GROWTH DYNAMICS AND HEALTH CONDITIONS OF NORWAY SPRUCE PLANTATIONS ON THE BULLDOZER-SPREAD WINDROWS AFTER FERTILIZATION, IN THE ORE MOUNTAINS – KRUŠNÉ HORY (2002–2006)*

M. Kouba

Czech University of Life Sciences, Faculty of Forestry and Wood Sciences, Department of Silviculture, Prague, Czech Republic

The paper describes the effect of fertilizers on the growth dynamics and nutrition status of 765 Norway spruce plants on windrows spread by bulldozer in the 7th altitudinal forest zone in the Ore Mountains (Krušné hory). Plants were planted out in lines on the new plots within the frame of the partial restoration of the substitutive tree species stand. There were 2 types of fertilizers (Silvamix Forte powder and tablets; Cererit) applied immediately after planting to support the plantation growth. There was a significant damage by browsing observed in 2006, up to 23% of plants in one of the variants. After 5 years of monitoring the results showed that the application of Silvamix Forte had a significantly positive influence on the average height, height increment, lowered mortality and had no influential effect on competition with the forest weed. After 4 years it had no influence on the yellowing of the plantation. Fertilizer Cererit had a negative effect – an increased mortality of plantations.

soil degradation; bulldozer site preparation; chemical amelioration; Silvamix; Cererit; site restoration; needle analysis; harmonic nutrition

INTRODUCTION

The high plateau of the Ore Mountains (Krušné hory) offered ideal conditions for the multiple use of mechanized preparation of forest localities for reforestation during the period of the air pollution disaster. The soil was scarified when excavators and bulldozers were used for the preparation of soil aiming forest restoration. Soil profiles relatively undamaged by air pollution were uncovered and uniform reliefs of windrows were formed (Vavříček, Šimková, 2006). The conditions of windrows allowed for a repeated fast going reforestation and the application of chemical amelioration (Podrázský et al., 2001). From the beginning, there were a lot of different opinions on the persistently bulldozered preparation of localities, nevertheless, it was used on relatively extensive areas. According to Kula (2006) more than 30,000 ha of stand area (damaged by air pollution) were replanted in the eighties. Mauer and Hobza (2006) considered the Ore Mountains as the most problematic region damaged by air pollution, where an almost coherent area of substitutive tree species stands of 35,000 ha was established. Pop (2004) states that bulldozer preparation was applied on about 4,100 ha of the forest area and Podrázský (2006) specifies that according to Forest Management Institute Brandýs nad Labem (ÚHÚL in Czech language) record it was applied on 4,396.5 ha.

In recent years, the restoration of substitutive tree species stands by planting target tree species becomes a more observed activity in the forest regeneration of the Ore Mountains. Success or non-success of these restorations depend on many factors, such as climatic and soil conditions of the site, genetic and physiological quality of planting stock. There is also an influence of the method of restoration – whether there is an under-planting, inter-planting, or in the case of restorations: planting on new cleared area, e.g. spread windrows. The success of restoration is affected by the quality of implementation of a given plantation. The losses after planting were exceeding often 35% of planted trees as documented Mauer and Hobza (2006). A serious problem of a realized plantation is that most of planted plants are in shock for a long time persisting up to 5 years. Mauer et al. (2006) observed a very slow growth with damaged tree tops up to a height of about 2.5 m above-ground part. The forest regeneration is significantly impacted by game browsing too.

The increase in root system volume (reduction of losses) and support of growth dynamics after planting is representing a desired effect of amelioration in the forest regeneration. The fertilizers are made with respect to specific requirements of the forest (variability, slow solubility, long term effect and lowest demands on accuracy of realization of operation). The application of fertilizer in tablet form is quick and easy. Decomposition of a Silvamix fertilizer (primarily tablet form) depends on soil moisture,

* This article originated as a part of the research projects – National Agency for Agricultural Research (NAZV) 1G57073 Factors influencing the changes of forest soils under anthropogenically influenced conditions and The Czech Science Foundation (GAČR) GA205/07/0941 Application of soil magnetometry for pollution mapping in regional scale (Ore Mts. Region).

its deficit inhibits fertilizer decomposition (Mudrová, 2005).

