

HEIGHT CHANGES OF A FIVE-YEAR OLD PINE PLANTATION DEPENDING ON THE METHOD OF MANAGEMENT OF CUTTING RESIDUES AND WAY OF SOIL PREPARATION

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Abstract. The performed investigations concerned the effect of the application of different methods of management of cutting residues and ways of soil preparation on height changes of a five-year old pine cultivation. Both methods of residue management and ways of soil preparation exert a significant influence on the height of cultivation. Out of the applied five methods of management of clear-cutting residues, the following two turned out most favourable: a) the method which involved chopping of the residues and mixing them with the surface soil layer and b) leaving intact felling residues on the soil surface. On the other hand, the best way of soil preparation was ploughing furrows by a double-furrow plough with a simultaneous softening of the furrows with a subsoiler.

Key words: plantation height, Scots pine, soil preparation, cutting residues

INTRODUCTION

Biomass production in forest ecosystems depends, to a considerable degree, on the quantity of nutrients returned to the system in the form of forest litter and the extent of its degradation by soil microorganisms. Due to the alluvial process taking place in the soil which dominates in coniferous sites situated in the region of the Polish Lowland, on the one hand, and to nutrient losses following the removal of the timber raw material on the other, soil fertility decreases gradually [Wittich 1961]. Nutrient losses caused by leaching observed in natural forest soils are usually counterbalanced by nutritional elements released in the course of weathering processes derived from the forest litter as well as by substances which find their way into the soil from the atmospheric air in the form of precipitation. That is why the natural decline of soil fertility is a very slow process [Ulrich 1980].

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It is widely believed that the traditional harvesting of wood in the timber of the bole does not result in soil impoverishment because the concentration of mineral substances in timber is relatively small [Mälkönen 1976]. Investigations revealed that the harvesting, during the felling process, of the entire over ground part of Scots pine, in comparison with the harvest of the bole with bark alone, resulted in the following loss increases of biogenic elements in the forest environment: nitrogen – by 40%, phosphorus – by 55%, potassium – by 76%, calcium – by 31% and magnesium – by 22% [Gornowicz 2002]. The harvesting of felling residues leads to considerable losses in soil humus which, in turn, contributes to the decline in soil fertility and changes in soil physico-chemical properties, such as: reduced sorption capacity and regulation capability, increased water and air permeability as well as deterioration of soil structure [Kowałkowski 1983]. The removal of post-felling residues may, in the long run, accelerate the process of soil acidification [Nilsson 1987]. On the other hand, leaving cutting residues, i.e. branches and needles, on the forest soil surface does not in itself solve the problem of utilization of the post-felling residues. It seems necessary to elaborate recommendations regarding the technique of management of these residues which would, on the one hand, take into consideration the method of forest regeneration and, on the other, would not accelerate already serious changes in the forest ecosystem caused by the clear cutting process itself. In other words, it is essential to combine and coordinate two operations connected with the preparation of the post-felling area: utilization of the felling residues and soil preparation for the ensuing regeneration process.

The aim of this study was to determine the impact of different methods of utilization of felling residues and ways of soil preparation on the height of the Scots pine cultivation. With the exception of rare investigations [Gornowicz et al. 2004, Marciniak 2007], there is little literature available in Poland dealing with the complex preparation of clear cut areas for forest regeneration.

RESEARCH METHODOLOGY

The experimental surface was established on the fresh coniferous forest site situated in the Kalisz Pomorski Forest District in the 321a sub-compartment. The 90-year old stand was characterised by the following parameters: stocking – 0.8, moderate closure, mean breast height diameter – 27 cm, height – 20 m, site index – II.5, quality – 3, and large timber volume of 250 m³ per hectare. The felling operations were carried out in the first quarter of 1999 employing the system of large-area clear cutting (Ia). The felling area of 2.80 ha was divided into three rectangular blocks measuring 156 × 60 m each. Each part was then divided into five belts perpendicular to the longer side of the felling and the following methods of post-cutting residue management were employed randomly on them:

- leaving the post-felling residues intact
- removal of the post-felling residues from the surface
- burning the residues
- chopping the post-felling residues and leaving them on the surface
- chopping the post-felling residues and mixing them with the mineral soil.

The post-felling residues were chopped using an active, rotation grinder with a vertical rotation axis designed by engineer Piórkowski. The main element of the grinder is a horizontal disk with rotating beater knives fixed to its edge. Additionally, the grinder was equipped with elastic flat bars to allow them to rake the non-chopped residues. In the case of plots on which the cutting residues were chopped and then mixed with mineral soil, a disk-plough was employed additionally.

