

EFFICIENCY OF PRUNING SCOTS PINE (*PINUS SYLVESTRIS* L.) USING DIFFERENT TYPES OF SAWS

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Abstract. The study assessed pruning efficiency of Scots pine (*Pinus sylvestris* L.) using different types of specialist pruning saws. Elements used in the study included the diameter and number of removed knots, pruning time per tree and passage time from one tree to another.

Key words: tree pruning, pruning efficiency, pruning tools, Dauner saw, Bushman saw, Hengst saw, Deutsche model

INTRODUCTION

Pruning is a procedure preceding the natural process of clearance of branches, i.e. self-pruning. As a result it reduces the occurrence of knots and increases the clean wood zone. Pruning eliminates the rotten knot zone, limits the occurrence of the dead knot zone and makes it possible to obtain an extensive zone of clean wood. According to studies by numerous authors, "approx. 70% large-sized pine timber, 82-91% spruce timber, 92% Douglas fir timber and 50-80% fir timber may not be classified to higher quality classes due to knot incidence. The frequency of other defects is much lower and pertains to maximum 4.5% classified pines" [Giefing 1994]. Thus we may state that at least 2/3 large-sized timber may not be classified to higher quality classes due to knot incidence.

Appropriate performance of a pruning procedure is affected by the selection of appropriate methods, dates, pruning rate, tools and techniques. Used tools for pruning have an effect on time consumption and labour productivity. At present there are many different specialist types of pruning saws available on the market. In this study four types of saws were used: the Dauner saw, Bushman saw, Hengst saw and the Deutsche model. The use of appropriate tools not only ensures reduced time consumption of the procedure, but also reduces the risk of infection and damage to the tree.

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THE SITE AND METHODOLOGY OF THE STUDY

Tests were conducted at a seed orchard of Scots pine (*Pinus silvestris* L.), established in 1983 at the Zdrojowa Góra Forest District, the Regional Directorate of State Forests in Piła. Trees were pruned at the age of 12 years to the height of 1.5 m, realizing 1st degree pruning at optimal date. Four types of saws were used: the Dauner, Bushman, Hengst and the Deutsche model. They were, after Giefing [1999]:

- “Bushman” straight saw with a wood handle, of 260 g and saw blade 400 mm long, for pruning up to the height of 2.0-2.2 m,
- “Deutsche model” straight saw with a wood handle, of 150 g and saw blade 350 mm long, for up to the height of 2.0-2.2 m,
- “Hengst” straight large-toothed saw, of 960 g and saw blade 715 mm long; for pruning above the height of 2.0 m, adapted to be mounted on a “Helms” extension arm,
- “Dauner” web-saw of 880 g, with saw blade 500 mm long, and triangular toothing.

A total of 110 trees were pruned in the study. Factors affecting the time consumption and efficiency of the pruning procedure include among others the diameter of branches and their number. For each tree all diameters of removed knots were measured, and classified to the adopted diameter classes: 0.0-3.0 mm, 3.1-5.0 mm, 5.1-7.0 mm and above 7.1 mm. For each tree effective working time (T_1) and auxiliary time (T_2) were measured accurate to 1 s. Effective working time was measured from the moment the saw was put to the first branch until the last branch on a given tree was removed (the time of tool transfer from one branch to the next was very short and it was disregarded). Auxiliary time of labour was the time, which the worker spent moving with the saw after the removal of the last branch on a given tree until the saw was put to the first branch on the next tree. Operation time of labour T constituted the total of effective time of labour (T_1) and auxiliary time (T_2).

RESULTS

Pines in the plantation were growing at the initial spacing of 4.0×4.0 m, and after loosening up it was 8.0×8.0 m. A lack of competition and side shading contributed to the excessive growth of lateral branches and stopped self-pruning. The diameter of the thickest removed branches exceeded 8 cm inside bark. It was analysed whether the value of the diameter of removed branches varied depending on the used tool. Analysis of variance showed a lack of statistically significant differences between knot diameters and used tools in the following diameter classes: 3.1-5.0, 5.1-7.0 and 7.0- ∞ . The only statistically significant differences were found between saw types for knots with a diameter of 0.0 cm to 3 cm. In this case the calculated f value was bigger than the f value from the table ($f_{\text{obl.}} > f_{\text{tab.}}$) and the value of the actual error p was lower than 0.05. Further analysis of variance using the RIR Tukey test showed that they are differences between the Hengst and Deutsche model saws, and between the Bushman and Deutsche model saws (Fig. 1). These differences probably resulted from the fact that the Deutsche model saws in the diameter class of 0.0-3.0 mm was used to remove the biggest number of knots, the mean number per 1 tree in this class was almost 14, while for the other saws it was from 10 to 12 knots (Fig. 1).