The impact of the amelioration treatments on the health improvement of a forest stand and on the acceleration of growth dynamics of a man-made forest was confirmed for example by Remeš and Podrázský (2002) or Remeš et al. (2005). The demand for tablet fertilizers has relatively decreased at the present time. Its use is mainly associated with curative application in places with a proven nutrient deficit. Remeš et al. (2006) consider increasing the importance of fertilization especially in the restoration of forest ecosystems in unfavourable locality conditions. Reforestation of anthropogenic degraded localities (Podrázský, Remeš, 2004) or chemical amelioration have become an important measure with a high potential for restoration support of species diversity – e.g. supporting growth of more demanding deciduous trees on localities with the lowest production ability.

The aim of this article is to evaluate an impact of used fertilizers on increment increase, seedlings rooting (mortality) and the reduction of nutrients deficiency symptoms.

MATERIAL AND METHODS

Observed plots are located approximately 2 km NNW from the village Boleboř in the Ore Mts. on the standproperty "Lesy města Jirkova" on the high plateau, at an altitude 840–860 m. above sea level. Acidic metamorphic rock (mica schist) prevails as geologic bedrock. Soil type is Cambisol (brown forest soil), similarly Cryptopodzol (Hraško et al., 1987), forest type is 7K4 (Fageto-Piceetum acidophilum), pollution damage zone is A (Podrázský et al., 2003). From a climatic point of view locality belongs in cold region CH6 (Quitt, 1971). Climate area C1 (mildly cold climate) is the largest in a given area that corresponds with the high plateau. Average annual temperature ranges between 4–5 °C, average temperature in July between 14–15 °C, average temperature in January between –4 to –5 °C. Precipitation does not decrease below 800 mm on the high plateau but on the slope there is a decrease in altitude from 800 mm to 550 mm. Rainfall total in the growing season range is between 600–700 mm, and in the winter season between 400–500 mm. Number of days with snow cover is 120–140 per year, and the number of frost days is 140–160.

In winter 2001/2002 windrows were spread by bulldozers within the frame of the currently running reconstruction of the stands of substitute tree species in the Ore Mts., and four year old plants of Norway spruce (2y + 2y) with beech (between rows), were planted into new created fields with spread material from the windrows. Due to the absence of protection against game, beech was completely damaged by game browsing within a few years, and now there are only 9 individuals of beech on all 16 observed areas. There are 4 variants in 4 series, in total 16 observed plots, and on each of them there are approximately 50 plants, totally 765 plants.

Variants of treatment:

C – control, without fertilizer

Ce – Cererit – 50g/1 plant

T – 4 tablets of SILVAMIX Forte fertilizer, 4 x 5g per 1 plant (total 20 g)

Pw – 20 g of SILVAMIX Forte fertilizer in powder form per 1 plant.

Shortcuts of each of variants (shown as letters C, Ce, T or Pw) are used in following text to mark each variant.

Fertilizers were applied immediately after plantation. Cererit and Silvamix Forte in a powder form were scattered around plants at a distance 50 cm from stem, 4 pieces of Silvamix Forte in tablet form were pressed into the soil at a distance 20–30 cm from the stem in all directions. The content of nitrogen in all variants of fertilizers is identical.

Measuring of the plant heights was not carried out immediately after planting but for the first time in autumn 2002. The height of plants in year 2001, i.e. height at the time of plantation, was determined retrospectively. The height of plants is measured each year at the end of the growing season with an accuracy of 0.5 cm. Height increment being determined as the difference of height in a given two years (height increment 2003 = height in year 2003 – height in year 2002).

Mortality, yellowing and browsing was described each year and was statistically evaluated by multiple comparison for parameter p of binomial distribution at α 0.05 significance level. This method evolves from the thesis of Hayter (1984).

Excessive damage caused by browsing in the year 2006 had an indispensable impact on average height and average increment and it leads to the modification of the methods of the valuation calculating to eliminate the effect of browsing. Originally, impacted trees were totally eliminated from the valuation. But, because in 2006, there were not enough individual plants for statistical evaluation, we had decided to eliminate only those that did not meet the average increment of all plants for each specified plot in a specified year. The measurement of each series (i.e. out of 4 plots) of each variant was matched together when being statistically evaluated. The values presented in tables and figures are these summaries of each of variant.

For the statistic evaluation we used the one-factor multi-criterion ANOVA analysis by the Tukey HSD Test (Statistica 8.0; significance level at $\alpha = 0.05$) and then the comparison of each variant using the Dunnett Test (the value higher than control is marked by +).

