Survival and growth of outplanted seedlings of selected tree species on the High Tatra Mts. windthrow area after the first growing season

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ABSTRACT: Bareroot and containerized seedlings (seedling type) of Norway spruce, Scots pine, European larch, European beech, and sycamore maple were outplanted in autumn 2008 and in spring 2009. Roots of a half of the seedlings were dipped into the commercial fungal product Ectovit prior to spring outplanting. Fifty seedlings were planted for each tree species and seedling type in each of 3 treatments (Autumn, Spring, Spring+Ectovit) and 3 replications (4,500 seedlings in total). Eighty-one per cent of containerized and 75% of bareroot seedlings (most – 89% of bareroot spruce, least – 59% of bareroot pine seedlings) survived after the first growing season. Planting time and Ectovit did not have a marked effect on survival, with the exception of the lower survival of containerized beech and spruce in autumn than in spring. The most extensive damage caused by game and mechanical weed control was found out in both broadleaves; most of the dry leading shoots occurred in beech. Besides beech, higher annual height increment of seedlings was observed in autumn than in spring planting time. Effect of Ectovit on seedling growth was not obvious.

Keyword: reforestation; outplanting time; fungal inoculation; bareroot seedlings; containerized seedlings

Southern foothills of the High Tatra Mts. with almost 2.5 million m^3 of fallen wood on the area of 12,600 ha were the most affected territory after windthrow in 2004. After processing of windfalls, fire started to spread on windthrow clearings and it changed conditions on the soil surface as well as soil moisture and temperature regimes.

Many authors studied destructive consequences of windthrows, fires, and subsequent regeneration of forest on devastated areas. Konôpka (2008) noted that we must consider areas that resulted from 2004 windbreak in the High Tatra Mts. as very endangered from the viewpoint of the mechanical effect of wind. Regarding the stabilization of stands against wind the author emphasised sufficient proportions of the most stable tree species that are broadleaved tree species, larch, and pine. Senn and Schönenberger (2001) stated that short-term experimental plantations need not give relatively serious results being suitable for predicting reforestation under extreme conditions. The authors recorded almost 100% survival rate for Swiss stone pine and bog pine in the first three years after planting, while higher losses were found for larch. During the entire assessed period (1975–1995) the number of individuals dropped from the former plantation of Swiss stone pine to 15.6%, bog pine to 32.5% and of larch to 71.5%. Bachofen (1993) noted that the proper time of outplanting has a more significant effect on the development of aboveground part and root collar diameter than the method and intensity of treatment. Frey (1996) and Reinecke (1998) emphasised the importance of basic nutrients and fertilization on high-mountain clearings and windthrow plots after fires.

Not only the time of planting, fertilization, but also first of all seedling quality used for outplant-

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ing is a decisive factor of good adaptation and subsequent survival of plantations (Tučeková 2006). Jančařík (2006) reported that shortcomings in reforestation and necessity of repeated reforestation are caused by using low-quality planting stock, neglecting site conditions, insufficient soil preparation, outplanting of a low amount of seedlings and insufficient protection of plantations. Jurásek and Martincová (2000) presented the results of cultivation of Norway spruce from seed in the 8th altitudinal vegetation zone grown in two different nurseries. The results showed that longer cultivation of planting stock in so-called acclimation nurseries was not suitable. Individuals from such nurseries had smaller heights than those from nurseries at lower altitudes where seedlings had better qualitative and quantitative characteristics.

Šebeň (2009) described the state of revitalization of an area in the High Tatra Mts. damaged by wind. Regarding the tree species composition, spruce accounts for the highest proportion in stands. He found out by means of monitoring the terrestrial network that in the numbers of individuals there were not any differences between salvage clearing and undamaged well-preserved stands. Most individuals were from natural regeneration, and only few individuals were from artificial regeneration, which accounts for a very low proportion in total regeneration. Good results were recorded in the reforestation of windthrow clearings in state forests of TANAP by sowing (Tučeková 2009). Eleven tree species were sown to so-called vegetation cells, in which also hydroabsorbents formed a part of the substrate. The author considered this way of regeneration of salvage clearings as progressive in the situation when there was an insufficient amount of high-quality seedlings for windthrow sites.

The objective of this study was to assess the effect of planting time and application of the commercial mycorrhizal product Ectovit, containing symbiotic fungi, on survival, damage and growth of bareroot and containerized planting stock of some forest tree species in the first growing season after outplanting on windthrow and subsequently burned area in the High Tatra Mts.