HSD (unequal N); variable 0-3, const. efficiency Marked differences are significant at $p < 0.05$ HSD (nierówne N); zmienne 0-3, wydajność stała Zaznaczone różnice są istotne z $p < 0,05$				
Types of saws Typy pił	{1} M = 12.607	{2} M = 10.036	{3} M = 10.074	{4} M = 13.815
Dauner {1}		0.248359	0.276116	0.824784
Hengst {2}	0.248359		0.999994	0.040320
Bushman {3}	0.276116	0.999994		0.043269
Deutsche model {4}	0.824784	0.040320	0.043269	

Fig. 1. The RIR Tukey's test for unequal numbers between diameters of removed knots in diameter class from 0.0 to 3.0 cm and used saw types

Rys. 1. Test RIR Tukeya dla nierównych liczebności między średnicą usuwanych sęków w klasie grubości od 0,0 do 3,0 cm a użytymi typami pił

While analysing the number of removed branches in individual diameter classes (Fig. 2) it may be observed that 63% were knots from 0.0 to 3.0 cm in diameter. In terms of the mean number of removed branches from each tree in individual diameter classes using different saw types the values were comparable (Fig. 3). Analysis of variance showed a lack of statistically significant differences between types of saws and the number of knots removed with these saws up to the height of 1.5 m. For knots with a diameter from 0.0 to 3.0 cm on average on 1 tree there were from 10.4 to 13.81, for diameter class of 3.1-5.0 cm there were from 5.27 to 6.52 knots. Bigger knots from the diameter class of 5.1-7.0 cm were fewer, i.e. from 1.1 to 2.06, while for the diameter class of above 7.1 cm there were on average from 1 to 2 per tree. The mean number of knots removed from 1 tree up to the height of 1.5 m ranged from 17 to 19.

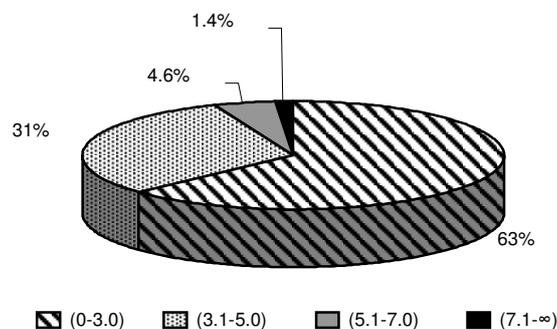


Fig. 2. The percentage of removed knots in different diameter classes

Rys. 2. Procentowy udział usuwanych sęków w różnych klasach grubości

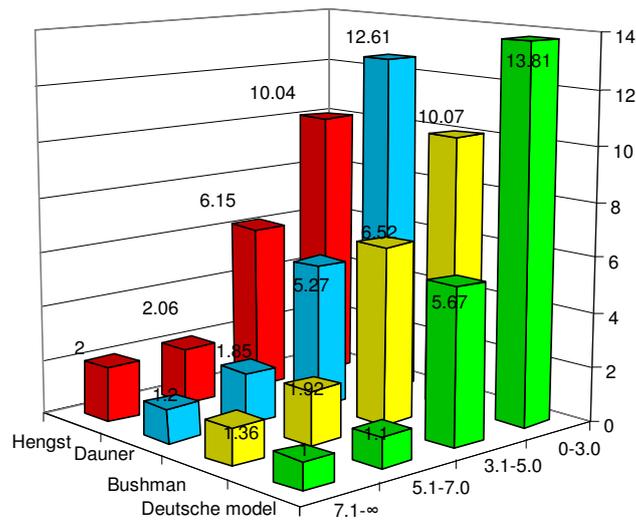


Fig. 3. Mean number of removed knots per 1 tree in a given diameter class

Rys. 3. Średnia liczba usuniętych sęków dla jednego drzewa w danej klasie grubości

Effective time of pruning per 1 tree depending on the applied types of saws was the most advantageous for the Dauner saw, amounting to 2 min 30 s. The effective time of pruning 1 tree with the Hengst saw was two times longer, i.e. 5 min 12 s (Fig. 4). One-way analysis of variance for effective time of removing all branches from 1 tree up to the height up to 1.5 m and different types of saws showed that the differences are statistically significant for $f_{\text{obl.}} > f_{\text{tab.}}$ (Fig. 5). Following analysis of variance the RIR Tukey test was performed for unequal sample sizes. Significant differences in pruning time were found between the Hengst saw and the three other saws (Fig. 6). The shortest

