

THE INFLUENCE OF CUTTING RESIDUES MANAGEMENT AND SOIL PREPARATION METHODS ON HEIGHT OF 3-YEAR-OLD SCOTS PINE (*PINUS SYLVESTRIS* L.) PLANTATION

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Abstract. The aim of this study was to determine the influence of soil preparation on height of 3-year-old Scots pine plantation. Three methods of cutting residues management and three methods of soil preparation were analysed. Height structure was determined and mean heights in specific variants were statistically analysed. Conducted analysis showed, that the influence of soil preparation method was much greater than cutting residues management. Statistically significant impact on tree height was found in case of scarifying and mixing of topsoil with rotary tiller, where greatest mean height was observed. Ploughing furrows with LPz-75 plough proved to be the most beneficial method of soil preparation. In this case the greatest heights of 3-year-old Scots pines were measured.

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

INTRODUCTION

Substantial part of forest area in Poland is covered by Scots pine monocultures, that are managed in clear cutting system. Timber utilisation requires cutting trees down and delimiting, while cut off branches are left on the area [Gałązka et al. 2002]. To enable reforestation, a proper site preparation is essential. First, cutting residues must be utilised and then soil must be mechanically cultivated for artificial regeneration.

It is, therefore, necessary to combine these two treatments of site preparation, in a way that minimises the harmful effects of human activities. Utilisation of cutting residues should impoverish the soils nutrient capital as little as possible. Soil cultivation should be least invasive and should not lead to ecosystem devastation [Gornowicz 2004].

From a biological and silvicultural point of view, cutting residues should be comminuted on cutting area and return to nutrient circulation [Zięba 1982]. Utilising of forest organic matter in form of needles, dead branches, bark and twigs leads to habitats impoverishment and degradation [Janiszewski 1970]. The other studies prove that leaving twigs and needles or their comminution on cutting area, inhibits minerals leaching into deeper layers of soil. On the other hand, residues comminution and mixing with topsoil contributes to intensification of mineralisation process, but also increases mineral leaching from upper layers of soil [Gornowicz 2004].

Kocjan [2000] believes, that residues comminuted and scattered on the cutting area improve the soil structure, provide better oxygen access and water absorption. According to [Marciniak 2007] in first two years of cultivation, mean heights of saplings from plots where various methods of cutting residues management were employed, were similar. In the third year of cultivation, the greatest height was measured on plots where mechanical comminution of residues and mixing with topsoil was applied (69.4 cm). In turn [Tamminen and Saarsalmi 2013] maintain, that complete removal of trees with roots from the cutting area does not affect negatively the growth of young pines for 10 years after reforestation.

Another essential condition of plantation establishment success is a proper soil cultivation, therefore the omission of this treatment is the most common reason of a reforestation failure [Rudnicki 1954]. Marciniak [2007] in his research, evaluating cutting residues utilisation, also took into consideration various soil cultivation methods and their influence on Scots pine growth in first years after planting. In his experiment in the Forest District Osie two treatments were compared: ploughing furrows with double mouldboard plough LPz-75 and rotary tiller. It turned out, that both treatments had a significant effect on mean height of Scots pine saplings.

Andrzejczyk and Augustyniak [2007], comparing two soil cultivation methods: ploughing with LPz-75 plough and active plough U162, concluded, that both methods have a significant effect on pine growth in first years, but do not determine the establishment success. Marciniak [2007] also proved, that soil preparation method significantly influences the mean height of saplings. Analysis of the plantation in first three years showed, that height difference between plots where LPz-75 plough with subsoiler and rotary tiller were employed, increases with age, for the benefit of plots prepared with rotary tiller. In turn, according to Kocjan [1994], soil preparation might be regarded as a site improvement treatment, that benefits to the growth of plantation.

During the research conducted on wet habitats, it was also found that soil preparation method significantly improves the growth and the quality of Scots pine plantations [Pigan 2009].

THE AIM OF THE STUDY

The aim of the study was to analyse the influence of three soil preparation methods and three ways of cutting residues utilisation on height of 3-year-old Scots pine plantation. Measurements of height and height increment were performed on twelve plots, where various combinations of soil preparation and residues management were employed, in three repetitions.