MATERIAL AND METHODS

The research planting plot was established on a clearing where wood was processed after windthrow in 2004 and fire in 2005. The dominant soil type of the locality is modal heavily acidic Cambisol, while the parent rock is moraine and polygenetic debris. The soil is formed of stones and even of boulders in some places. The tree species composition before the windthrow was Norway spruce 70% and European larch 30%; the average age of the stand was 80 years, the typological unit of the site according to Slovak classification is *Lariceto-Piceetum* (larch-spruce stands). Currently, a very sparse mature stand of larch (age above 140 years) is growing on the plot. This stand is a certified stand for the collection of reproductive material and it is a part of gene reserve forests. Norway spruce undergrowth, rarely Scots pine and European mountain ash (*Sorbus aucuparia*) individuals also occur locally on the site. The herbaceous cover of the experimental plot is formed mostly of *Chamaenerion angustifolia*, *Calamagrostis arundinacea*, *Avenella flexuosa* and locally of raspberry shrubs, heather and blueberry shrubs. The forest management plan prescribes for the respective subcompartment artificial regeneration by Norway spruce, sycamore maple, European larch, Scots pine and silver fir. Natural regeneration of European mountain ash is expected. It is done in accordance with a partial revitalization project. From the aspect of orography, the research plot is situated in the Popradska basin, Tatra's foothills. The altitude of the plot is 1,000–1,070 m a.s.l., aspect SE and slope 20–30%.

Bareroot and containerized seedlings of Norway spruce (*Picea abies* [L.] Karst.), Scots pine (*Pinus sylvestris* L.), European larch (*Larix decidua* MILL.), European beech (*Fagus sylvatica* L.) and sycamore maple (*Acer pseudoplatanus* L.) were planted on the research plot. Basic information on seedlings is presented in Table 1.

The volume of (one-cell) Jiffy 7 container was 90 cm^3 after peat tablet swelling, Lännen Plantek 115 cm^3, HIKO 150 cm^3 and 310 cm^3. Planting stock of spruce, pine, larch, and sycamore maple was cultivated in the nursery (centre of the gene pool of tree species) of the State Forests of Tatra Mts. National Park, Rakúske lúky locality and beech in the nursery of the State forests of the Slovak Republic in Jochy locality.

Seedlings were planted in autumn (mid-October 2008) and in spring (end of April 2009). Prior to autumn planting weeds were removed by a scrub cutter on the whole area. In spring the root systems of a half of the plants that were to be outplanted were dipped into the product Ectovit (Symbiom, Lanskroun, Czech Republic), containing spores and mycelium of ectomycorrhizal fungi. The preparation was applied as a gel that was prepared by mixing dry components (mixture of perlite and fine-grained peat containing spores of fungi, mixture of natural substances and powder hydrogel),

Table 1. Basic characteristics of the bareroot and containerized planting stock of forest tree species planted in autumn 2008 and spring 2009 (with and without application of the commercial fungal product Ectovit) at a planting site in the High Tatra Mts. destroyed by windthrow in 2004 and subsequently by fire in 2005

Tree species	Identification No.	Seed source	Transmission zone	Age	Container
Norway spruce	01426PP-010	certified stand category A	2 – Fatransko-podtatranská	1+0[1]	Jiffy 7–36 mm
	01526PP-005	certified stand category B	2 – Fatransko-podtatranská	2+2[2]	
Scots pine	05125PP-023	seed orchard	2 – Podtatranská	1+0[1]	Jiffy 7–36 mm
	05125PP-023	seed orchard	2 – Podtatranská	2+0[2]	
European larch	13526PP-315	category B	2 – Stredoslovenská	1+0[1]	BCC-HIKO; V-150
	13525LM-016	category B	2 – Stredoslovenská	2+2[2]	
European beech	26515BR-776	category B	1 – Podtatranská	1+0[1]	Lännen Plantek PL64F
	26515BR-776	category B	1 – Podtatranská	1+0[2]	
Sycamore maple	28615PP-027	identified	1 – SR	1+0[1]	BCC-HIKO; V-310
	28615TS-003	identified	1 – SR	2+0[2]	

[1]Containerized seedlings cultivated in a greenhouse; [2]Bareroot seedlings cultivated in a nursery bed

fungal mycelium and adequate amount of water. Fifty seedlings of each tree species, seedling type and compared treatments (Autumn, Spring, Spring+Ectovit) were planted in each of three replications (blocks), 4,500 seedlings in total. The experiment was established in a complete randomized block design with three blocks (replications).

