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THE GROW-IN AND GROWTH OF PINE AND SPRUCE CONTAINER SEEDLINGS IN SITE TYPE HYLOCOMIOSA GROWING CONDITIONS

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Abstract: *In normal humidity mineral soil of site type Hylocomiosa, pine and spruce forest stands of the site quality index I grow. In 2004, in an independent experimental object, pine and spruce container seedlings HIKO V-120SS were planted in 5 planting terms from April 27 until July 12 in a new clearing area, in soil prepared by the disk trencher TTS DELTA. Research results of the first three years show that pine and spruce container seedlings could be successfully planted in new clearing areas, if they are previously disinfested in the nursery against vermin. During the first six months, pine and spruce container seedlings are recommended to plant in the II and III ten-day period of April and the I of May. Planting could be continued in the II and III ten-day period of May. It is not recommended to plant the container seedlings during the intense growing period.*

1. Introduction

In Latvia, the most of the territory is occupied by forest - 45% or 2.9 million ha. Forests grow in different soil fertility and humidity conditions. The forest typology of Latvia is subdivided in 23 site growing conditions. 21% of the total area of forest stands grow in the site type *Hilocomiosa*. In well-aerated, medium fertile mineral soils of this site type, pine and spruce of the site quality index I grow, as well as birch unmixed and mixed stands. When a natural succession takes place, silviculturally less valuable foliage tree species renovate in the clearing area in a natural way after a clear cutting of pine and spruce forest stands. The valuable conifer stands are renovated artificially by planting pine or spruce. In order to facilitate a better grow-in of the planted trees and their overcoming of negative influence of the competing plants, the measures could be as follows: time period between the stand cutting and planting should be reduced; a planting material which grows in well and forms a relatively big increases in height in the first and the after years should be used.

In Latvia, mainly two-year field seedlings have been used for pine planting up to 2002. They grow in well and grow also in low-fertile mineral soils, but much worse in fertile and humid soils. Spruce forest stands were planted by using only four or three years old bare-rooted plants (Mangalis, 2004).

After establishment of three modern forest nurseries in Latvia, more and more often pine and spruce container seedlings are being used for forest renovation, especially in state forests, the seedlings being grown up according to the firm BSS technology in HIKO modification containers V – 120SS. The quadrangular prism 120 cm 3 containers are combined in a 40-place cassette. The containers are designed with slots on sides and on bottom, thus preventing roots from deformation during the growing of seedlings. In forest renovation, one-year pine and two-year spruce container seedlings are used.

Since 2003, researchers from the Forestry Research Institute "Silava" and LUA Forest Faculty perform researches in independent research objects, which aim at determining optimal planting periods of pine

and spruce container seedlings during vegetation period, the growth-in and growing conditions of container seedlings and the influence of ecological factors on seedlings. In this article the planting results of one research of pine and spruce container seedlings within the first three vegetation periods are analysed.

2. Materials and methods

The experimental object was established in the first half of vegetation period of 2004, in a new clear-cut clearing area of site type *Hylocomiosa*, in a typically medium-podzolic soil. The total area of the experimental object was 0.5 ha. The pine – spruce mixed stand was cut in winter, 2004. Soil was prepared by the disk trencher TTS –DELTA in April, forming shallow furrows. Pine and spruce container seedlings were planted in 5 terms from April 27 until July 12. During each planting term, 200 pine and 200 spruce container seedlings were planted. The planting was performed by handheld tools specially made for planting of container seedlings. The agrotechnical treatment of plantings was performed only during the third year after planting.

Meteorological conditions in 2004 were in general favourable for establishment of all terms plantings (Table 1). The vegetation period started in the II ten-day period of April. Starting with the III ten-day period of April, the precipitation fell in sufficient amounts, which together with humidity accumulated during winter and spring ensured normal humidity conditions in soil. Only the strong frost in the end of May had a negative influence on the new sprouts of spruce.

Before carrying out of each term planting, 120 sizes of pine and 120 of spruce, having been grown in 3 container cassettes, were stated for characterization of planting material (Table 2). Non-sorted container seedlings were used for planting, as it is done in production conditions, therefore the scope of sizes is relatively wide.