RESULTS AND DISCUSSION

Conditions on the spread windrows are strongly differentiated and the allocation of the organic matter through the spreading of the windrows is indeed useful, however, its amount is insufficient and very often covers only 1/3 of the vegetation area. Plantations are generally growing slowly with the accompanied effects of out planting shock (Mauer et al., 2006) and high mortality. This fact was

Table 1. Average height of the spruce plantations (cm)

Height (cm)	2001	2002	2003	2004	2005	2006
C – control	34.2ab	40.6ab	46.5a	54.7a	70.0b	89.3a
Ce – Cererit	33.7a	39.8b	46.8a	55.5a	72.3ab	91.5a
T – tablets	35.4ab	42.6a+	51.2b+	60.2b+	75.8a+	90.4a
Pw – powder	35.7b	42.8a+	50.4b+	60.1b+	75.1a+	92.0a

Note: Different indexes indicate significant differences, + indicate that the value is higher than control (due to Dunnett test), significance level at $\alpha = 0.05$

Values represented in the table are summaries (approximate) values out of 4 series of each variant. Mean values were calculated by the method of least squares in programme Statistica 8.0

Table 2. Average increment of the spruce plantations (cm)

Increment (cm)	2002	2003	2004	2005	2006
C – control	6.4a	6.3a	8.8a	15.2a	20.7a
Ce – Cererit	6.3a	6.2a	9.5a	17.3a	20.3a
T – tablets	7.2a	8.4b+	8.9a	15.7a	17.8a
Pw – powder	7.2a	7.5ab+	10.1a	15.5a	18.8a

Note: Different indexes indicate significant differences, + indicate that the value is higher than control, significance level at $\alpha = 0.05$

expected also on research plots and therefore the application of fertilizers appeared as proper supportive tool.

The average heights of variants were slightly different at the time of planting (Table 1), but the variants Ce and Pw were significantly different. The Dunnett test did not significantly prove a difference of higher values of the variants Ce, T and Pw compared to C. Already in the first year of the monitoring (2002) this test proved the significant differences in variants T and Pw (the heights compared to C were significantly higher, marked + in Table 1).

This difference was yearly significant over the following 3 monitored periods (2003–2005). Tukey's test proved a significant difference between monitoring C and variants T and Pw, the second year after planting (2003) and further on for the next 2 years (2004–2005). In the first year after planting these variants (T and Pw) were significantly different only compared to variant Ce. In the fifth year after the planting (2006) the differences between variants equalized and no test proved any significant difference. That might be caused by the abating of the fertilizer's effect (producers are stating four years of effect) but certainly also by the abnormal browsing by game in 2006 which will be discussed later.

Even though the spreading the windrows should help the area growing conditions, the plantations are showing a minimum growing increment in the first two years (Table 2). Although the increase of absolute values is not outstanding, the fertilizing effect on average heights comparing to C has been significant for four years. Simultaneously, the variants treated with Silvamix (T and Pw) decreased in mortality. Mortality on Silvamix variants after 5 years when compared to Control is half-sized (Fig. 1). Variant Ce (quickly dissolvable industrial fertilizer Cererit) compared to T and Pw was significantly lower in the second until the fourth year after planting. The average height increase of the of Ce variant in second year (even though the decrease of the increment) was caused by the extreme mortality rate, mostly of the lower seedlings (10% in comparison to 3% on a control and 2 to 3% on variants with Silvamix) as a result of nutrient disproportion and dry year 2003. Mortality of Ce variant was significantly higher than variants T and Pw in 2002 and higher than control C and Pw in 2003. Cererit fertilizer is for forest wood nutrition absolutely unsuitable, above all, with its principle of fast releasing bigger amount of its nutrients.

The influence of the dry year 2003 showed a decrease of the increment on control (C), while at the Silvamix application its increment increased (Table 2). The increment of C was higher already in the first year, significantly (tablet form – T) after the year 2003. In addition the Dunnett test proved at variant T (simultaneously also Pw) in the second year (2003) significantly higher values against the control (C). The increments of the fertilized variants as compared with C were also higher in the following years, even though not significantly (Table 2).

Since the fourth year of monitoring the increment of variant Ce was even higher than variants T and Pw. During the fourth year there were colour changes on the assimilatory organs of the fertilized variants T and Pw and they were reached values of C. Differences between variants insignificant, only variant T was significantly different from other variants in the third year (2004). During the fifth year (2006) the number of yellowing individuals was even higher than value C (Fig. 2).