Seedlings were planted into holes regularly placed in square spacing. Planting distance and number of seedlings per ha (stock density), equally for non- and containerized seedlings, were as follows: spruce 2.0 × 2.0 m (2,500 seedlings·ha^{-1}), larch 2.25 × 2.25 m (2,000 seedlings·ha^{-1}), pine, beech and sycamore maple 1.6 × 1.6 m (4,000 seedlings·ha^{-1}). Fifty seedlings of spruce were planted on an experimental plot of the area of 200 m^2, of larch on 255 m^2, and of pine, beech and sycamore maple on the area of 130 m^2. The size of one block (5 tree species, 2 types of seedlings, 3 treatments) was 5,070 m^2 and of the whole experimental plot 15,210 m^2 (1.52 ha). The regular placement of seedlings at outplanting could not always be observed due to piles of waste after felling and root balls. Individual protection of plants against game by the painting of terminal shoot with the chemical repellent Cervacol was carried out after autumn planting. During the growing season, weeds were removed twice (at the beginning of June and in August), using a scrub cutter on the whole area.

Root collar diameter and stem height of seedlings were measured after outplanting in spring (after the establishment of the whole experiment) to find out the values of these basic biometric characteristics at the time of planting. Survival of seedlings after the winter season was also recorded. Root collar diameter and stem height, and in addition height increment, were repeatedly measured after the first growing season (at the beginning of October). Seedling losses (missing and dry plants) and damage (missing leading shoot, dry terminal bud or leading shoot, damage by game, rodents, weed removal) were recorded at the same time. The volume of the aboveground part of seedlings was calculated according to the equation $1/3\pi \times 1/2h^2 \times v$ (modification of Ruehle 1982, who determined the volume of the aboveground part as $h^2 \times v$).

For each tree species and seedling type, the experiment was a two-way classification (combination of planting time and Ectovit application; block) arranged in a randomized complete block design. Survival and damage of seedlings were calculated as a percentage of the number of living individuals from the total number of outplanted seedlings and damaged individuals from the number of survived seedlings, respectively. The growth characteristics were analysed by one-factorial analysis of variance (ANOVA) followed by Tukey's test (P = 0.05) to determine differences among treatments. ANOVA was carried out using the PC SAS statistical package.

RESULTS

The average survival rate of bareroot and containerized seedlings of all tree species outplanted at different seasons and with the application of the fungal product Ectovit was 78% after the first growing season. The survival rate of bareroot and

Table 2. Survival of seedlings after the first winter season (WS) and the first growing season (GSS) planted at different time and with the application of the fungal product Ectovit at a planting site in the High Tatra Mts. disturbed by windthrow in 2004

Tree species		Autumn		Spring	Spring+Ectovit	Average	
		WS	GSS	GSS	GSS	WS	GSS
Norway spruce	bareroot	97	95	86	85	97	89
	containerized	76	65	82	91	76	70
Scots pine	bareroot	98	65	48	63	98	59
	containerized	84	84	90	83	84	86
European larch	bareroot	92	72	80	67	92	73
	containerized	88	80	74	73	88	76
European beech	bareroot	94	74	81	80	94	78
	containerized	92	69	89	80	92	80
Sycamore maple	bareroot	85	76	75	84	85	78
	containerized	84	81	90	81	84	84

containerized seedlings ranged in the interval of 59–89% (on average 75%) and 70–86% (on average 81%), respectively (Table 2).

Regardless of the planting time, the lowest survival was found for bareroot Scots pine (59%), while the highest one for bareroot Norway spruce (89%) seedlings. The most marked differences in survival caused by planting time and Ectovit occurred in containerized spruce between autumn planting (65%) and spring planting + Ectovit application (91%) and in containerized beech between autumn (69%) and spring (89%).

Seedling damage after the first growing season expressed as a proportion of damaged seedlings from all the survived living ones ranged in the interval 0–53% with regard to individual tree species, planting time and Ectovit application (Figs. 1 and 2).

The most frequent was damage caused by game, mechanical weed control and drying of terminal shoot. The highest extent of damage was found for the broadleaves European beech and sycamore