By the end (the III ten-day period of September) of each (years 2004, 2005 and 2006) vegetation period, the number of growing trees from the planted ones in percent was counted. All trees were measured for height and its increase in the current year. The dominating plant species and the level of grass sward in all planting sites was determined.

The computer programmes EXCEL and SPSS (Arhipova, Bāliņa, 2003) were used for data processing.

Table 1: Meteorological conditions during the establishment of experimental object. (March - July, 2004)

Month	Monthly average air temperature	Monthly precipitation amount, mm
March	2.5	34.8
April	10.3	7.2
May	13.5	32.2
June	17.0	77.0
July	19.6	34.4

Table 2: Sizes of pine and spruce container seedlings V-120SS before planting

Planting		Pine seedlings		Spruce seedlings	
No	Date	Height, cm	Root neck diameter, mm	Height, cm	Root neck diameter, mm
1.	27. 04. 04.	13.2	2.3	21.9	2.8
2.	14. 05. 04.	11.7	2.1	20.9	3.0
3.	28. 05.04.	14.3	2.7	18.6	2.9
4.	21. 06. 04.	14.2	2.4	29.0	3.4
5.	12. 07. 04.	15.6	2.9	33.0	3.7

3. Results

3.1 Growth-in and survival of pine in different term plantings of container seedlings

On average 85% of the planted container seedlings had grown-in in pine plantings by the end of the first vegetation period. In the first two (of April 27 and May 14) plantings 95-97% of pine had grown in, which was considerably more than in later plantings, where pine was in its intense growing phase.

During the second vegetation period, the number of growing pines in the experimental object reduced for 6 % on average. In autumn of 2005, on average 79% of the planted pines were growing in the experimental object. During the first two periods, the number of trees did not change considerably, however, in plantings of the last terms (June 21 and July 12), the number of trees reduced for 18 and 10% accordingly. The reason of tree mortality was insufficient moisture and weevil damages, which were more often in the vicinity of swaths of spruce branches.

By the end of the third vegetation period, on average 77% of the planted pines were growing in the experimental object, that was for 2% less than in the previous year (Table 3). During a year, pines mostly (8%) faded in the first planting, were soil was swarded considerably stronger by cereal grass than in other experimental variants. Dispersion analysis shows that the number of the survived trees differs considerably in different term plantings ($F = 9.9 > F_{fad} = 5.2$). By the end of the third vegetation period also, more (88 – 94%) trees had survived in the plantings of May 27 and 14.

Table 3: Growth-in and survival of pine and spruce in different term plantings of container seedlings in the second and third vegetation period in site type Hylocomiosa

Planting		Growth-in Y. 2004 %	Survival, % of the initial number			
			Y. 2005	Year 2006		
No	Date			I repet.	II repet.	In total
Pine container seedlings V-120SS						
1.	27.04.04.	97	96	87	89	88
2.	14.05.04.	95	94	96	93	94
3.	28.05.04.	70	67	60	72	66
4.	21.06.04.	82	64	56	64	60
5.	12.07.04.	83	73	62	77	75
On average		85	79	72	79	77
Spruce container seedlings V-120SS						
1.	27.04.04.	95	93	50	79	64
2.	14.05.04.	92	87	73	82	78
3.	28.05.04.	75	72	53	66	60
4.	21.06.04.	74	72	66	56	62
5.	12.07.04.	93	82	73	73	73

Vidēji	86	81	63	71	67

3.2 Growth-in and survival of spruce in different term plantings of container seedlings

On average 86% of the planted container seedlings had grown-in in spruce plantings by the end of the first vegetation period. In the first two plantings (April 27 and May 14) and of July 12, 92 –95% of the planted container seedlings had grown in. However, during the terms when the spruce being in the phase of intense growing was planted, only 74-75% grew in.