This effect is signalizing the abating of the supportive effect of the Silvamix fertilizer. The result of Silvamix from an application point of view (tablets, powder) seems to be equal. After 5 years of monitoring (except the year 2003), the powder form seem to be more effective.

The needle analysis of seedlings with deficiency effects in 2006 is resulting in a loss of Magnesium (Mg) and Calcium (Ca) at all variants (C, Ce, T and Pw). In T and Pw variants the content of Magnesium is three times higher than on control due to Silvamix (Table 3). On variant C

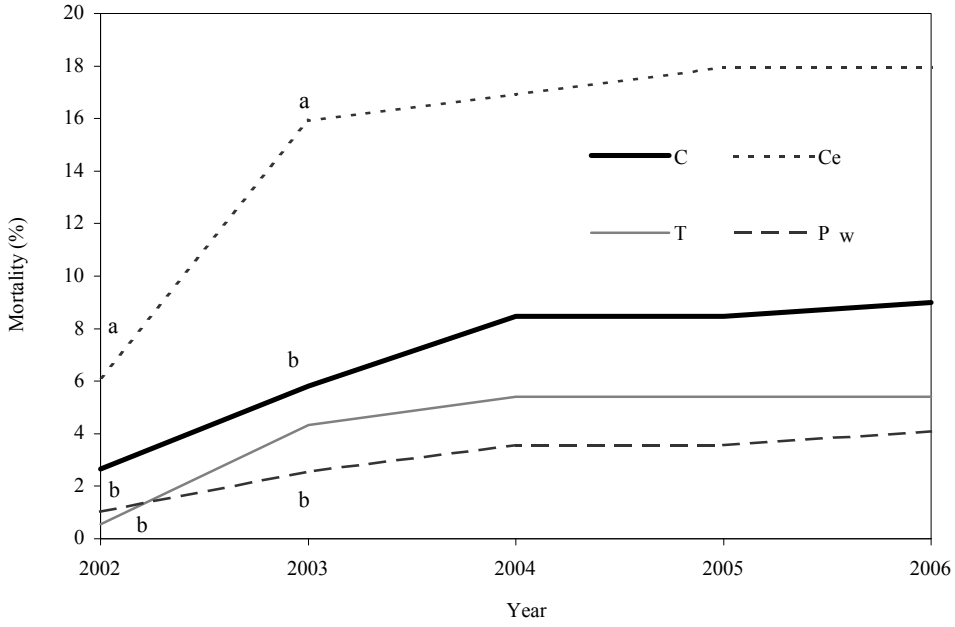

Fig. 1. Mortality of the spruce plantation (%)
Note: Different indexes indicate significant differences

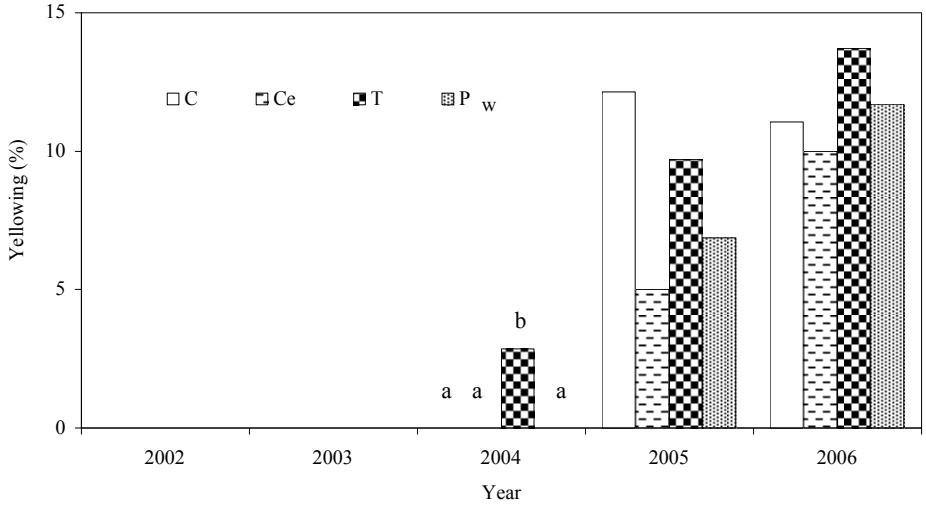

Fig. 2. Yellowing of the spruce plantation (%)
Note: Different indexes indicate significant differences

the content of Magnesium is critical compared with the content of Calcium that is close to optimum. The optimum content of Calcium (2003) in variants Pw and Ce decreased after 3 years below a deficit level even though this area was treated with lime in 2001. The absence of bases 5 years after the appliance of dolomite is outstanding. With the increasing of this increment, the need of this element is higher, but the deficit is also showing a very low reserve of the bases in the humus layer of the spread windrow. There is no soil analysis available, unfortunately to prove this opinion.