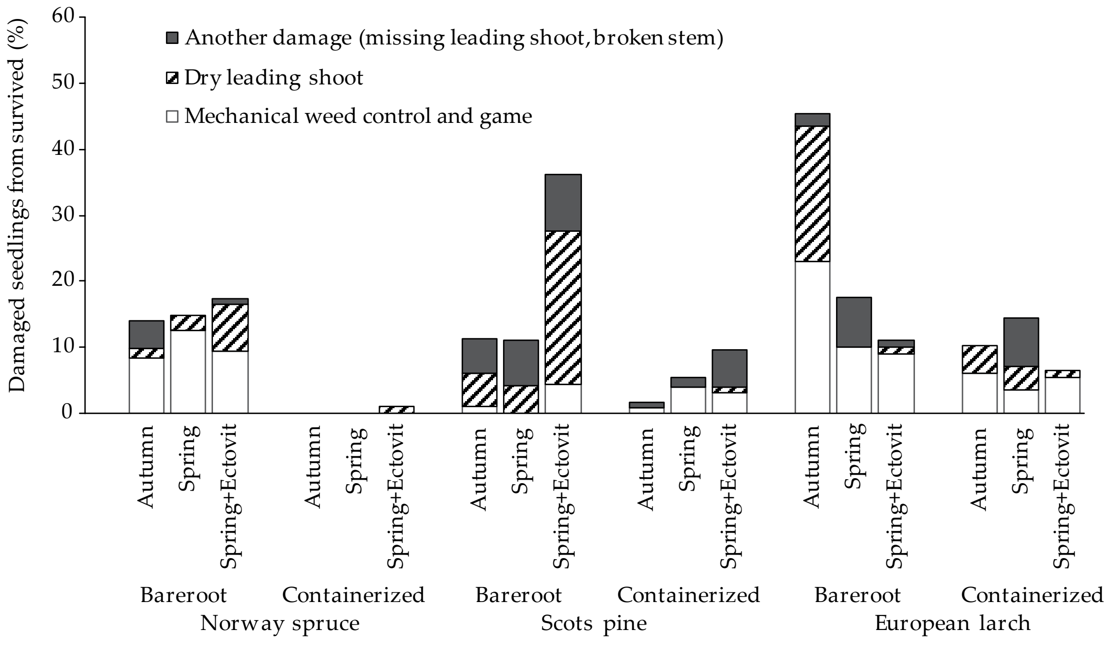

Fig. 1. Damage to plantations of Norway spruce, Scots pine and European larch after the first growing season planted at different time and with the application of the fungal product Ectovit on the plot in the High Tatra Mts. after windthrow in 2004