During the second vegetation period, the number of growing spruce in the experimental object reduced for 5% on average. In autumn of 2005, on average 81% of the planted trees were growing in the experimental object. In plantings of the first four terms, the number of trees had reduced for 2-5%, but in the last planting of July 12 - for 11%.

By the end of the third vegetation period, on average 67% of the planted spruces were growing in the experimental object that was on average for 14% less than in the previous year (Table 3). Almost the third part of spruce had faded in the first term planting, especially in the repetition I of this planting. Trees in this planting have faded mostly due to vermin damages. The number of trees in the rest terms' plantings had reduced for 9-12%, the main reason of tree mortality was weevil damages to spruce with lesser stem diameter. Dispersion analysis shows that the number of the survived trees, which varies from 60 to 78%, does not differ considerably in different term plantings ($F = 1.0 > F_{fad} = 5.2$). The most number of the survived trees was in the planting of May 14 – 78%.

3.3 Pine damages in different term plantings of container seedlings V-120SS

During the first vegetation period, only a small number of the grown-in trees in all experimental variants had considerable damages.

It was found during the registration performed by the end of the second vegetation period that on average 16% of the growing pine were damaged. Location of the damaged trees was irregular, and the number of damaged pine, in particular in repeated plantings, differed even for more than two times. Firstly, it is related to weevil damages. These vermin have damaged trees more in the places close to cutting remains. Vermin damages and diseases made on average 34% of the total number of the damaged trees. However, the most part (66% on average) of all damages were made by forest animals.

It was found by the end of the third vegetation period that on average 37% of the growing pine have damages, the 80% of which were bitten tops and side sprouts by forest animals. This shows that pine plantings in sites with high animal density, independently of the location, should be prepared with repellents in the first three years. Number of the damaged trees in different term plantings range from 25-47%, however, differences among the numbers of the damaged trees in experimental variants are not essential ($F = 1.1 < F_{fad.} = 5.2$).

3.4 Spruce damages in different term plantings of container seedlings V-120SS

During the first vegetation period, the spruce trees suffered from the late spring frosts both in the nursery and in the first plantings in forest. Damages of other reasons in the first vegetation period were insignificant.

It was found during the registration performed by the end of the second vegetation period that on average 13% of the growing spruce were damaged; it is for 3% less than in pine plantings. Also in this year, the reason of 62% of damages were spring frosts in the previous year. Forest animals have damaged spruce less than pine. These damages in spruce plantings were 25% of the total number of damages. A small part of all damages, on average 13% were made by vermin and diseases.

By the end of the third vegetation period, on average 23% of the growing spruce were damaged. The young tree damages were made by forest animals, biting the tops and branches. Dispersion analysis shows that the number of the damaged trees does not differ considerably in different term spruce plantings ($F = 0.07 < F_{fad} = 5.2$).

3.5 Growing of pines in different term plantings of container seedlings V-120SS

All the increase in height of trees in the cutting area during the planting period developed only in the first planting and was 8 cm on average. During the second planting term, half of the 6 cm increase developed even in the nursery. In the rest three plantings, all the increase in height of pine had developed even in the nursery.

Increase in height in all plantings during the second vegetation period was more than two times, 21 cm on average in the whole experiment. The most increase (22- 24 cm) in height was in the first three plantings, which have been established from April 27 up to May 28. In the last two plantings, during which trees in their intense growing phase were planted, the increase in height was considerably less (17-18 cm).

During the third vegetation period, the increase in height of pines in the experiment was 20.3 cm on average that is as much as in the previous year (Table 5). The most increase in height (26-27 cm) has been found in the plantings of May 14 and 28. A considerably less increase in height in comparison with the previous year was in the first planting (15 cm), where the cereal grass sward was considerably higher than in the rest experimental area. Like in the previous year, less increase in height was in the last two terms' plantings. In these plantings, the growing of trees with a small stem diameter was impeded by weevil damages. Most of the trees have weevil damages on the lower part of stem; however, vermin damages do not influence significantly the tree growing, if the root neck diameter is more than 1 cm. As the dispersion analysis shows, the increase in height differs considerably in different term plantings ($F = 6.7 > F_{fad} = 5.2$).