In the fourth quarter of 1999, the soil for regeneration on the experimental plots was prepared using three different methods. The blocks prepared earlier were divided into three belts parallel to the longer side of the felling on which, alternatively, the following ways of soil preparation were applied:

- ploughing furrows with the LPz-75 plough
- ploughing furrows with the active U-162 plough
- ploughing up ridges using a plough-miller.

The bottom of furrows was softened to the depth of 40 cm with the assistance of a forest subsoiler L-01 as modified by engineer Piórkowski. On the other hand, before making ridges, the soil surface was ploughed using a disk plough.

The establishment of parallel and perpendicular belts on the experimental area allowed to obtain 15 plots on each block on which different combinations of methods of the felling residue utilization as well as soil preparation were employed.

The entire experimental areas was regenerated artificially in April 2000 using one-year old planting material of Scots pine derived from the forest nursery situated in the Kalisz Pomorski Forest District. Pine seedling were wedge-planted using a stick at 1.5 m × 0.6 m spacings.

Height measurements of the five-year old plantation were conducted in the first decade of September 2004. During the measuring process, 25% of the entire experimental area was measured (every fourth row of trees), with the exception of the extreme rows. Measurements were performed with the accuracy of 1 cm using for this purpose a 2 m long measuring stick. The collected data allowed to calculate mean tree heights. In order to determine the influence of the applied methods of post-clear cutting residue management as well as the way of soil preparation on the plantation height, the calculated values were subjected to the analysis of variance. When the examined factors were determined to have exerted a significant effect on the height of the plantation, additionally the authors carried out a test of significance of differences of the mean values using Duncan's method.

RESULTS

The highest mean height of the 5-year old cultivation (140 cm) was recorded on the experimental plot where intact cutting residues were left on the surface and the soil was prepared into furrows using the LPz-75 plough (Table 1). Furthermore, the performed experiments showed that good growing results were also observed in the treatment when the felling residues were chopped and mixed with the mineral soil. The mean height of the plantation in the case of this method of the cutting residue utilisation reached 134 cm on plots where furrows were ploughed using the LPz-75 plough or the active U-162 plough and 131 cm in the treatment with ridges made using the plough-miller.

Table 1. Mean cultivation heights as affected by the applied methods of utilization of the post felling residues and way of soil preparation

Tabela 1. Średnie wysokości uprawy ze względu na zastosowane metody utylizacji pozostałości zrębowych i sposoby przygotowania gleby

Methods of utilization of the post felling residues Metody utylizacji pozostałości zrębowych	Mean cultivation heights as affected by the way of soil preparation Średnia wysokość uprawy w zależności od zastosowanego sposobu przygotowania gleby cm		
	furrows – LPz-75 bruzdy – LPz -75	furrows – active plough bruzdy – pług aktywny	ridges – plough-miller wałki – pługofrezarka
Leaving the felling residues intact Pozostawienie resztek pozrębowych w całości	140.4	130.5	127.1
Removing the felling residues on the surface Usunięcie pozostałości zrębowych z powierzchni	122.7	121.0	123.4
Burning felling residues on the surface Spalenie pozostałości zrębowych na powierzchni	116.3	118.0	125.2
Chopping post felling residues and leaving them on the surface Rozdrobienie resztek pozrębowych i pozostawienie ich na powierzchni	131.4	128.1	117.8
Chopping post felling residues and mixing them with mineral soil Rozdrobienie pozostałości i zmieszanie z glebą mineralną	134.1	134.0	131.3

The lowest mean pine heights were found in the treatments after burning the felling residues: 116 cm in the case of the plot with the furrows made using the LPz-75 plough and 118 cm – on the plantation with furrows made by the active plough U-162. The performed statistical analysis at the level of significance of $\alpha = 0.05$ showed a significant influence of the method of residue management and the way of soil preparation on the height of the examined 5-year pine cultivation. The applied Duncan's test for mean pine heights resulting from the employed methods of utilization of the cutting residues revealed that the highest cultivation (133 cm) was achieved following the chopping of the residues and mixing them with the mineral soil and after leaving post-felling residues intact on the soil surface. The lowest mean cultivation heights were recorded after chopping the residues and leaving them on the soil surface (126 cm), following the complete removal of the post-felling residues from the surface (122 cm) and after burning them (120 cm). These heights differed statistically significantly.