The nitrogen content (N) was good on the control C in the year 2003, but the other variants were found to be in deficit. Samples in 2006 are documenting the increase of Nitrogen in every variants. Silvamix reached its optimum values and now in (2006) it is deficient only in Ce. In addition, there was Phosphorus (Table 3) content decrease, mostly on the control plot. The increase of Nitrogen confirms a presently increasing deposition of nitrogen against deposition of sulphur oxides (S l o d i č á k et al., 2008). This deposition will increase with the ageing of the trees. There was a decrease of Potassium (K) content under the deficit level on control. The other nutrition elements were within the other variants in optimum.

The so-called harmonic proportion of nutrients was alerting an imbalance of mutually antagonistic elements Potassium : Magnesium (K : Mg) in all variants, mainly because of the deficit content of Magnesium. Above all in Silvamix variants there is a potential risk of blocking the intake of Magnesium and Calcium (Table 3). The highest part of nutritional imbalance is, as expected, in control (2006), where the proportion Nitrogen : Magnesium (N : Mg) is extreme, followed by variant Pw (2006).

A separate chapter relates to the damage to plantations by game browsing and its negative influence on the growing and quality of seedlings that is monitored every year (Fig. 3). It is appearing not only with decreased increments, but also with a building of substitutive terminals and "spreading". Extremely high values have been reached and reached an almost a limiting condition of success and quality forest restoration in the conditions of substitute tree stands reconstruction in 2006.

Table 3. Nutrition status of the spruce needles on particular variants after fertilizing (mg/kg)

Nutrient	Limit		C – control		Ce – Cererit		T – tablets		Pw – powder	
	deficit	optimum	2003	2006	2003	2006	2003	2006	2003	2006
N	13	15	13.32	16.25	11.12*x*	13.6*x*	12.3*x*	15.70	12.71*x*	18.50
P	1.2	1.5	1.97	2.82	1.84	2.02	1.90	2.03	1.84	2.45
K	4	6	5.05	2.82*x*	5.44	6.42	4.97	9.41	4.62	9.35
Ca	2	3	2.96	2.82	3.03	0.7*x*	2.96	0.53*x*	3.14	0.65*x*
Mg	0.7	1	0.67	0.16*x*	0.69	0.39*x*	0.75	0.55*x*	0.88	0.54*x*
N : P		6–12	6.8	5.8*x*	6.1	6.7	6.5	7.7	6.9	7.6
N : K		1–3	2.6	5.8*x*	2.0	2.1	2.5	1.7	2.8	2.0
N : Ca		2–20	4.5	5.8	3.7	19.2	4.2	29.6*x*	4.0	28.5*x*
N : Mg		8–30	19.9	104.8*x*	16.1	34.9*x*	16.4	28.5	14.5	34.3*x*
K : Ca		0.8–2.4	1.7	1.0	1.8	9.0*x*	1.7	17.8*x*	1.5	14.4*x*
K : Mg		2.2–6.4	7.5*x*	18.2*x*	7.9*x*	16.5*x*	6.6*x*	17.1*x*	5.3	17.3*x*

Note: Index *x* indicates extreme imbalance of harmonic proportion of nutrients

There were 23% of seedlings on control C browsed in 2006 (variants T and Pw over 20% and Ce 17%), what could probably influence the results of the values of average heights and average increment in this year. Due to similar rates of plants browsing the presumption of increasing attractivity of the plantations on fertilized options was not confirmed. Significant difference was between variant T, Ce and C only in 2003, not in any other year, because browsing on variant T was 0% (Fig. 3).

Even more remarkable seems to be the locations of the variants – the most damaged variant C was closest to the transit wildlife pathway. Extensive losses caused by game are a limiting factor for regeneration and planting of especially broadleaved species in the Ore Mountains, but coniferous species to a large extent are also damaged. Fencing could considerably reduce browsing, but it is not normally realized in Norway spruce plantations in such localities. Then the results would reflect the effect of fertilizers under conditions which are not common in the Ore Mountains and it would not be an objective.