MATERIAL AND METHODS

The research was conducted in the Forest District Bierzwnik, forestry range Chojnowo, subcompartment 89 g on area of 4.03 ha. Before the experiment a clear-cut was carried out (belt clear-cut Ib) on 100-years-old Scots pine stand, site index II on fresh coniferous site, on proper rusty soil. Next, a research area was set up in the shape of rectangle: 180 m × 80 m and the area of 1.44 ha. For research reasons it was divided into three blocks consisting of twelve plots measuring 20 m × 20 m and the area of 400 m². On each plot, a specific combination of cutting residues management and soil cultivation method, was employed. In spring 2010 the area was planted with Scots pine. Following spacing was used:

- 1.7 × 0.65 m → ploughing ridges
- 1.6 × 0.80 m → without soil preparation
- 1.2 × 0.65 m → scarifying with rotary tiller
- 1.5 × 0.60 m → ploughing with LPz-75 plough.

The research area was divided into 9 belts, perpendicular to the longer side, 3 in each block, where following methods of cutting residues management were used: complete removal (raking and carrying out of the area), leaving twigs (≤ 4 cm) and utilising bigger branches (> 4 cm), comminution of all residues. These methods were repeated in each of three blocks, but always in different order. In the next stage, the research area was divided into four strips, parallel to the longer side, where the following soil preparation methods were used: ploughing ridges, without soil preparation, comminution and scarifying of soil in rows (rotary tiller), and ploughing furrows with double mouldboard plough LPz-75 (Fig. 1).

Measurements were performed on 27 plots, covering all variants of cutting residues management and three methods of soil preparation. Nine plots, on which soil had not been prepared, were not taken into account, as the plantation establishment failed and was regarded lost.

As a result, 9 plots with the same combination in three repetitions were qualified for the research. On each plot, height of every tree in every second row, excluding the extreme rows, was measured. In plots where ridges were ploughed measurements were made on 36.4% of the plots area, which corresponded to 4 out of 11 rows. On plots where soil was cultivated with rotary tiller or LPz-75, 38.5% of area was measured, which equalled to 5 out of 13 rows. This method allowed to exclude the influence of neighbouring plots with a different combination of treatments. Measurements were done with a tape measure, height from ground level to the top bud was rounded to the nearest centimetre.

The collected data allowed to carry out a statistical analysis of height of 3-year-old Scots pine plantation, depending on the method of cutting residues management and the method of soil preparation.

As a result of a two-way analysis of variance, the significance of influence of particular variant on plantation height was calculated. For comparison of the detected significance, the Duncan test was performed.

block III	1	1	1	1
	3	3	3	3
	2	2	2	2
block II	2	2	2	2
	1	1	1	1
	3	3	3	3
block I	3	3	3	3
	1	1	1	1
	2	2	2	2
	ploughing ridges	without soil preparation	scarifying with rotary tiller	ploughing furrows with LPz-75

Fig. 1. Layout of sample plots with various combinations of clear-cut site preparation: 1 – complete removal (raking and carrying out of the area), 2 – leaving twigs (≤ 4 cm) and utilising bigger branches (> 4 cm), 3 – comminution of all residues

Rys. 1. Układ działek z określonymi kombinacjami poszczególnych sposobów zagospodarowania powierzchni zrębowej: 1 – uprzątnięcie odpadów (zgrabienie i wyniesienie poza powierzchnię działki), 2 – pozostawienie cienkich gałęzi (≤ 4 cm) i pozyskanie grubych (> 4 cm), 3 – rozdrobnienie wszystkich gałęzi

RESULTS

Determination of the influence of various site preparation methods on height of 3-year-old Scots pine plantation

The analysis of mean height of 3-year-old Scots pine plantation depending on the method of soil preparation and cutting residues management. The Figure 2 presents a summary of mean heights of plantation, covering soil preparation methods divided into three ways of cutting residues management.

