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INFLUENCE OF STUMP EXTRACTION, THINNING AND PERENNIAL LUPINE INTRODUCTION ON THE GROWTH OF EXPERIMENTAL COMMON SPRUCE FOREST PLANTATIONS

The results of research of studies of the effect uprooting stumps broad and narrow stripes on the productivity of fir in mossy fir are submitted. Found that uprooting stumps wide strips have a negative impact on the productivity of stands. However, with the introduction of long-term lupine and holding of selection thinning of young stands negative consequences of this measure significantly mitigated.

Introduction. Methods of soil cultivation can have a great impact on the growth of common spruce. I. V. Shutov and other authors [1] understand by "soil cultivation" such activities as hydro- and forest reclamation, area marking, narrow-band forest clearing from stumps, windfall and stones. The authors also include different types of activities which create favourable conditions for vital functions of planted trees. Along with biological reclamation and thinning of stands soil cultivation is a most important activity for successful plantation silviculture.

Main part. The study of the impact of different activities on common spruce growth has been carried out in an experimental plot of quarter 51 of Proshkovskoye forest station of Dvinskaya experimental forest base of the Forest Institute of Belarus NAS. Forest plantation were created there in the spring of 1984 in the cut-over area to determine efficiency of stump extraction in wide and narrow bands, biological reclamation, thinning of young stands and branch cutting [2]. The type of forest-growing conditions were B_2, the forest type was mossy spruce forest, the plot area being 4.8 ha.

The experiment foresaw four options:

1) control (without stump extraction, soil cultivation by forest multi-purpose plough PKL-70, thinning, branch cutting);

2) wide-band stump extraction, lupine planting, no thinning, branch cutting;

3) wide-band stump extraction, lupine planting, thinning, branch cutting;

4) narrow-band stump extraction, thinning, branch cutting.

Forest plantations were formed by three-year selection spruce seedlings grown in the nursery of Glubokoe forestry experimental station from clone 3 seeds taken from the famous seed plantation in Ozertsy. The seedlings were planted by tree planting machine ML-1 aggregated to tractor T-74. During planting 30% of inferior seedlings were sorted out. Experimental plantations were created in double-row lanes with alternating wide (3–3.5 m) and narrow (1.5–2 m) inter-row spacings. The planting density comprised 5.0 thousand per 1 ha.

Stump extraction was carried out in the spring of 1983 by stumper MP-2B aggregated to tractor T-130. Perennial lupine was introduced after two years of spruce growing and planted in wide-band stump-extracted areas. Selection thinning of young stands was carried out after 12 years of their growing. Only standard-bearing trees were left for further growing, their density being 1.5–1.8 thousand trees per 1 ha. The results of biometric measurement of September 2012 carried out on the experimental plot in quarter 51 of Proshkovskoye forest station are given in the table below. The maximum average height of 29-year-old mossy spruce stand (14.6 m) was registered in the experimental site with stump extraction, perennial lupine planting, thinning of young stands.

Silvicultural-taxation characteristics of experimental common spruce forest plantations with different soil cultivation

Silvicultural-taxation parameters	Experimental options			
	Control (no stump extraction, PKL-70, thinning, branch cutting)	Wide-band stump extraction, no thinning, branch cutting, lupine planting	Wide-band stump extraction, thinning, branch cutting, lupine planting	Narrow-band stump extraction, thinning, branch cutting
Forest type	Mossy spruce forest	Mossy spruce forest	Mossy spruce forest	Mossy spruce forest
Average height, m	14.1	10.8	14.6	13.1
Average diameter, cm	14.7	9.4	13.8	13.4
Total cross-sectional area, m^2	25.84	25.42	26.50	24.40
Density	0.86	1.03	0.86	0.85
Growth class	Ia	II	Ia	I
Thickness, thousand trees/ha	1500	3540	1729	1743
Volume, m^3/ha	193	159	214	175

The control site without stump extraction and lupine planting revealed the average height by 3.5% lower as compared to the described above. In experimental sites without thinning the average stand height was lower by 23% which can be explained by many stunted trees present in the plantation.

The control forest stands reached the average diameter of 14.7 cm and outstrip those stands grown in the wide- and narrow-band stump-extracted sites with perennial lupine planting. The tree diameter was larger by only 6–9% in thinned stands, by 36% in stands without thinning. This can primarily be explained by many stunted trees in the areas without thinning.

Some average diameter differences between the control and thinned plots can be explained by lower conservation of the cultivated trees and their density (229-243 trees per 1 ha) in the control forest stand.

It should be highlighted that all plots have formed high-density forest stands by the age of 29 years independent from the soil cultivation method. However the forest stand without thinning shows higher density than the thinned one which goes without saying.