After 5 years of monitoring, the results showed that the application of Silvamix Forte had a significantly positive influence on the average height, height increment, lowered mortality but had no influential effect on competition with the forest weed. Also, after 4 years it had no influence of the yellowing of the plantation. Fertilizer Cererit had a negative effect – an increased mortality of plantations.

Additional observation could probably answer the question whether there will be a growth depression after a fading of the fertilizer effect.

Acknowledgments

For supplying necessary information and help with the creation of this article – grateful thanks to my colleagues from the Faculty of Forestry and Wood Sciences, especially to Ing. Iva Ulbrichová, Ph.D., and Ing. Daniel Zahradník, Ph.D.

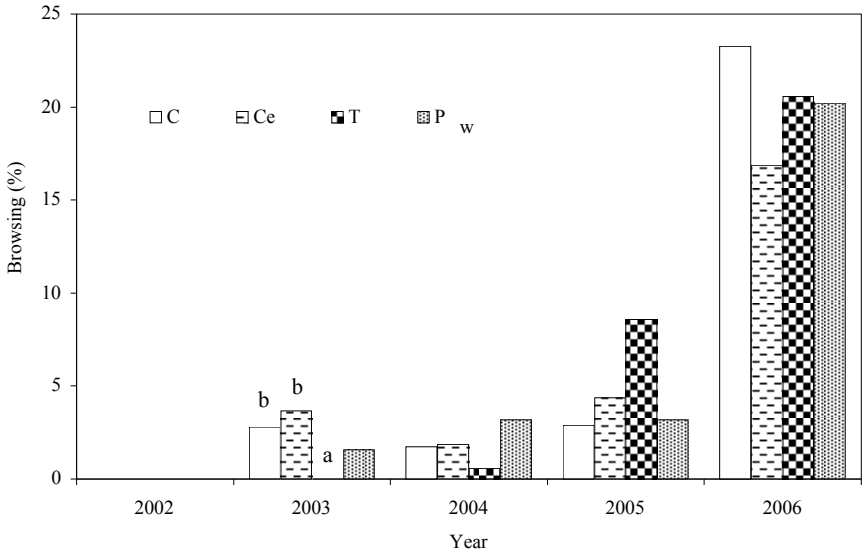

Fig. 3. Damage by browsing (%)
Note: Different indexes indicate significant differences

REFERENCES

HAYTER, A. J.: A proof of the conjecture that the Tukey-Kramer multiple comparisons procedure is conservative. Ann. Statist., *12*, 1984: 61–75.

HRAŠKO, J. et al.: Morfogenetický klasifikačný systém pod ČSSR (Morphogenetic classification system of soils of the Czech Socialist Republic). Bratislava, ČSAV 1987. 107 pp.

KULA, E.: Poznámky k potencionálnímu ohrožení nově zakládaných porostů ve vazbě na porosty náhradních dřevin ve východním Krušnohoří (Notes to the potential endangering of newly-established stands in the bond to stands of substitute tree species in the Eastern Ore Mountains region). In: SLODIČÁK, M. – NOVÁK, J. (eds.): Lesnický výzkum v Krušných horách 2006 (Forestry Research in the Ore Mts. in 2006). Opočno, VÚLHM VS 2006: 145–152.

MAUER, O. – HOBZA, P.: Smrk ztepilý – Krušné hory – Biotechnika sadby a úspěšnost obnovy lesa (Norway Spruce – the Ore Mts. – Biotechnics of plantations and fruitfulness of restoration). In: SLODIČÁK, M. – NOVÁK, J. (eds.): Lesnický výzkum v Krušných horách 2006 (Forestry Research in the Ore Mts. in 2006). Opočno, VÚLHM 2006: 285–295.

MAUER, O. – POP, M. – HOBZA, P. – KUBÍK, P. – MAŇAS, P.: Smrk ztepilý – Krušné hory – odrůstání kultur a porostů založených po změně imisní situace (Norway Spruce – the Ore Mts. – growing up of cultures and stands after change of immission situation). In: SLODIČÁK, M. – NOVÁK, J. (eds.): Lesnický výzkum v Krušných horách 2006 (Forestry Research in the Ore Mts. in 2006). Opočno, VÚLHM 2006: 273–283.

