FOREST REGENERATION AND FOREST GROWING

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MODERN TECHNOLOGIES OF NORWAY SPRUCE SEEDLINGS GROWING IN NURSERIES

Researches on various ways of making and technology of cultivation of saplings of a *Picea Abies* at the compacted schools are conducted. Dependence of application of different practies on individual qualities of saplings, such as the mass of root system, a ratio of above-ground and root parts, diameter of a root neck and height is established. The best term of a making of the compacted school is the late summer during the maximum growth of roots – from August 1 to September 5. Planting at a later date amounts to their winter storage.

Introduction. The State Programme for Forestry Development of the Republic of Belarus for 2011–2015 provides research and implementation of intensive agrotechnologies of open and protected ground cultivation using the newest growth regulators, pesticides, micronutrient fertilizers and plant irrigation systems [1]. Great attention is paid to the use of large-sized planting material for forest cultures cultivation, which requires technically sound approach to forest nursery establishment. It's particularly topical for nurseries laid out for Norway spruce transplants that are sown on high density plant beds. Implementation of comprehensive mechanization to cover all stages from nursery establishment to planting material lifting will help to obtain more high quality transplants in short terms. The main advantage of transplanted seeding over direct seeding is that a transplant is quite a large tree with crown, trunk and root system. Transplants sooner enter a period of rapid growth, sooner get beyond negative influence of grassland vegetation and low-value broadleaved species.

Plan of Measures of the Ministry of Forestry provides phase transition of forestry establishments to Norway spruce cultivation using exceptionally large-sized planting material [2]. Use of spruce tree transplants helps to avoid numerous time consuming agrotechnical treatment. Previous technologies of cultivating of large-sized planting material, which also include a Russian technology of cultivating large-sized seedlings without transplantation, didn't provide resulting high quality material [3]. Individual characteristics of a transplant include the following: tree crown shape and root system shape, correlation between aerial part and roots, root neck diameter and height, presence and condition of apical bud on the leading shoot [4]. Therefore it's necessary to work out innovating technologies of Norway spruce cultivating.

Main part. The technology of high density planting in forest nurseries includes various procedures, from land rotation cultivation to planting material lifting and storage. Research of various technological procedures, dense nursery laying out methods and growth technique influence on planting material quality were conducted in forest nurseries in various geobotanical subzones. It was found out that application of specific technique determines individual characteristics such as root system weight, correlation between aerial part and roots, root neck diameter and height.

For Norway spruce transplants, root system weight is considered to be the most important characteristic, and it heavily depends on soil conditions and tillage system. The testing of traditional tillage system and Yield rotation in forest nurseries elicited range of essential shortcomings, which demands their improvement in the techniques of planting material growing.

The main disadvantage of moldboard plowing is disconnection of the topsoil and subsurface soil capillary links, and formation of over-consolidated layer that is called plough sole. Research suggests that moldboard cultivation together with moldless one allows to avoid plough sole appearance, and minimum or zero tillage in forest nurseries can significantly improve technique of planting material growing. Zero tillage farming (also called no-till) is a way of growing from year to year without disturbing the soil through tillage, and the soil surface is laid by mulch – shredded plant residues. Zero tillage demands special technique and by no means comes down to abandon ploughing. Zero tillage is widely used in Europe, the United States, Canada, gains popularity in Russia and Ukraine.

No-till farming's key principle is the use of natural processes, which take place in the soil. Traditional ploughing is considered by no-till followers to be not only needless but harmful. Fallowed field at a depth of 1–2 meters is penetrated by numerous capillaries left after plant roots and as a result of vital activity of earthworms and other soil organicms. Water infiltrates into the soil, in winter water freezes and tears up thin and deep channels. That's the way natural tillage happens.

The technique of minimum tillage is considered to be a bridging phase to zero-tillage. This system is also called mini-till. In this system mulch cover is also regarded as highly important. In the forest nurseries it's possible to be implemented if green-manured fallows and seed fallows are used in the Yield rotation system. In Belarus nurseries with dense laying out are mostly established for cultivating bulk quantity of large-sized Norway spruce planting material for silvicultural targets. They are featured by narrow space between rows and not large in-the-row spacing. This leads to increase of transplants yield to 100,000 pcs per hectare. We conducted investigations of different ways of dense laying of Norway spruce nursery. The investigations had following options:

1) according to planting system: row method (narrow rows, equal dispersion of rows), belt-type method (3–4-row belt-type areas with inter-belt space), combined method (one or more belts of close planted nurseries with growing period of 3 years are put into inter-row space of trees with growing period of 6–8 years);

2) according to applied equipment: hand planting with the help of Kolesov's planting iron or a shovel, para-ploughs of various constructions, planting machines (SShP–5/3, EMI–5M, PRM–4), planting machines of new generation (L–218 «Lidselmash», Egedal (Denmark), 2–4-row seedling planting machine);

3) according to planting time: spring, autumn, late summer (starting on the 1st of August).