The performed test of the significance of differences for the pine mean heights resulting from the way of soil preparation showed that the highest cultivation height, statistically different from the remaining ways, was achieved on the plots with furrows ploughed using the LPz-75 plough – 129 cm (Fig. 2). Lower heights were recorded on plots

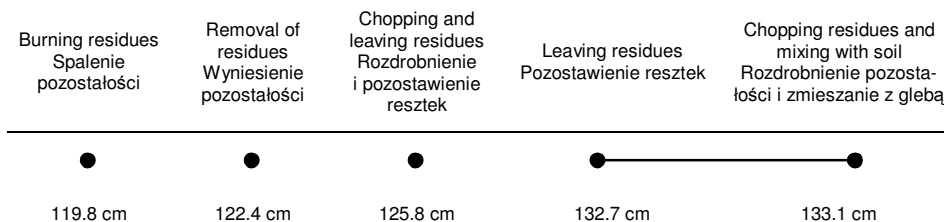


Fig. 1. Graphic presentation of Duncan's test for mean cultivation heights as affected by the method of utilization of the post-felling residues

Rys. 1. Graficzne przedstawienie testu Duncana dla średnich wysokości uprawy ze względu na metody utylizacji pozostałości zrębowych

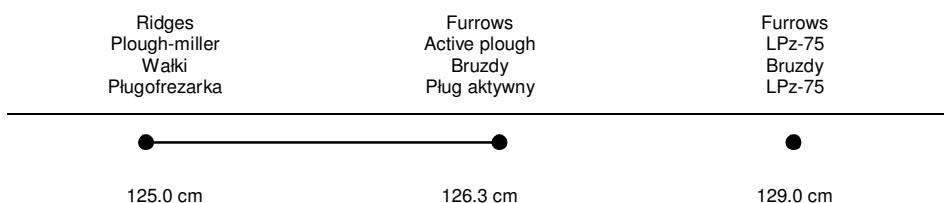


Fig. 2. Graphic presentation of Duncan's test for mean cultivation heights as affected by the way of soil preparation

Rys. 2. Graficzne przedstawienie testu Duncana dla średnich wysokości uprawy ze względu na sposoby przygotowania gleby

where the furrows were ploughed using the active U-162 plough – 126 cm and after making ridges using the plough-miller – 125 cm but differences between these heights were not statistically significant (Fig. 2).

CONCLUSIONS

The results obtained from the performed experiments allowed the authors to draw the following generalizations and conclusions:

1. Both the methods of post-felling residue management and ways of soil preparation employed in this study exerted a significant influence on the height of the 5-year pine cultivation.

2. The greatest height was recorded in the treatment where the felling residues were chopped and mixed with the top layer of the mineral soil and in the treatment where the residues were left intact on the soil surface. On the other hand, the lowest cultivation height was found after burning the cutting residues on the soil surface.

3. The best way of soil preparation encouraging pine growth was making furrows with a two-furrow plough LPz-75 with a simultaneous softening of the bottom by a subsoiler. When other ways of soil preparation were employed, i.e. ploughing furrows with the active U-162 plough with a subsoiler and making ridges using a plough-miller, the height of the cultivation was significantly lower.

4. The obtained research results indicate that one of the important factors influencing the growth of the cultivated plants is the weight and rate of mineralization of the forest litter. The removal from the clear cut area or burning of branches and needles resulted in a significant loss of organic matter and, hence, the growing effects of the cultivation were the worst. Also the quick rate of organic matter mineralization 5 years after the establishment of the cultivation in the treatment where soil on the clear cut area was first ploughed with a disk plough and then ridges were formed using a plough-miller exerted a negative influence on the growth of the cultivation. On the other hand, the slow rate of recovery of nutrients from the forest litter observed when the post cutting residues were left intact on the surface and when furrows were ploughed using the LPz-75 plough exerted a positive impact on the growth of the cultivation.

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ZMIANY WYSOKOŚCI PIĘCIOLETNIEJ UPRAWY SOSNOWEJ W ZALEŻNOŚCI OD ZAGOSPODAROWANIA POZOSTAŁOŚCI ZRĘBOWYCH I PRZYGOTOWANIA GLEBY

Streszczenie. Przeprowadzone badania dotyczyły wpływu zastosowania różnych metod zagospodarowania pozostałości zrębowych i sposobów przygotowania gleby na zmiany wysokości pięcioletniej uprawy sosnowej. Na wysokość uprawy wpływają istotnie zarówno metody zagospodarowania pozostałości, jak i sposoby przygotowania gleby. Spośród pięciu zastosowanych metod postępowania z pozostałościami zrębowymi najkorzystniejsze okazały się metody polegające na rozdrobieniu pozostałości zrębowych

i mieszaniu ich z wierzchnią warstwą gleby mineralnej oraz na pozostawieniu resztek pozrębowych w całości na powierzchni. Z kolei najlepszym sposobem przygotowania gleby pod względem wysokości uprawy było wyoranie brzd pługiem dwuodkładnicowym z jednoczesnym ich spulchnieniem pogłębiaczem.

Słowa kluczowe: wysokość uprawy, sosna zwyczajna, przygotowanie gleby, pozostałości zrębowe

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