MUDROVÁ, S.: Vývoj porostů náhradních dřevin na výzkumné ploše Boleboř – Lesy města Jirkova (The development of stands of substitute tree species on the research area – Forest of the city Jirkov). ČZU FLE Praha, DP, 2005. 76 pp.

PODRÁZSKÝ, V.: Rychlost revitalizace horských půd v podmínkách Krušných hor po buldozerové přípravě stanovišť (The rate of revitalization of mountain soils in conditions of the Ore Mountains after bulldozer-spread preparation of sites). In: SLODIČÁK, M. – NOVÁK, J. (eds.): Lesnický výzkum v Krušných horách 2006 (Forestry Research in the Ore Mts. in 2006). Opočno, VÚLHM 2006: 39–48.

PODRÁZSKÝ, V. – REMEŠ, J.: Vliv vápnění a přihnojení na růst výsadeb lesních dřevin v oblasti Českomoravské vrchoviny (The effect of liming and additional fertilization on the stand of plantations of forest woody species in region of Bohemia-Moravian Highlands). In: NEUHÖFEROVÁ, P. (ed.): Krajina, les a lesní hospodářství (Landscape, forest and forestry management). Praha, 2004: 85–90.

PODRÁZSKÝ, V. – REMEŠ, J. – ULBRICHOVÁ, I.: Biological and chemical amelioration effects on the localities degraded by bulldozer site preparation in the Ore Mts. – Czech Republic. J. Forest Sci., *49*, 2003: 141–147.

PODRÁZSKÝ, V. – ULBRICHOVÁ, I. – MOSER, W. K.: Ecological impact analysis of mechanised site preparation techniques. J. Forest Sci., *47*, Special Issue, 2001: 146–149.

PODRÁZSKÝ, V. – VACEK, S. – ULBRICHOVÁ, I.: Effect of fertilization on Norway Spruce needles. J. Forest Sci., *49*, 2003: 321–326.

POP, M.: Imisní kalamita Krušných hor a celoplošná příprava půdy (Immission disaster of the Ore Mountains and whole-area preparation of the soil). In: PEŇÁZ, J. – MARTINEK, J. (eds.): Hlavní úkoly pěstování lesů na počátku 21. století (The principal tasks of the cultivation of forests at the beginning of the 21st century). MZLÚ Brno Křtiny, 2004: 89–99.

QUITT, E.: Klimatické oblasti Československa. Academia, Studia Geographica 16, GÚ ČSAV v Brně, 1971. 73 pp.

REMEŠ, J. – PODRÁZSKÝ, V.: Vliv opatření biologické a chemické meliorace na obnovu humusového profilu na stanovišti degradovaném buldozerovou přípravou v Krušných horách (The effect of measures of biological and chemical amelioration on restoration of humus profile at the site bulldozer-degraded preparation). In: NEUHÖFEROVÁ, P. (ed.): Krajina, les a lesní hospodářství (Landscape, forest and forestry management). Kostelec nad Černými lesy, 2002: 43–51.

REMEŠ, J. – VÝLUPEK, O. – PODRÁZSKÝ, V. – ZAHRADNÍK, V.: Využití chemické meliorace při obnově lesních ekosystémů v Krušných horách (The use of chemical amelioration in restoration of forest ecosystems in the Ore Mts.). In: NEUHÖFEROVÁ, P. (ed.): Meliorace v lesním hospodářství a v krajinném inženýrství (Amelioration in forest management and in landscape engineering), Kostelec nad Černými lesy, 26.–27. 1. 2006, pp. 251–257.

REMEŠ, J. – ZAHRADNÍK, D. – PODRÁZSKÝ, V. – KUBÍČEK, J. – NÁROVEC, V.: Účinky pomalu rozpustných tabletovaných hnojiv (Effects of slow-release tablet fertilizers). Lesnická práce, *84* (6), 2005: 312–314.

SLODIČÁK, M. – BALCAR, V. – NOVÁK, J. – ŠRÁMEK, V.: Lesnické hospodaření v Krušných horách (Forestry management in immission region of the Ore Mts.). Hradec Králové, Lesy České republiky; Strnady, Výzkumný ústav lesního hospodářství a myslivosti, 2008: 480 pp.

VAVŘÍČEK, D. – ŠIMKOVÁ, P.: Strukturní a fyzikálně chemické hodnocení původních liniových valů na monitorovacích plochách LS Klášterec (Structural and physico-chemical properties of Windows on monitored areas of the LS Klášterec). In: SLODIČÁK, M. – NOVÁK, J. (eds.): Lesnický výzkum v Krušných horách 2006 (Forestry Research in the Ore Mts. in 2006). Opočno, VÚLHM 2006: 65–78.