Tree height in the whole experiment reaches 49 cm on average. Like in the previous year, pines were higher (52-54 cm) in the first three terms' plantings. Height of trees does not differ considerably in different term plantings ($F = 3.2 < F_{fad} = 5.2$).

Table 5: Increase in height of pine and spruce in the plantings of container seedlings in the site type Hylocomiosa during the first three years

Planting		In 2004	In 2005	In 2006
No	Date			
Plantings of pine container seedlings				
1.	27.04.04.	8	24	15
2.	14.05.04.	6	22	26
3.	28.05.04.	5	22	27
4.	21.06.04.	4	17	13
5.	12.07.04.	5	18	21
	Vidēji	6	21	20
Plantings of spruce container seedlings				
1.	27.04.04.	7	16	15
2.	14.05.04.	8	14	14
3.	28.05.04.	8	14	14
4.	21.06.04.	8	13	14
5.	12.07.04.	13	14	15
	On average	9	14	14

3.6 Growing of spruce in different term plantings of container seedlings V-120SS

Increase in height of spruce in the first three plantings in 2004 developed after the planting of container seedlings in the clearing area and was 7-8 cm on average. The same increase in height was in the planting of June 21; 6 cm of which developed in the nursery, the rest 2 cm – after planting in the clearing area. Increase in height (13 cm) of trees in the last, July 12, planting developed only in the nursery.

During the second vegetation period, increase in height of spruce was more or equal in comparison with previous year, and it ranged from 13 up to 16 cm. The average increase in height of trees in the whole experiment – 14 cm. Like in the pine plantings, the most increase in height (15 – 16cm) was in the first plantings, where just non-opened spruces were planted. Increase in height of spruce planted in the middle of summer was 13-14 cm. By the end of the second period, the average height of spruce in the experiment was 38 cm, and the root neck diameter – 7.0 mm.

During the third vegetation period, the increase in height of spruce planted in 2006 was 14 cm on average, that is as much as in the previous year (Table 5). Differences of the average increase in height among different term plantings do not exceed 2 cm. Dispersion analysis shows that differences among the experimental variants (planting terms) are not essential ($F = 1.01 < F_{fad.} = 5.2$). The average height of spruce is 46 cm on average. The average height difference in different term plantings does not exceed 5 cm and does not reach the margin of significance ($F= 0.46 < F_{fad.} =5.2$).

3.7 Sward and the dominating plants in the grass level and their influence on pine and spruce growing

By the end of the third vegetation period, the sward of grass, small bushes, foliage trees and bushes was non-uniform in the experimental area. In more than half (54%) of the planting sites there was found a medium sward, in 20%- low and in 9% of the planting sites – strong. 17% of the planting sites still are free of sward.

Cereal grass is the most often dominating in the planting sites (in 31% of planting sites), and in most cases they form a medium sward. However, almost half of the planting sites covered by strong sward consist of cereal grass. Cereal grass most often is found in the first planting.

Raspberries are the dominating species in 30% of the planting sites. Also raspberries mostly form a medium sward. Raspberries grow in sites with rough humus, which is formed by the forest organic layer and cutting remains. The clearing area pioneer species (willow herbs, hemp nettles) are dominating in 13% of the planting sites.

Birch natural renovation is numerically low in the clearing area for the present, and it competes with pine only in 9% planting sites.

Table 6: Pine sizes in the plantings of container seedlings depending on the level of sward and on the dominating plant species in the planting site Hylocomiosa

Plant species, dominating in the planting site	Level of grass sward in the planting site			On average
	low	medium	high	
Height of trees, cm				
Seed weeds	49.1	47.8	-	48.4
Cereal grass	49.5	45.6	43.1	46.1
Raspberries	51.7	46.7	44.8	47.7
Foliage trees	44.3	44.2	-	44.2
On average	48.6	46.1	44.0	
Increase in height of the trees in 2006, cm				