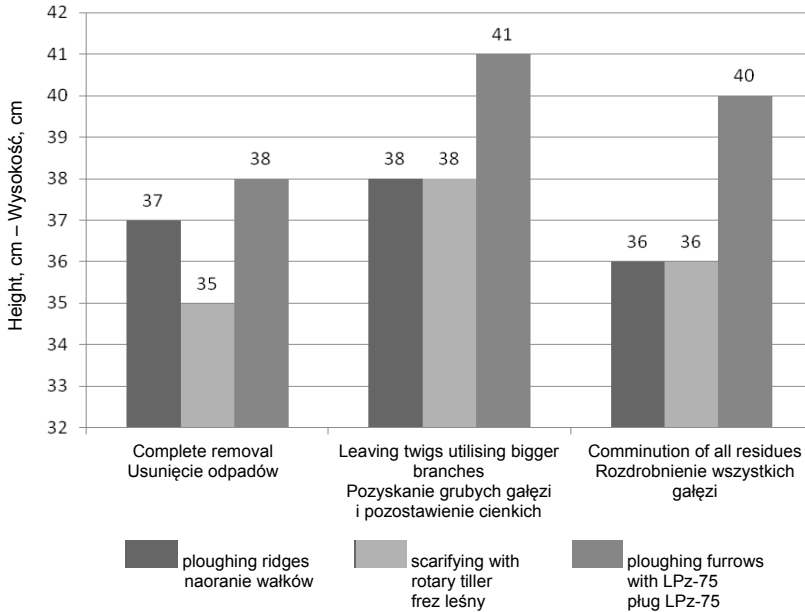


Fig. 2. Mean heights of 3-year-old Scots pine plantation in three groups of cutting residues management methods divided by soil preparation method

Rys. 2. Średnie wysokości 3-letniej uprawy sosnowej w podziale na sposoby zagospodarowania pozostałości zrębowych z uwzględnieniem metod przygotowania gleby

The graph shows, that the most beneficial, for height of 3-year-old Scots pine plantation, way of harvesting residues management was the option, where thick branches were utilised and twigs left on the area. On the other hand, the lowest values were found on plots where residues were removed completely, especially on plots where soil was prepared with rotary tiller. In this variant, height was 35 cm – the lowest of all the analysed values. It is worth emphasising, that on the plots where plough LPz-75 was used, mean height of the trees was significantly higher. The lowest result of this range was found on plots where it was combined with a complete removal of residues. In combination with residues comminution it was 40 cm. The best result – 41 cm, was found in variant with utilising thick branches and leaving twigs, while soil was prepared by ploughing furrows with LPz-75. In case of comminution of all residues and for variant with utilising

Table 1. Results of Duncan test of influence of soil preparation methods with complete removal of cutting residues, on height of a 3-year-old plantation

Tabela 1. Wyniki testu Duncana wpływu przygotowania gleby w wariacie uprzątnięcia odpadów na wysokość 3-letniej uprawy

Number of sub-class Numer podklasy	Soil preparation method Sposób przygotowania gleby	Mean height Średnia wysokość	1	2
2	rotary tiller frez leśny	11.03691		****
1	ridges wałki	15.91277	****	
3	plough LPz-75 pług LPz-75	17.70055	****	

thick branches and leaving twigs (excluding plots where soil was prepared with LPz-75), no influence was found of other two methods of soil preparation. Height of the plantation equalled, respectively, 36 cm and 38 cm.

Two-way analysis of variance was conducted in order to verify if mean heights of Scots pine trees differ significantly depending on the method of soil preparation while employing various cutting residues management methods.

Calculated values showed, that only in case of complete residues removal, the *p*-value was below the level of statistical significance (0.05) and equalled 0.01209. In all other cases, the analysis showed no statistically significant influence of soil preparation method on height of Scots pine plantation.