Investigating how density of planting (100,000 to 400,000 pcs per hectare) influences on growth and root nutrition of spruce transplants, it was determined, that during the first season vital activity develops normally in nurseries with all kinds of density, but by the end of the second year growth declines in dense-planted areas. Best growth and development indices were shown in areas with planting density of 180,000–230,000 pcs per hectare.

To achieve high quality of production it's recommended to use the following planting plan 4(0.25)–0.5×0.15, which provides transplants 220,000 pcs per hectare output (see Fig. 1).

As a result of lack of planting machinery, up to the present day hand planting is used while close planting nurseries establishment.

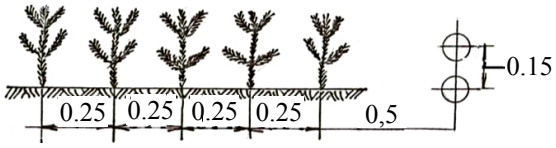

Fig. 1. Plan of nursery with high planting density

This way has a range of disadvantages, such as labour intensity, time consumption and ineffective technique. Its usage in forestry should be excluded and replaced by modern technologies, and there's no need to explain it in details. Recent years some Belarusian forestry establishments have started to apply para-ploughs of various constructions, including ones of Polish production. Seedling planting and root systems compaction in the soil are put into prepared V-shape holes by hand. Seedling establishment and growth during the first year are satisfactory.

But detailed investigation of root systems shows that using this way it's impossible to receive planting material of high quality, because there are no normal conditions for transplants' root system development.

Planting furrows are made by pressing V-shape disc into the soil, as a result of which soil is getting compressed in the place of seedlings planting, V-shaped hole leads to root systems bending. Planting material turns out to have light-weighted abnormal root system (see Fig. 2). Planting material of described kind if it is used for forest restoration affects longevity of the planted forestry Yields. Trees may perish prematurely due to badly developed root system. Much better results may be achieved at the implementation of planting machines of new generation: L–218 produced by "Lidselmash" and "Egedal" (Denmark). They are featured by high productivity, high planting quality, and as a result standard planting material output increases.

Transplant parameters in certain batches may essentially differ depending on agrotechnique level, age and size of seedling used for planting. In low soil fertility circumstances it's not always possible to get normative quantity of standard spruce transplants in two year period, so their growing period is prolonged for one more year. Almost 100% of five-year old fir transplants meet the standards, but due to prolonged period of growing on the same spot correlation between aerial part and tender roots mass worsens.

In forest cultures the period of postplanting depression gets one year longer. In silvicultural production process sometimes it's necessary to receive large-sized planting material to complement forestry Yields which aren't ready to be planted in the forested areas. In this case to get larger-sized planting material 4-year old fir transplants are

planted for two more years in second stage nursery. 6-year old transplants (2+2+2) have compact, well developed fibrous root system, root neck's stipe diameter reaches 12 mm and more, height reaches 60–100 cm.

The use of notch planting or petrol-auger planting allows to receive 95–100% root-taking rate. If seedlings are grown without the second transplantation (2+4), even after root cutting they are higher, but have insufficient quantity of tender absorbing roots, which increases adaptation duration and slows down trees growth in the first years.

Utilization of planting material of this kind is prospective for complement forest Yields that are dedicated for planting in forested areas, along with being planted on areas with extreme environment (areas suffered from deadfalls and areas where is difficult or impossible to conduct aftercare etc).

In the general system of intensive technologies of material high density planting it's worth to pay special attention to experience of late summer transplantation of fir seedlings for transplants cultivation. From the theoretical point of view this agrotechnical method is based on considering root system's seasonal growth peculiarities and their regeneration qualities.

Root regeneration is root's mass, length and surface recovery after damage, and also further development of younger root branches on its intact part. In nurseries root regeneration most actively happens after their damage or intended cutting.

It is known that plants' growth and development is regulated by water and soil solution absorption, and it depends on branching of the root system and quantity of endings. The more intensively root system is branched out, the larger absorbing surface it has. Total extent and absorbing surface of tender roots in the root system considerably exceed ones of thicker roots.

Therefore organic mass production value of a wood plant increases proportionally with its total root absorbing surface development. Reduction of a share of tender roots in the total mass and length causes decrease of ratio of nutrients got from the soil per plant's unit mass, which leads to worsening of its biological resilience[5].

The stated above conditions of formation of wood plants root systems are based on late summer close transplanting of 2-year old spruce transplants. Belt-type plantations are established using "Egedal" planting machine, space between rows is 25 cm, plant spacing is 15 cm. It's determined that root regeneration and development take place in the year of transplanting. Next year in spring it causes rapid growth of transplants. We examined peculiarities of growing and seedling producing in different terms of transplanting (Table 1).