Seed weeds	15.0	14.0	-	14.5
Cereal grass	14.2	13.3	12.7	13.4
Raspberries	13.8	14.0	12.7	13.5
Foliage trees	10.7	12.5	-	11.6
On average	13.4	13.4	12.7	
The root neck diameter of trees, mm				
Seed weeds	10.6	9.2	-	9.9
Cereal grass	10.8	10.2	10.4	10.5
Raspberries	11.0	10.4	9.5	10.3
Foliage trees	11.1	10.2	-	10.6
On average	10.9	10.0	10.0	

By increasing of sward in planting sites with grass, brushes and foliage trees, the sizes of pine decrease. So the average height of pine in the planting sites with low sward is for 4.6 cm more than that of pine growing in strong sward conditions. Also the increase in height of trees in 2006 and the root neck diameter reduces, if the sward increases, however, the differences are not remarkable.

Sizes of pine which have grown in planting sites swarded by cereal grass (mainly Calamagrostis arundinacea (L)Rth.), at equal sward level are less than those of pine have grown in planting sites swarded by raspberries. Cereal grass when forming a dense turf, impede growing of pine roots and other vegetative organs. Whereas raspberries provide pine with additional nutrients when destroying the rough humus. Also the competition between pines and raspberries is less pronounced both in surface and in root area. Influence of other plants (clearing area pioneer species, foliage trees) on pine growing could not be evaluated correctly due to the insufficient number of records.

Two-factor dispersion analysis shows that the sizes of pine (height of trees, increse in height in 2006 and root neck diameter in planting sites where cereal grass or raspberries dominate, but not the level of the sward ($F = 0.21$, 0.08 and $0.04 < F_{fad.} = 4.26$), and none of the mentioned plant species influence significantly.

The spruce sizes decrease in plantings, when the sward in planting sites intensifies by the plants most common in the site (grass, bushes, foliage trees). Height of trees grown in strongly swarded planting sites is for 7.4 cm less, increase in height in 2006 – for 4.9 cm less and the root neck diameter is for 3.4 mm less than that of the spruce grown in low sward conditions (Table 7).

In spruce plantings like in pine plantings, the trees mostly compete more with cereal grass (Calamagrostis arundinacea (L)Rth.) than with raspberries. The clearing area pioneer species (willow herbs, groundsels, fleabanes) and foliage trees have less impact on spruce growing. However, the influence of these plants could not be evaluated correctly due to the small number of records.

The two-factor analysis shows that the spruce height differs significantly if they have grown in differently swarded planting sites ($F = 7.7 > F_{fad.} = 3.4$), but the differences in increase in height and in root neck diameter for spruce in planting sites with different sward level are not significant ($F = 2.56$ un $2.03 < F_{fad.} = 3.4$). Sizes of spruce grown in planting sites with different dominating plant species (cereal grass and raspberries) do not differ significantly at equal sward level ($F = 1.39$, 0.03 and $0.20 < F_{fad.} = 4.26$).

Table 7: Spruce sizes in the plantings of container seedlings depending on the level of sward and on the dominating plant species in the planting site Hylocomiosa

Plant species, dominating in the planting site	Level of grass sward in the planting site			On average
	low	medium	high	
Height of trees, cm				

Seed weeds	56.7	52.6	49.1	52.8
Cereal grass	49.6	48.9	47.0	48.5
Raspberries	50.7	51.1	48.3	50.0
Foliage trees	58.5	47.5	41.5	49.2
On average	53.9	50.0	46.5	
Increase in height of the trees in 2006, cm				
Seed weeds	27.0	28.0	20.4	25.1
Cereal grass	23.5	20.7	21.1	21.8
Raspberries	24.0	21.6	21.3	22.3
Foliage trees	26.1	24.5	18.5	23.0
On average	25.2	23.7	20.3	
The root neck diameter of trees, mm				
Seed weeds	13.4	11.5	10.1	11.7
Cereal grass	13.3	12.4	12.2	12.6
Raspberries	13.9	13.3	11.1	12.8
Foliage trees	16.3	14.4	10.0	10.2
On average	14.2	12.9	10.8	

4. Discussion

Planting material which roots are put in substrate during the growing process, was started to use more widely in forest renovation during the last 50-60 years. Now the container seedlings and container plants have become a widely used planting material in many countries over the world. During the period of more than 50 years, different kinds of container seedlings and container plants have been created and tried in practice, as well as various substrate compositions and volumes, container materials and designs. The researches have been performed in different climatic and forest environment conditions. Therefore different results have been obtained in researches and in production conditions (Balisky et al,1995, Bušs, 1974, Halter et al, Mangalis,2004 and others).