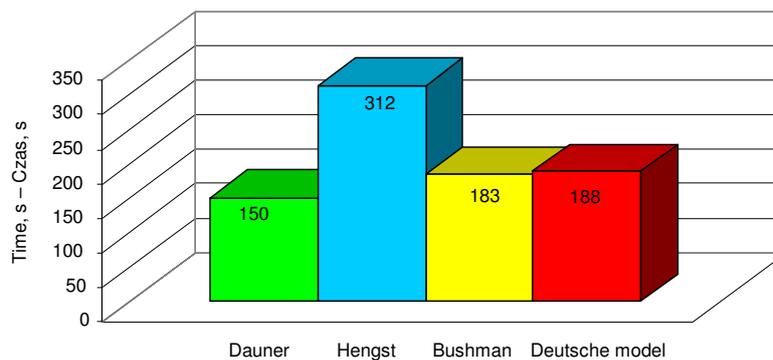


Fig. 4. Mean pruning time per 1 tree for different types of saws

Rys. 4. Średni czas podkrzesywania jednego drzewa dla różnego typu pił

Analysis of variance – Analiza wariancji						
Source of variance Źródło wariancji	SS	df	MS	F	Value p	F test
Type of saw Typy pił	413 012.6	3	137 671	11.63705	1.27E-06	2.693724
Within one group W obrębie grup	1 206 700	102	11 830			
Total – Razem	1 619 713	105				

Fig. 5. Analysis of variance for pruning time for different types of saws

Rys. 5. Analiza wariancji czasu podkrzesywania przez różne typy pił

HSD (unequal N); variable – mean cutting time (const. efficiency) Marked differences are significant at $p < 0.05$ HSD (nierówne N); zmienna – średni czas cięcia (wydajność stała) Zaznaczone różnice są istotne z $p < 0,05$				
Types of saws – Typy pił	{1} M = 149.86	{2} M = 312.46	{3} M = 183.37	{4} M = 187.74
Dauner {1}		0.000139	0.670399	0.577577
Hengst {2}	0.000139		0.000297	0.000422
Bushman {3}	0.670399	0.000297		0.998927
Deutsche model {4}	0.577577	0.000422	0.998927	

Fig. 6. The RIR Tukey's test for unequal numbers of pruning time between different types of saws

Rys. 6. Test RIR Tukeya dla nierównych liczebności czasu podkrzesywania między różnymi typami pił

effective time of branch removal was recorded for the Dauner saw. It needs to be remembered that there were no statistically significant differences between parameters of knots in diameter classes of 3.1-5.0, 5.1-7.0 and 7.0-∞, and the number of removed branches using individual types of saws. Statistically significant differences were found in diameter class of 0.0-3.0, but they did not pertain to the Dauner saw.

While analysing the mean pruning time for saws depending on the diameter of knots also the Dauner saw showed the best efficiency, irrespective of the diameter of knots (Fig. 7), removing all branches in the shortest time.

DISCUSSION

First remarks on the analysis of tools used for pruning come from the turn of the 19th and 20th centuries [Guillebaud 1933, Laar 1966, May 1889, 1890]. Various tools were used for the procedure, but their efficiency or the effect on pruning results were not analyzed. In mid-1900's the first saw for tree pruning appeared on the market [Sterzik 1968], and world literature on the subject presented numerous studies concerning the advantages of this procedure. Results of those studies were transferred to forest practice and were further developed.

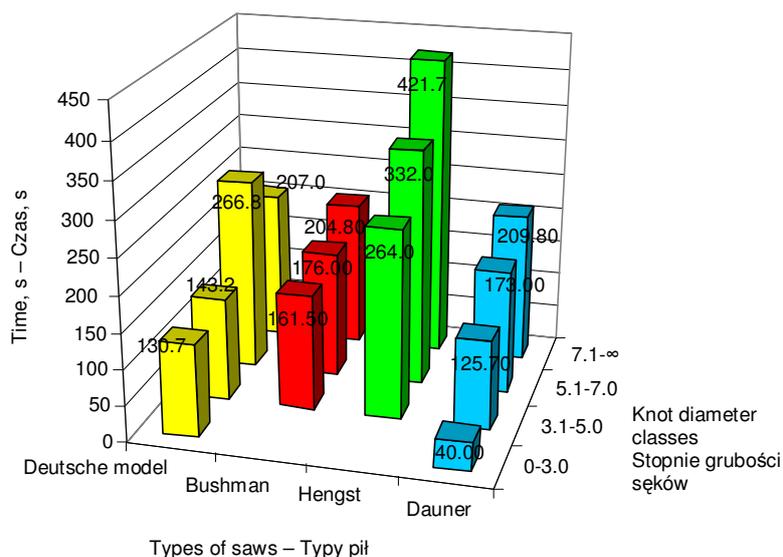


Fig. 7. Mean pruning time depending on knot diameters
Rys. 7. Średni czas podkrzesywania w zależności od grubości sęków