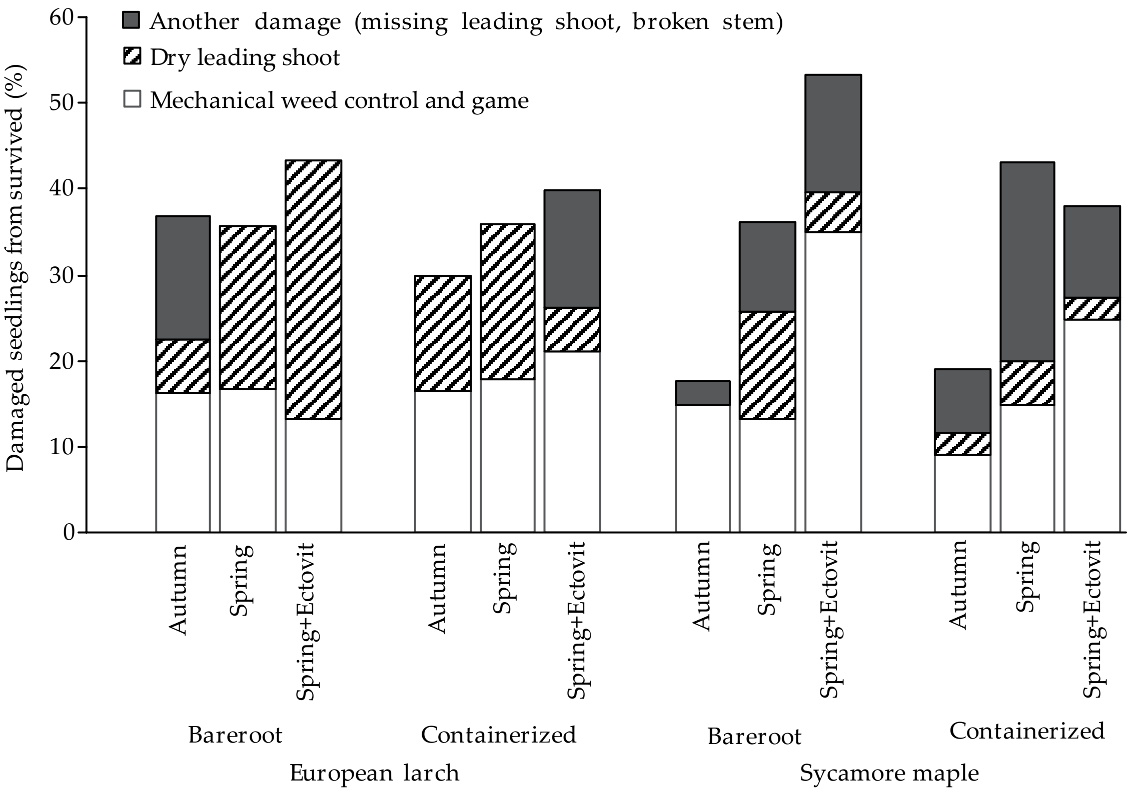

Fig. 2. Damage to plantations of European beech and sycamore maple after the first growing season planted at different time and with the application of the fungal product Ectovit on the plot in the High Tatra Mts. after windthrow in 2004

maple. Damage due to the drying of terminal shoot was more frequent in beech. Sycamore maple was damaged mostly by game and mechanically during weed removal. In coniferous tree species, a greater extent of damage was found only in bareroot Scots pine from spring planting with Ectovit application (36%) and bareroot European larch from autumn planting (45%).

Among the measured biometric parameters of seedlings, height increment reflected the most markedly the effect of different planting time or Ectovit application on seedlings after the first growing season at the planting site (Tables 3 and 4).

A positive effect of autumn seedling outplanting on height increments was detected particularly in bareroot plants with the exception of beech. Significant differences ($P < 0.05$) between the average values of height increments of seedlings from autumn and spring outplanting were found only for bareroot Norway spruce and containerized sycamore maple. An opposite trend was observed for containerized Scots pine seedlings which were in the advanced phase of height growth at spring planting. Height increment of containerized Scots pine seedlings from spring outplanting with the application of Ectovit was significantly higher ($P < 0.05$) than that from spring planting without Ectovit.

DISCUSSION

With the exception of spruce, containerized seedlings of the other assessed tree species (pine, larch, beech and maple) had on average higher survival than bareroot ones. A difference between the seedling types of pine was almost 20% in autumn and even 42% in spring outplanting. However, especially the comparison of bareroot and containerized spruce and pine seedlings in this experiment is not reliable because of different age and thus the size and quality of seedling types. For this reason, the growth of seedling types of neither of the tree species was statistically compared.

The risk of lower physiological quality is substantially higher in bareroot than in containerized planting stock. A decisive parameter is the condition of the root system, first of all the growth of new roots that facilitate the uptake of nutrients and water for rooting and bud-breaking of plants. Advantages of using the containerized type of planting stock are generally known and they were described e.g. in studies of Mauer (1999), Tučeková and Ábelová (2002), Šmelková and Tichá (2003) and Tučeková (2004a). Containerized seedlings are the most suitable material for reforestation or afforestation of eroded sites (Tučeková 2004a).

Table 3. Analysis of variance (*F*- and *P*-values) of the effect of planting time and application of the fungal product Ectovit on growth characteristics of seedlings at planting time and after the first growing season on the research plot in the High Tatra Mts. disturbed by windthrow in 2004

