 'Idared' trees grafted on the same rootstock. The highest amount of pruned branches, almost 3 kg per tree annually can be obtained in ten and twenty year old orchards. The total mass of wood gained from such orchards is from 2 t/ha to more than 5 t/ha, on average 3.0-4.4 t/ha annually.

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OCENA ILOŚCI DREWNA ENERGETYCZNEGO POZOSTAJĄCEGO PO CIĘCIU SADÓW JABŁONIOWYCH

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S T R E S Z C Z E N I E

Celem badań było określenie ilości drewna pozostającego po cięciu pielęgnacyjnym sadów jabłoniowych. Obserwacje prowadzono przez trzy sezony, podczas produkcyjnego cięcia sadów towarowych z drzewami (na podkładce M.26) pięciu odmian: 'Jonagold', 'Elstar', 'Idared', 'Jonica' oraz 'Rubinstar'. Szerokość międzyrzędzi wynosiła 3,5-4,4 m, odległość między drzewami w rzędach od 1,5 do 2,5 m. Obcięte gałęzie zbierano z całej szerokości międzyrzędzi z odcinków wyznaczonych wzdłuż 20 kolejnych drzew. Masę uzyskanego drewno przeliczano na pojedyncze drzewo oraz jeden hektar powierzchni sadu. Najwięcej gałęzi pozostawało po cięciu najstarszych drzew, 17-letnich kwater z odmianą 'Elstar'. Z pojedynczego drzewa uzyskiwano od 1,92 kg do 2,43 kg, co daje 3,7-4,6 t drewna z powierzchni hektara. W sadach najmłodszych, w wieku 4-6 lat z odmianami 'Rubinstar', Jonica' oraz 'Jonagold', najmniej gałęzi uzyskano z odmiany 'Jonica' (średnio 1,59 kg/drzewo), najwięcej z odmiany 'Rubinstar' (2,27 kg/drzewo). Istotne różnice obserwowano w kolejnych latach uprawy wraz ze starzeniem się drzew. W 4, 5 i 6 roku uprawy najwięcej gałęzi pozostawało po cięciu 'Rubinstara', odpowiednio: 960, 1700 i 2050 kg/ha. W tym samym okresie masa gałęzi pozyskanych na odmianie 'Jonica' wynosiła: 780, 630 oraz 1450 kg/ha. W kwaterach odmian 'Jonagold' i 'Idared', w 8, 9 i 10 roku uprawy większą masę gałęzi uzyskano podczas cięcia 'Jonagolda', odpowiednio: 2100, 2000 oraz 2250 kg/ha. Istotnie mniej gałęzi dała odmiana 'Idared': 780, 1440 oraz 1350 kg/ha.

Słowa kluczowe: sad jabłoniowy, cięcie, źródła energii, drewno z sadu