This study concerns the effective pruning time of pines growing in a seed orchard. Trees were 12 years and were pruned to the height of up to 1.5 m. Mean effective pruning time of pines with large branches, depending on the used type of saw was as follows: the Dauner saw – 2 min 30 s, the Bushman saw – 3 min 3 s, the Deutsche model – 3 min 8 s, the Hengst saw – 5 min 12 s. Results turned out to be statistically significant (Fig. 6). Trees used in the experiment exhibited strong branching and large knot diameters up to 8 cm inside bark. For comparison, diameters of removed branches in production stands were approx. 3 cm inside bark. In studies by Maćkowiak [1997] and Giefing and Maćkowiak [1998] in production stands the time consumption of pine pruning using different types of saws up to the height of 2.20 m did not vary statistically. Additionally, Łukowski [2003] stated that: “Up to the height of 2 m both in case of the ARS saw and the Bushman saw, the diameter of branches does not have an effect on time consumption of branch clearing”. It may be assumed that in case of pruning in production stands to the height of up to 2 m the type of used saw model is of no importance, as obtained results were similar. However, when pruning trees with large-diameter branches, where all removed branches are living, the type of used tool is of some importance.

Other studies confirmed that: “Efficiency of pruning is to a considerable degree dependent on the type of branching of trees” [Giefing et al. 1996]. For this reason publications of world literature [Dummel 1979, Göler and Ravensburg 1970] may not be accepted unquestionably, without their proper verification in Polish pine ecotypes. In the presented studies the largest removed branches had a diameter of 8 cm inside bark. In turn, due to considerable spacing (4 × 4 m) and optimal light availability over the entire length of the crown, the natural self-pruning process was stopped. A similar problem is found in production stands with open crown closure and low stocking degree, where trees exhibit strong branching. “Pruning of stands with loosened spacing and too large spaces occupied by individual trees is very time-consuming. Pines in those areas take the

character of wolf trees and are so strongly branched that even pruning the lower butt end section of their stems in the 1st class using the conventional method (0.00-2.50 m) is by 35-45% more time-consuming in comparison to closed stands" [Maćkowiak 1997].

The Dauner saw had the lowest mean effective pruning time per 1 tree up to the height of 1.5 m, amounting to 2 min 30 s. In a production stand mean pruning time for 1 tree to the height of up to 2 m using the Dauner saw was 1 min 2 s, while for the Bushman saw it was 54 s [Giefing 1996]. For comparison, the mean pruning time of 1 tree up to the height of 5 m with the Dauner saw was 4.3 min [Maćkowiak 1997]. Thus, pruning of pines with branches being large and growing rank takes 2.5 times longer than in production stands. It needs to be remembered that all removed branches were living. "Removal of living branches in production stands was by approx. 35% more time consuming than cutting dead branches" [Giefing and Łukomski 2005]. Resin bleeding during the procedure was deposited on the blade and as a result slowed the process of branch removal. On the basis of literature on the subject [Giefing and Maćkowiak 1998] it may be observed that production stands, where some branches are dead and their dimensions smaller, the Bushman saw is optimal. After Maćkowiak [1997] it may be stated that time consumption of cutting individual branches during pruning of trees in stands growing in a too fertile site and large-branched, using a given type of tool, differs statistically significantly. The obtained effective time for pruning pine in a typical coniferous forest site was by 25% lower when using a very efficient Dauner saw than it was the case for the same hand-held saw in a forest site. The larger branching rate and branches with larger diameters in a too fertile site make it more difficult to transfer the cutting tool from one branch to another and as a result it prolongs effective time of branch removal. It results from this study that the Dauner saw is recommended for large-branched stands in the 1st pruning class. The Dauner web-saw works excellent in case of strong branching and large diameter knots. Results obtained showed an even two times shorter effective pruning time in comparison with other types of saws.

CONCLUSIONS

The type of applied tool when cutting living branches up to the height of 1.5 m in case of branches with large diameters in pines has a significant effect on effective time of the performance of the procedure. Differences between types of tools are statistically significant.