Growth parameter	Source of variability	Bareroot (B)				Containerized (C)			
		at planting time		after 1st growing season		at planting time		after 1st growing season	
		F	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Norway spruce									
Root collar diameter	treatment	1.61	0.307	0.34	0.731	2.78	0.175	376.98	0.001
	block	0.31	0.748	0.84	0.494	4.91	0.084	222.54	0.001
Stem height	treatment	0.98	0.451	3.93	0.114	0.57	0.605	0.35	0.723
	block	0.12	0.886	0.02	0.980	0.97	0.454	0.54	0.621
Stem volume	treatment	1.33	0.360	0.89	0.479	1.02	0.440	216.90	0.001
	block	0.11	0.901	0.46	0.662	10.80	0.024	88.85	0.001
Height increment	treatment	–	–	24.73	0.006	–	–	1.28	0.373
	block	–	–	0.75	0.530	–	–	0.88	0.482
Scots pine									
Root collar diameter	treatment	6.43	0.056	8.00	0.040	3.46	0.134	14.12	0.018
	block	0.24	0.795	0.92	0.468	0.69	0.553	2.24	0.225
Stem height	treatment	184.98	0.001	13.68	0.016	0.38	0.708	3.25	0.145
	block	0.39	0.700	0.72	0.542	1.11	0.414	0.01	0.986
Stem volume	treatment	33.13	0.003	9.18	0.032	2.13	0.234	16.11	0.012
	block	0.48	0.649	1.20	0.390	0.52	0.630	2.43	0.204
Height increment	treatment	–	–	6.92	0.050	–	–	13.55	0.017
	block	–	–	0.33	0.739	–	–	0.88	0.481
European larch									
Root collar diameter	treatment	1.59	0.310	0.02	0.985	2.19	0.227	1.45	0.336
	block	0.60	0.590	6.86	0.051	0.07	0.930	1.19	0.394
Stem height	treatment	4.60	0.092	2.01	0.248	7.27	0.047	2.95	0.163
	block	2.46	0.201	2.81	0.173	0.10	0.903	0.08	0.926
Stem volume	treatment	2.05	0.243	0.91	0.474	3.14	0.151	1.33	0.361
	block	1.11	0.414	6.45	0.056	0.07	0.931	0.77	0.521
Height increment	treatment	–	–	1.31	0.366	–	–	2.67	0.183
	block	–	–	3.13	0.152	–	–	1.40	0.346
European beech									
Root collar diameter	treatment	3.52	0.131	1.81	0.276	5.91	0.064	0.42	0.684
	block	2.02	0.247	0.12	0.889	1.44	0.338	1.95	0.256
Stem height	treatment	27.11	0.005	12.16	0.020	2.04	0.245	0.28	0.773
	block	1.31	0.364	0.93	0.467	0.04	0.960	0.38	0.707
Stem volume	treatment	17.67	0.010	4.59	0.092	3.16	0.150	0.74	0.531
	block	4.78	0.087	0.09	0.918	1.24	0.382	0.59	0.594
Height increment	treatment	–	–	0.01	0.990	–	–	0.47	0.658
	block	–	–	0.39	0.700	–	–	0.56	0.611
Sycamore maple									
Root collar diameter	treatment	3.10	0.154	3.25	0.145	6.35	0.057	11.36	0.022
	block	0.79	0.515	1.21	0.387	1.31	0.364	4.74	0.088
Stem height	treatment	0.32	0.743	0.89	0.478	4.84	0.085	4.17	0.105
	block	0.35	0.727	0.55	0.617	1.03	0.435	0.60	0.590
Stem volume	treatment	2.92	0.165	2.52	0.196	5.47	0.072	8.88	0.034
	block	0.74	0.533	0.65	0.570	2.04	0.246	1.74	0.286
Height increment	treatment	–	–	5.98	0.063	–	–	9.61	0.030
	block	–	–	2.51	0.197	–	–	0.01	0.989

Table 3 to be continued

Source	Degrees of freedom									
	Norway spruce		Scots pine		European larch		European beech		Sycamore maple	
	B	C	B	C	B	C	B	C	B	C
Ectovit	2	2	2	2	2	2	2	2	2	2
Block	2	2	2	2	2	2	2	2	2	2
Error	4	4	4	4	4	4	4	4	4	4
Residual	421	388	402	370	388	387	356	295	337	334
Total	429	396	410	378	396	395	364	303	345	342

B – bareroot; C – containerized

Related to survival, similar results like in this study were reported by Lokvenc (1990) in detailed analysis of Norway spruce plantations at the altitude of 1000 m affected by air pollutants two years after outplanting. The author found out that dieback was 18% higher in bareroot than in containerized seedlings. Also Pellissier (1992) described higher survival of containerized spruce seedlings in comparison with bareroot ones four years after outplanting. Tučeková (2001) presented higher survival of containerized (95–98%) than bareroot seedlings (83–85%) of European larch and Austrian pine in an air-polluted magnesite region (pH of soil 8.1). Repáč (2009) reported 92% survival of containerized rooted cuttings of Norway spruce four years after outplanting, inoculated with ectomycorrhizal fungi at the rooting time in a greenhouse.

The smallest differences in the survival rate between containerized and bareroot planting stock were recorded for beech (2%) in this experiment. Studies on survival and subsequent growth of beech seedlings are rather scarce. In Slovakia, positive results were recorded with the planting of containerized beech seedlings in the Duchonka locality after strong windthrow, when their survival rate was 50% higher in comparison with bareroot ones (Tučeková 2004b).

Planting time did not have a considerable effect on seedling survival of any of the tree species and seedling type. The markedly lower survival rate of containerized spruce from autumn planting (65%) in comparison with spring planting (82%) was caused by lower values of biometric parameters of planted seedlings and thus by increased vulnerability to harsh winter conditions and subsequent weed competition during the growing season. The lower survival rate of containerized beech from autumn planting compared to the spring time (20% difference) is in contradiction with expectations based on practical experiences. With regard to high losses of beech seedlings planted in autumn during the subsequent growing season, reasons for their lower survival are most probably the physiological state at planting, injury during winter and/or further destruction by abiotic and biotic harmful pests. Bareroot spruce seedlings survived better when outplanted in autumn (95%) than in spring (86%). Gubka (2001) and Repáč (2005) also reported that the survival of bareroot spruce seedlings at the autumn time of planting may be equally reliable or even better than at the spring time.