Obtained data analysis shows that 3-year old fir transplants grow much faster if planted in late summer period in comparison with spring period planting. Transplants are 30% higher, root neck diameter is 23.8% wider, root system is 24.1% longer. The same tendencies can be seen relatively to structural parts of plants biomass. It should be mentioned that 3-year old fir seedlings have almost the same body height as 3-year old transplants, but they are considerably less developed in root neck diameter and biomass. Therefore, it's better to lay out dense-planting nurseries during the maximal root growth – from the 1st of August to the 5th of September. Later planting is equivalent to heeling-in of transplants for winter. Researches on detection of features of Norway spruce transplants dense planting were conducted in Ivatsevichsky, Starodorozhsky, Gluboksky, Volkovyssky and Negorelsky forestry stations. It was ascertained that para-plough planting of Norway spruce transplants caused root system bending, and it couldn't straighten in the process of growth (Fig. 2).

The use of planting machine provides seedlings planting without root system bending, and further it develops proportionally. Thus spruce transplants after application of planting machine have better growth characteristics (Table 2).

Table 1

Fir tree planting material growth and propagation parameters

Variant of experiment	Biometrics data, g			Biomass of a plant, g		
	trunk height, cm	trunk diameter at root neck, mm	roots length, cm	trunk	needle	roots
3-year old seedling, late summer seedling, standard seedlings 2 ± 1	28.3 ± 0.10	5.2 ± 0.06	24.2 ± 1.8	3.24 ± 0.12	2.35 ± 0.09	1.88 ± 0.05
3-year old seedling, late summer seedling, standard seedlings 2 ± 1	22.2 ± 0.09	4.2 ± 0.05	19.5 ± 1.2	2.38 ± 0.10	1.96 ± 0.10	1.08 ± 0.06
3-year old seedlings, CH3	22.7 ± 0.09	2.5 ± 0.05	18.9 ± 1.5	0.90 ± 0.11	0.69 ± 0.13	0.27 ± 0.02
2-year old seedlings, CH2	12.2 ± 0.07	2.2 ± 0.05	16.2 ± 1.4	0.58 ± 0.7	0.55 ± 0.12	0.20 ± 0.01

a *b* *c*

a, *b* – using para-plough; *c* – using planting machine L-218

Fig. 2. Development of root system of Norway spruce transplants

Table 2

Norway spruce planting material growth indices relatively to planting methods

Variant of experiment	Average biometrics data, g			Phytomass of one seedling in dry condition, g	
	arial part, cm	root collar diameter, mm	root length, cm	aerial part	root system
Using tree-planting machine					
Seedlings, S_{2+3}	52.6 ± 1.10	12.1 ± 0.20	39.4 ± 0.31	8.24	3.97
Seedlings, S_{2+2}	39.3 ± 0.81	7.7 ± 0.17	32.3 ± 0.20	7.83	3.05
Using para-plough					
Seedlings, S_{2+2}	33.7 ± 0.21	6.2 ± 0.22	26.1 ± 0.12	6.27	2.01

Data analysis shows that 4-year old spruce transplants after being transplanted using planting machine grow more intensively than after being transplanted using para-plough. For example, transplants' average body height is 16.6% higher, root neck diameter is 24.2% thicker, and root system length is 23.8% longer. The same refers to the phytomass of plants. For instance, the phytomass of aerial part of 4-year old fir tree transplants which were grown using transplanting machine is 24.9% more, and roots phytomass is 51.7% more.

Therefore when Norway spruce in nurseries is densely planted, it's better to use planting machines, because in this case trees' growth indices are higher, and root system develops without bending. In some nurseries of Mogilev region they practice a technology of using 1-year seedlings when grow Norway spruce transplants. Seedlings are grown in protected ground, and their biometrical parameters are close to the ones of standard 2-year old seedlings, which were grown in open ground. As a result terms of cultivation of Norway spruce transplants reduce by 1 year, and this reduces production cost.

As can be seen, standard spruce transplants are grown during three or four years. The biological age of this planting material is one year younger, that's why in maturity it is behind transplants derived from 2-year old seedling. Besides, greenhouse cultivation causes increase of total production cost.

Conclusion. The task of increasing the yield of high quality planting material in a great measure is possible to be completed by correct soil cultivation.

The main type of planting material for silvicultural production should consist of large-sized transplants grown in densely planting nursery 2 + 1.5, 2 + 2, 2 + 3. The best period for transplanting is late summer – a period of maximal growth intensity: the 1st of August to the 5th of September.

Later planting is equivalent to heeling-in of transplants for winter. Planting carried out according to following plan: 5-row belts, planting space 15 cm, density about 220,000 pcs per hectare. Utilizing of planting machines can provide normal development of root systems. Planting material should be represented by mature 2-year old seedlings. In this case rather high growth indices of Norway spruce transplants in close planting nursery can be achieved.

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