Mean pruning time per 1 tree using the Dauner saw was 2 min 30 s. Effective pruning time per 1 tree with the Hengst saw was two times longer, amounting to 5 min 12 s (Fig. 4).

Removal of living branches in large-branched pines in a seed orchard is 2.5 times longer than in production stands.

REFERENCES

- Dummel G., 1979. Reichtzeiten für Douglasienwertästung mit Baumvelo. Forstl. Versuchs- und Forschungsanstalt Bad. Württ., Freiburg, Int. Versuchsbericht, 12.
- Giefing D.F., Hołota R., Stefański P., Diameterki J., 1996. Badanie pracy przy podkrzesywaniu drzew – czasochłonność i wydajność [A study of labour input at tree pruning – time consumption and productivity]. *Sylwan* 140, 1, 37-44 [in Polish].

- Giefling D.F., Łukomski H.Ł., 2005. Pruning time consumption of single branches of Scots pine (*Pinus sylvestris* L.) trees. EJPAU, Forestry, 8, 4.
- Giefling D.F., Maćkowiak Sz., 1998. Czasochłonność podkrzesywania sosny zwyczajnej (*Pinus sylvestris* L.) różnego typu piłami [Time consumption in pruning Scots pine (*Pinus sylvestris* L.) using different types of saws]. Sylwan 142, 12, 33-47 [in Polish].
- Giefling D.F., 1994. Czy warto podkrzesywać drzewa w lesie? [Is it worthwhile to prune trees in the forest?] Las Pol. 7, 7 [in Polish].
- Giefling D.F., 1999. Podkrzesywanie drzew w lesie [Pruning trees in the forest]. Wyd. AR Poznań [in Polish].
- Göler V., Ravensburg R., 1970. Die Wertästung der Kiefer in arbeitswirtschaftlicher Sicht. Dissertation, Hann. Münden [in Polish].
- Guillebaud W.H., 1933. Pruning in plantations. J. For. 27, 122.
- Laar A.V., 1966. A comparison of tools for pruning *Pinus pinaster*. South Afric. For. J. 57, 13.
- Łukomski Ł., 2003. Analiza ekonomiczna podkrzesywania sosny zwyczajnej (*Pinus sylvestris* L.) za pomocą specjalistycznej piły ARS [Economic analysis of pruning Scots pine (*Pinus sylvestris* L.) using a specialist ARS saw]. Manuscript AR, Poznań [in Polish].
- Maćkowiak Sz., 1997. Badania czasochłonności i wydajności prac przy podkrzesywaniu sosny zwyczajnej (*Pinus sylvestris* L.) w zależności od zastosowanych metod i narzędzi [A study on time consumption and productivity of labour at pruning of Scots pine (*Pinus sylvestris* L.) depending on applied methods and tools]. Kat. Użyt. Lasu AR, Poznań [typescript; in Polish].
- May R.J., 1889. Geschichte der Aufästungstechnik und Aufästungslehre. Forstwiss. Zentralbl. 16, 96.
- May R.J., 1890. Geschichte der Aufästungstechnik und Aufästungslehre. Forstwiss. Zentralbl. 84.
- Sterzik H.K., 1968. Zur Technologie der Wertästung. Forsttech. Inf. 4, 30.

OCENA WYDAJNOŚCI PODKRZESYWANIA SOSNY ZWYCZAJNEJ (*PINUS SYLVESTRIS* L.) Z ZASTOSOWANIEM RÓŻNEGO TYPU PIŁ

Streszczenie. W pracy przeprowadzono ocenę wydajności podkrzesywania sosny (*Pinus sylvestris* L.) z użyciem różnego typu specjalistycznych pił stosowanych do podkrzesywania. W pomiarach uwzględniono takie elementy, jak grubości i ilość usuwanych sęków, czas podkrzesywania jednego drzewa oraz czas przejścia od drzewa do drzewa. Badania zostały przeprowadzone na grubogałęzistych sosnach pochodzących z plantacyjnej uprawy nasiennej. Rodzaj użytego narzędzia przy obcinaniu gałęzi żywych do 1,5 m wysokości w wypadku grubogałęzistych sosen ma istotny wpływ na efektywny czas wykonania zabiegu. Różnice między typami narzędzi mają charakter statystycznie istotny. Usuwanie żywych gałęzi sosen grubogałęzistych na plantacyjnej uprawie nasiennej jest 2,5-krotnie dłuższe, niż w drzewostanach gospodarczych.

Słowa kluczowe: podkrzesywanie drzew, wydajność podkrzesywania, narzędzia do podkrzesywania, piła Dauner, piła Bushman, piła Hengst i Deutsche model

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