Beech and maple were the most damaged tree species (up to 53%), as was expected in regard to their attractiveness to wildlife and their difficult identification at the site at weed control. Dry terminal shoot, most probably the expression of transplant shock in consequence of insufficient physiological quality, was the most frequently observed in beech. A high amount of dry leading shoots on pine from Spring+Ectovit treatment was probably related to mechanical damage of the root system of transplanted seedlings caused by harsh lifting from the nursery bed and emphasized by the inappropriate effect of Ectovit applied in gelatinous form to such roots. Considerable damage to bareroot European larch seedlings outplanted in autumn (45%) could be caused by a combination of the above-mentioned factors (root system quality, attractiveness to game, weed control, winter conditions). Total damage, especially drying of leading shoots, was generally observed more frequently in bareroot than in containerized seedlings for all tree species. Larger differences in damage percentage between bareroot and containerized seedlings were found out for coniferous than broadleaved species. Twenty years after plantation establishment in the Swiss Alps, Senn and Schönnenberger (2001) recorded even 95.5% damage to tree species such as Swiss stone pine, bog pine and larch (game browsing, weather factors, and others).

Table 4. Mean values of growth characteristics of seedlings at planting time and after the first growing season outplanted at different time and with the application of the fungal product Ectovit at a planting site in the High Tatra Mts. disturbed by windthrow in 2004. Values followed by different letter are significantly (Tukey $P < 0.05$)

Treatment	Root collar diameter (mm)		Stem height (cm)		Volume of aboveground part (cm^3)		Height increment after 1st growing season (cm)
	at planting time	after 1st growing season	at planting time	after 1st growing season	at planting time	after 1st growing season	
Norway spruce, bareroot							
Autumn	7.84^a	7.88^a	32.46^a	40.10^a	5.49^a	6.88^a	8.37^a
Spring	6.60^a	7.17^a	28.98^a	33.57^a	3.63^a	5.01^a	4.61^b
Spring+Ectovit	7.47^a	7.38^a	30.34^a	33.08^a	4.83^a	5.21^a	4.69^b
Norway spruce, containerized							
Autumn	0.96^a	1.09^b	4.53^a	5.75^a	0.01^a	0.02^b	1.95^a
Spring	0.67^a	0.94^c	4.64^a	6.04^a	0.01^a	0.02^b	1.96^a
Spring+Ectovit	0.95^a	1.51^a	4.22^a	6.30^a	0.01^a	0.05^a	2.49^a
Scots pine, bareroot							
Autumn	5.27^a	5.78^a	20.44^a	24.71^a	1.59^a	2.46^a	6.83^a
Spring	4.56^a	4.86^{ab}	13.79^b	17.64^b	0.85^b	1.27^{ab}	4.74^a
Spring+Ectovit	4.44^a	3.95^b	13.56^b	18.74^b	0.79^b	0.87^b	3.96^a
Scots pine, containerized							
Autumn	2.77^a	3.02^b	12.77^a	17.25^a	0.29^a	0.49^b	7.56^b
Spring	3.91^a	4.25^a	12.70^a	22.01^a	0.60^a	1.22^a	8.51^b
Spring+Ectovit	4.01^a	4.67^a	13.88^a	26.01^a	0.65^a	1.60^a	10.90^a
European larch, bareroot							
Autumn	7.33^a	7.44^a	43.18^a	43.87^a	7.47^a	7.06^a	9.29^a
Spring	7.59^a	7.42^a	45.50^a	49.44^a	8.27^a	8.83^a	6.36^a
Spring+Ectovit	6.57^a	7.37^a	35.58^a	41.43^a	4.59^a	7.13^a	7.70^a
European larch, containerized							
Autumn	1.72^a	2.57^a	7.48^b	16.61^a	0.06^a	0.37^a	9.40^a
Spring	2.11^a	2.74^a	8.75^{ab}	18.64^a	0.12^a	0.46^a	9.74^a
Spring+Ectovit	2.52^a	3.13^a	11.51^a	18.88^a	0.23^a	0.55^a	6.53^a
European beech, bareroot							
Autumn	4.13^a	3.92^a	24.55^a	23.94^a	1.23^a	1.11^a	2.85^a
Spring	3.73^a	3.49^a	19.41^b	18.45^b	0.80^b	0.64^a	2.90^a
Spring+Ectovit	3.91^a	3.34^a	19.92^b	19.45^b	0.89^b	0.63^a	2.77^a
European beech, containerized							
Autumn	3.48^a	4.31^a	22.66^a	23.79^a	0.86^a	1.33^a	3.16^a
Spring	3.97^a	4.61^a	25.26^a	24.96^a	1.18^a	1.55^a	3.60^a
Spring+Ectovit	3.95^a	4.59^a	24.15^a	24.62^a	1.16^a	1.62^a	3.81^a
Sycamore maple, bareroot							
Autumn	7.39^a	7.47^a	42.62^a	47.97^a	10.53^a	12.54^a	4.31^a
Spring	5.51^a	5.24^a	38.63^a	39.63^a	3.36^a	3.37^a	2.33^a
Spring+Ectovit	5.81^a	5.43^a	38.28^a	38.73^a	3.83^a	3.44^a	2.24^a
Sycamore maple, containerized							
Autumn	3.89^a	5.24^b	16.22^a	20.80^a	0.82^a	1.74^b	6.83^a
Spring	4.78^a	6.13^a	22.97^a	24.60^a	1.64^a	2.86^a	3.81^b
Spring+Ectovit	4.54^a	5.80^{ab}	20.75^a	25.20^a	1.45^a	2.73^{ab}	5.32^{ab}