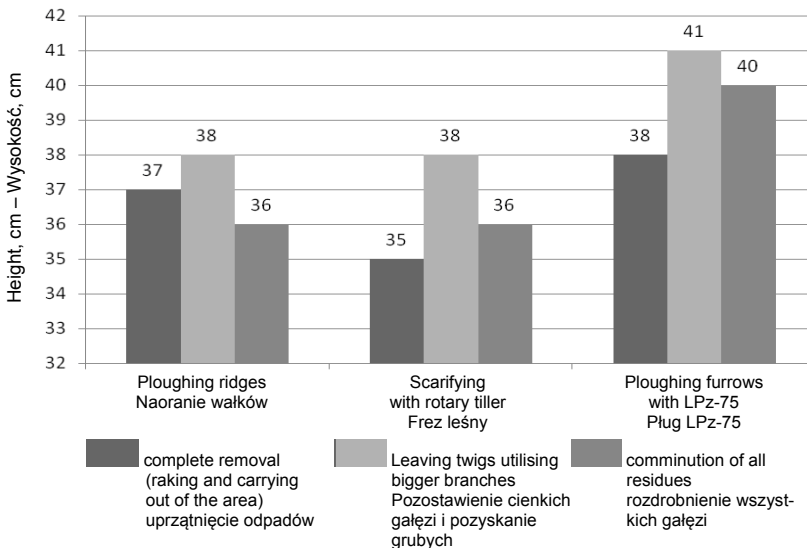


Fig. 3. Mean heights of 3-year-old Scots pine plantations in three groups of soil preparation methods divided by cutting residues management

Rys. 3. Średnie wysokości 3-letniej uprawy sosnowej w podziale na metody przygotowania gleby z uwzględnieniem sposobów utylizacji pozostałości zrębowych

The Duncan test, performed for variant where residues were completely removed from the area (Table 1), showed no significant influence on plantations height in case of ploughing ridges and ploughing furrows with LPz-75. Nevertheless, soil cultivation with rotary tiller proved to have a significant influence in this variant. Kocjan [1994] also stated, that appropriate soil cultivation is a basic condition of establishment success of reforestation and afforestation.

Figure 3 presents a summary of mean height of plantation, covering cutting residues management divided into three methods of soil preparation.

The graph clearly shows, that whenever soil was cultivated with LPz-75 plough, the mean heights of plantation were the highest for all cutting residues management methods. On the other hand, plots cultivated with rotary tiller were characterised by lowest mean heights. In all three variants of soil cultivation, the influence of various harvesting residues management methods on height was limited, and did not exceed 3 cm. It should be noted, that for all three cases, the highest values were observed for variant in which thick branches were utilised and twigs left on the area.

Complete removal of logging residues was least favourable, as mean values for this variant were the lowest for two out of three analysed methods of soil preparation.

Conducted two-way analysis of variance showed, that in all three variants of soil preparation, neither of the analysed residues management methods had a significant influence on height of 3-year-old Scots pine plantation (p -values for all three methods were above the significance level of 0.05).

STATEMENTS AND CONCLUSIONS

Significant influence of soil preparation with rotary tiller on height of 3-year-old Scots pine plantation was found in option where cutting residues were removed completely.

No significant influence of cutting residues management on height of plantation was found.

On plots, where soil was cultivated with LPz-75 plough, much higher mean heights were recorded, comparing to the other two analysed variants.

Greater mean heights, comparing to other variants, were noted on plots where thick branches were utilised and twigs left on the ground.

According to the authors' research, methods of cutting residues utilisation have no significant effect on height of 3-year-old Scots pine plantation, in contrast to methods of soil preparation.

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**WPLYW SPOSOBU ZAGOSPODAROWANIA
POZOSTAŁOŚCI ZRĘBOWYCH I PRZYGOTOWANIA GLEBY
NA WYSOKOŚĆ 3-LETNIEJ UPRAWY SOSNOWEJ**

Streszczenie. Celem pracy było określenie wpływu przygotowania powierzchni zrębowej na wysokość 3-letniej uprawy sosnowej. Analizowano trzy sposoby zagospodarowania pozostałości zrębowych oraz trzy metody przygotowania gleby. Określono strukturę wysokości oraz poddano analizie statystycznej ich średnie wartości w poszczególnych wariantach. Przeprowadzone analizy wykazały znacznie większy wpływ przygotowania gleby niż zagospodarowania pozostałości zrębowych. Statystycznie istotny wpływ na wysokość odnotowano w przypadku spulchnienia i przemieszania gleby za pomocą frezu leśnego, gdzie osiągnięto najmniejsze średnie wartości. Wyoranie bruzd pługiem LPz-75 okazało się najkorzystniejszym wariantem przygotowania gleby. W tym przypadku uzyskano największe wartości wysokości 3-letnich sosn.

Słowa kluczowe: uprawa sosnowa, wysokość, przygotowanie gleby, utylizacja pozostałości zrębowych

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