There is a popular viewpoint that the container seedlings and container plants could be planted from early spring until late autumn unless the soil in not frozen. The mentioned researches and other ones confirm this viewpoint, but they warn about a high risk in particular periods when the influence of unfavourable ecological factors is remarkable. The biological features of each tree species should also be taken into consideration. The main risk is to plant the conifer container seedlings during the period of active growing of the new sprouts. The growth-in of Latvia's first container plants "Brika" (volume of the sphagnum peat substrate 240 cm3) in different afforestable sites was at least for 5-8% lower than in spring plantings (Bušs and others, 1974). As our researches show, the growth-in of pines in plantings of container seedlings V-120SS during the active growing period is even for 14-15% less than in optimal terms.

During the last years, significant researches on advisable planting terms of spruce container seedlings were performed in Scandinavia (Helenius et al, 2002, Helenius, 2005, Luoranes et al, 2005). It was found in researches in spruce plantings established in summer that planting could be carried out in this period without a risk, if the substrate embracing roots is moist enough and if the period of drought is shorter than three weeks. Intensively growing spruce plants suffer from drought more than the plants kept at the same time in cold storage and being at rest state.

When planting the both pine and spruce container seedlings with a relatively long un unlignified the new top sprout, there is a high risk of damage during transportation and planting.

The obtained research results match with the analysed published conclusions that it is possible by using the pine and spruce container seedlings to extend planting season of pine and spruce container seedlings in the first half of the year until June, while the new top sprouts do not exceed length of 2-3 cm. The planting should be stopped during the intense growing period.

Like the bare-rooted seedlings and plants, also the plantings of container seedling are influenced negatively by vermin, forest animals and frosts. When analyzing the results of many researches, Mangalis (2004) has found that plantings of pine and spruce container seedlings and plants are more endangered by forest animals, especially in the first year, when there are more minerals in the needles. More often are also damages made by weevils *(Hylobius abietis)* and frosts. There was stated in our research that in plantings of container seedlings disinfected in the nursery with insecticide *Fastac*, the number of trees with weevil damages was small even in new clearing areas. However, in later years in favourable reproduction conditions, the number of weevil damages could increase. Number of trees with weevil damages does not differ considerably in plantings of the pine bare-rooted seedlings and the container seedlings. Damages made by forest animals in container seedling plantings do not differ considerably from the damages in bare-rooted plantings, if the trees have well-lignified sprouts. In conditions of increased population of deer and elks in a particular area, protection measures for all plantings should be necessary.

Although, the container seedlings grow in better and the increase in height of trees is more in comparison with bare-rooted seedlings and plants of the same size, but their growth is impeded by grass, foliage trees and bushes. In site type *Hylocomiosa*, the most competition for pine and spruce plantings is created by cereal grass. The agrotechnical treatment in plantings of pine and spruce container seedlings in site type *Hylocomiosa* most often is necessary in the second year after planting, but in new clearing areas – in the third year.

5. Conclusions

Pine and spruce container seedlings HIKO V-120SS could be successfully planted in spring and in summer, while the young top sprout has not reached 2-3 cm. The planting should be stopped during the active growing period.

For pine and spruce container seedlings, like for the pine bare-rooted seedlings and spruce bare-rooted seedlings, the best growth-in and increase in height are for the trees, planted in spring before vegetation period.

Pine and spruce container seedlings disinfected in the nursery could be successfully planted also in new clearing areas.

When planting in new clearing areas, the agrotechnical treatment of plantings of container seedlings could be started a year later than in plantings in two-year old clearing areas.

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