Taking into account development stage, short time after outplanting as well as certain biometric heterogeneity of the compared planting stock at the time of planting the assessment of growth parameters is problematic. Perhaps height increment expresses the adaptation and growth response of plants to the environment during the first growing season in the best way. Bareroot spruce plants and containerized sycamore maple plants planted in autumn reached significantly higher values of height increment than those from spring planting. A similar trend was also observed in bareroot plants of the other tree species with the exception of beech. The Ectovit application did not have any significant effect either on height increment or on the other assessed growth measurements of seedlings with the exception of containerized spruce on which a slight stimulative effect of the mycorrhizal product was detected. Outplanting time, mycorrhization, soil and peat admixtures to planting holes did not have any stimulative effects on the growth of 2+2 bareroot Norway spruce seedling one year after outplanting at a site in the Kremnické vrchy Mts. (Repáč 2005). Kriegel (1999) applied biodegradable geotextile to the holes before Norway spruce outplanting in mountain slope terrains where granite is the geological parent rock and debris is formed without any organic material in some places. Treated seedlings had significantly higher stem diameter, stem height and height increment than untreated ones.

Similarly like in our experiment, Castellano (1996) and Garbaye and Churin (1997) reported an indifferent impact of fungal inoculation on the survival and growth of outplanted seedlings. However, a stimulative effect of inoculation on seedling growth in some fungus-tree species-environment combinations was observed as well (Marx 1991; Castellano 1996; Garbaye, Churin 1997). Querejeta et al. (1998) pointed out that the inoculation effect (spores and forest soil) on seedling development depends on the mechanical preparation of soil and a positive response of seedlings to fungus application is more feasible in a water stress period.

CONCLUSION

Presented results document the planting stock of specific species, age and quality and therefore it is not possible to generalize them for material with different pattern. The average survival rate of all seedlings regardless of the tree species was 78%, whereas the survival rate of containerized seedlings was only slightly higher (81%) than that of bareroot ones (75%). The highest survival rate was found for bareroot spruce (89%), followed by containerized pine and sycamore maple. The lowest survival was determined for bareroot pine (59%), which was expected with regard to the low quality of the root system of seedlings of this tree species. The time of planting and Ectovit application did not have any more pronounced effect on survival in most of the tested tree species.

The seedlings were damaged to the largest extent by game browsing and mechanically at weed control whereas these factors could not be distinguished reliably. In consequence of attractiveness to game and difficult identification of herbs during weed removal, broadleaved tree species were damaged much more than conifers. Dried terminal shoot occurred most frequently in beech seedlings and in spring outplanting with Ectovit application in bareroot pine.

With regard to the short time after seedling outplanting the assessment of growth parameters is only preliminary and not reliable. Bareroot Norway spruce and containerized sycamore maple seedlings planted in autumn reached significantly higher values of height increment than those planted in spring. A similar trend was observed also in bareroot seedlings of the other tree species with the exception of beech. The Ectovit application did not have a significant effect on height increment.

In addition to the assessment of survival, damage and growth response of the aboveground part of seedlings, evaluation of root system, chemical analyses of soil and photosynthetic apparatus as well as physiological quality of seedlings will be performed in the next growing seasons.

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