It is known that mossy spruce forests form forests stands of growth class II, less frequently class I. In experimental forest plantations we can observe growth class Ia which can be explained by a higher average height of the forest stand after thinning as well as by increased efficiency of biological reclamation in thinned stands as photophilous perennial lupine is able to develop more intensively as compared to thicker young stands [2].

The density of standing trees in not-thinned stands is 3.54 thousand per 1 ha and exceeds this parameter of thinned stands 2.0–2.4 times. However in spite of the high density the volume of not-thinned stands makes up only 159 m3 per 1 ha which is by 18% lower than that of the control stand.

This is accounted for poorer fertility of forest soils resulting from wide-band stump extraction in the over-cut area as well as for lower efficiency of biological reclamation in the thinned stand.

Sharply decreased productivity (3–4 times) of not-thinned forest stands is noted in other experimental spruce plantations as well where stumps were extracted in wide bands. However prior introduction (in the second summer) of perennial lupine and selective cutting in the middle of the first age class can considerably mitigate negative impacts of this activity. Besides, other positive effects of this forest area cultivation method should be taken into consideration as it makes it possible to mechanize forest planting and to reduce costs of farming and silvicultural management. This method of planted afforestation can also produce positive effects in windfall and fire-damaged forests.

It should be further highlighted that putting of trees in two-row lanes provides for a sufficient planting density to create stands of dominating trees and necessary conditions for mechanized and chemical (contact method) care as well as for mechanized branch cutting, hauling and transportation of timber (Fig.). It also helps to reduce forest fire hazards by using some wide inter-row spaces as fire lines and integrated use of forested areas by growing additional forest plants in wide inter-row spaces. In over-cut areas future wide inter-row spaces can be used to bundle logging waste (instead of growing shrubs) thus reducing the labour consumption of this activity and providing conditions for high-quality soil cultivation.

Thus the study results of experimental spruce plantations prove that wide-band stump extraction in mossy spruce forests is not advisable as it produces a considerable negative effect on forest productivity.

Experimental spruce plantation in the cut area, stumps extracted in wide bands, with perennial lupine, thinning, branch cutting and two-row lane trees planting (29-year-old)

Narrow-band stump extraction has a number of advantages lover the wide-band one. Strip stump extraction and logging waste clearing lead to their insignificant reallocation over the area with the total volume of vegetable mass remaining the same [1]. Wide inter-row spaces with stumps and logging waste create favourable environmental conditions for the growth of grassy and woody plants, mushrooms as well as for habitats of birds, small predators and mouse-like rodents. Besides up to 450 kg of nitrogen, 100 kg of phosphorus and 100 kg of potassium remain in woody remnants per 1 ha of the cut area [1]. Narrow-band stump extraction also makes it possible to mechanize forest planting without prior soil cultivation, ensures optimum location of the planted trees over the area and reduces the costs of farming and silvicultural care.

The control plot (soil cultivation by forest multi-purpose plough PKL-70 without stump extraction and biological reclamation) demonstrates forest productivity which is only slightly lower than the option with wide-band stump extraction, thinning and perennial lupine planting. However it does not provide necessary access to the forest plantations. In the cut areas without stump extraction high-quality soil cultivation is not possible which makes growing of valuable forest plantations difficult. Intensive attrition of cultivated plants can be observed on fertile soils together with higher costs of farming and silvicultural care. The type of such plantations is out of accord with their name.

Conclusion. Forest plantations can primarily be created on old-arable soils and old cut areas. Forests improve soils [1], therefore forest plantations on degraded agricultural lands can be economically feasible. Narrow-band stump extraction presents a lesser and necessary "evil" for new cut areas.

Wide-band stump extraction is more advisable for windfall and storm-damaged areas where the amount of stumps exceed 500 stumps per 1 ha and other types of soil cultivation are not possible. The width of the stump-extracted bands should not be more than 12–13 m. In these bands mixed pine-spruce plantations are created where shade-tolerant and soil-demanding spruce trees are planted on the edge and light-demanding and more unpretentious pine trees are planted in the second row to ensure high conservation and favourable growth conditions for both species. This technique also provides for optimum conditions for mechanized forest planting, improves survival ability and conservation of the planted trees, reduces costs of farming care and improvement thinning of young stands, encourages sustainable and highly-productive pine and spruce plantations.

The study results show that wide inter-row spaces of forest pine-spruce stands can be planted with perennial lupine, berry and soil-improving plants or New Year spruce trees if necessary. Plant spacing for spruce stands is 0.7-1.0 m for pine and spruce, planting density being 5-6 thousand of trees per 1 ha.

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