Received for publication on November 26, 2008
Accepted for publication on January 14, 2009

KOUBA, M. (Česká zemědělská univerzita, Fakulta lesnická a dřevařská, Praha, Česká republika):

Růstová dynamika a zdravotní stav kultur smrku ztepilého po přihnojení na rozhrnutých valech v Krušných horách (2002–2006).

Scientia Agric. Bohem., *40*, 2009: 34–40.

Na lokalitě Boleboř byly na výsadby čtyřletých sazenic smrku ztepilého na rozhrnutých valech aplikovány dva druhy hnojiv (Silvamix Forte prášek a tablety – každé v dávce 20 g; Cererit v dávce 50 g) obsahující stejnou dávku dusíku a byl sledován jejich účinek na růstovou dynamiku a zdravotní stav kultur v porovnání s variantou bez aplikace. Hnojení bylo aplikováno bezprostředně po výsadbě, Cererit a Silvamix Forte ve formě prášku byl sypán okolo sazenic do vzdálenosti 50 cm od kmínku, Silvamix Forte ve formě tablet ve vzdálenosti 20–30 cm po 4 ks rozmístěných na všechny strany, zatlačených do půdy. Bylo sledováno celkem 16 ploch – tj. 4 varianty (C – kontrola, Ce – Cererit, T – tab-

lety, Pw – prášek) ve 4 opakováních, celkem 765 sazenic. Pozitivní efekt byl patrný u obou variant Silvamixu Forte, u varianty Cererit byl efekt negativní. U obou variant Silvamixu Forte byl po dobu čtyř let od aplikace pozorován statisticky významný růst hodnot průměrných výšek (tab. 1) a zvýšený průměrný přírůst, především u práškové formy (tab. 2). Pátým rokem je přírůst na kontrole vyšší. Ovlivnění hodnot průměrných výšek a průměrného přírůstu aplikací Cereritu bylo minimální, mezi 2. a 4. rokem je pozorován zřejmý trend zvýšeného přírůstu (tab. 2).

Ujímavost byla nejvyšší u Silvamixu prášek (obr. 1), třetím rokem po aplikaci dochází k přiblížení ke kontrole, u varianty Cererit je mortalita trojnásobně větší (obr. 1).

Žloutnutí, které se poprvé objevilo čtyři roky po aplikaci u všech variant, pátým rokem u variant Silvamixu více nebo podobně jako u kontroly ukazuje na již minimální vliv hnojiva a větší vliv jiných podmínek.

Listové analýzy jedinců s karenčními projevy v roce 2006 potvrzují nedostatečnou zásobu hořčíku (Mg) a vápníku (Ca) na všech variantách (C, Ce, T and Pw), u variant T a Pw je vůči kontrole obsah hořčíku aplikací Silvamixu trojnásobný (tab. 3). Z hlediska harmonického poměru živin je výrazná nerovnováha vzájemně antagonistických prvků draslíku a hořčíku (K : Mg) u všech variant.

Zvýšení „atraktivnosti“ biomasy k okusu zvěří vlivem účinku hnojiva se nepotvrdilo (obr. 3). Statisticky významně vyšší okus byl u Cereritu a kontroly vůči Silvamixu tablety v druhém roce sledování, v ostatních letech nejsou rozdíly signifikantní. Poškození se vyskytuje u všech variant a hlavním faktorem je náhodný výskyt zvěře na ploše.

Aplikace Silvamixu tedy pozitivně ovlivnila průměrné výšky a průměrný přírůst, snížila mortalitu, neměla výrazný vliv na odrůstání buřeni a po čtyřech letech již nijak pozitivně neovlivnila projevy žloutnutí.

Delší sledování by pravděpodobně odpovědělo na otázku, zda na podobných lokalitách s minimem humusu nedojde po odeznění efektu k růstové depresi.

degradace půd; buldozerová příprava půdy; chemická meliorace; hnojení; Cererit; revitalizace; analýza jehličí; harmonický poměr živin

Contact Address:

Martin K o u b a , Česká zemědělská univerzita v Praze, Fakulta lesnická a dřevařská, Kamýcká 1176, 165 21 Praha 6-Suchdol, Česká republika, e-mail: koubam@fld.czu.cz