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Fertilization of Norway spruce plantations on the bulldozer-spread windrows in the Ore Mts.

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ABSTRACT: The spreading of bulldozer-formed windrows represents a second stage of the site restoration with bulldozers utilization in the Ore Mts. In the first period, bulldozers were used to create windrows for mechanized reforestation of immission-declined stands, causing profound devastation of forest sites, because removed surface humus was the only source of nutrients and environment for tree species roots. Preparatory stands have been established, and have to undergo re-construction in the coming years. Nowadays, the windrows are spread by the bulldozers again, covering 1/3 f the whole area between windrows by the rest of holorganic matter. This substratum is impoverished by the extensive mineralization and connected nutrient (especially N) losses, representing differently suitable space for tree rooting. Presented paper documents the effects of fertilization by different types of the SILVAMIX fertilizer on the growth and prosperity of new spruce plantations. Effects of fertilization are visible very soon and they are significantly beneficial for the new forest plantations.

Keywords: Ore Mts., site preparation; tree species growth; fertilization; tree nutrition; SILVAMIX

Large areas of forests in the Czech Republic were destroyed due to air pollution. These damages were caused by extensive industrial development in the Central Europe region. Forest management had to resolve reforestation on the large areas, despite of hard climatic conditions and relatively technologically complicated terrain configuration (mountain plateau in the Ore Mts.). This situation, in coincidence with social-political pressure, has contributed for reforestation with using of bulldozing as a site preparation method resulting in approximately 10,000 ha of bulldozed plots, but precise extent of this forestry practice application is missing. This system was employed for a long time during the 70's–80's, in some cases on into the 90's (Podrázský et al. 2001, 2003). Bulldozers were used to create windrows for mechanized reforestation. Blue spruce and some other introduced and domestic species have been used for planting and creating of the preparatory stands on these sites.

Nevertheless, this method of a site preparation was shown very poor. Humus removal and nutrient cycle interruption were main causes of the degradation effects of this treatment. Removed surface humus was the only source of nutrients and environment for tree species roots. Growth and development of the preparatory stands have been very slow and difficult. Additional, inappropriate tree choice into the substitutive stands (especially Blue spruce *Picea pungens* Englm.) retarded improvement of the site and soil conditions (Remeš et al. 2002).

Since 1990, air pollution load was rapidly decreased (namely sulphur dioxide stress) and now we have to undergo re-construction of the preparatory stands in the coming years. The windrows are spread by bulldozers again, covering 1/3 of the whole area between windrows by the rest of holorganic matter. This substratum is impoverished by the extensive mineralization and connected nutrient (especially N) losses, representing differently suitable space for tree rooting.

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Because the succession processes are unable to restore the sites, forest managers are compelled to use of the forest-silviculture amelioration for important acceleration of this process. From the future forest ecosystems management, it is very important to have exact data from research plots, which were established for observation and evaluation of revitalization processes. The aim of this paper is to summarize briefly the first basic information about growth development and effect of chemical amelioration treatments on the experimental plots Boleboř. Some of them are in the second phases of bulldozer preparation – Norway spruce plantation on the plots after windrow spreading.

MATERIAL AND METHODS

The experimental plot Boleboř was established for evaluation of the plantations development on the localities with different soil surface disturbance in spring 2002. The windrows were spread by bulldozing in the previous year. The locality is located on the area of the Community Forests Jirkov, in the altitude 860 m a.s.l. It is possible to characterize the site by the forest type 7K4 (acid *Spruce with Beech site*), *Cambisols* to *Cryptopodzols* soil types and *A* pollution damage zone. Climatic area is determined as *C1* – slightly cold. Between the (today) spread windrows, the birch stands were established in early 1990's (Moravčík, Moravčíková 1994).

Fertilization was applied immediately during planting. Totally 16 plots were established, 4 variants by 4 replications. Every plot has about 40–50 spruce plantings. The variants were: control, without any fertilizer, SILVAMIX Mg powder, and 20 g per plant, SILVAMIX Mg tablets, and 4 pieces of 5 g per plant and Cererit fertilizer, comparable amount for nitrogen – 50 g per plant (Fig. 1).

Heights were measured in 2001 to 2003 and height increment was calculated in 2002 and 2003. The mortality was counted in particular years. The foliar samples were collected after the vegetation season of the year 2003 by standard way, the bulk samples of this season needles were formed from each variant. The results are very preliminary, but important practical outputs are expected.

RESULTS AND DISCUSSION

Bulldozer site preparation represents always a heavy disturbance of the locality (Ballard 1988; Burger 1983; Podrázský et al. 2001). Its consequences were described relatively early, but they were ignored almost totally (Jirgle 1984). Also on spread windrows, the soil conditions are far from optimum (Binkley 1986). This is reflected on our study plots as well – the plantations show the minimum growth rate in the first two years since plantation. Despite this fact, the effects of fertilizations are visible and statistically significant, despite of low absolute values of increment. The high number of plants has lead to this phenomenon, the variants did show the significant differences even before the fertilizers could affect the plantation growth (H_{2001} – height just at plantation). In the first year (2002), the significance of differences has disappeared; the statistically significant differences were documented in the year 2003 again. The increase of the growth rate was caused especially by the use of the SILVAMIX fertilizer; the effects of Cererit were not visible (Table 1). The very dry year 2003 was reflected by the increment decrease especially on the control variant. The most effective seems to be the variant with SILVAMIX tablets application.

Visible, but differentiated effects did show the fertilization also on the plantations mortality. It was

Spread windrow		Spread windrow
16 – P		8 – P
15 – T		7 – T
14 – Ce		6 – Ce
13 – C	Birch + Blue spruce Former between windrows	5 – C
12 – P		4 – P
11 – T		3 – T
10 – Ce		2 – Ce
9 – C		1 – C

Variants: C – control, Ce – complexe fertilizer Cererit in dose 50 g per tree, T – tablet SILVAMIX Forte fertilizer in dose 4 tablets by 5 g per tree, P – powder SILVAMIX Forte fertilizer in dose 20 g per tree. The same dose of nitrogen fertilizer was always applied

Fig. 1. Schema of the plots established for fertilizer experiment (Norway spruce on sites after windrow spreading)

Table 1. Effect of the SILVAMIX and Cererit fertilization on the growth new established Norway spruce plantations on the Boleboř locality (site after windrow spreading)

Variant	Number	H_{2001}	H_{2002}	H_{2003}	I_{02}	I_{03}	Mortality $_{02}$	Mortality$_{03}$
C – control	187	37 bc	43.1 a	46.6 a	6.5	3.5	2.6	6.3
Ce – Cererit	195	34.9 a	41.6 a	46.4 a	6.6	4.8	8.3	16.6
T – tablets	186	36 ab	43.1 a	51.1 b	7.2	8.0	0.6	4.4
P – powder	196	37.5 c	45.2 a	50.4 b	7.2	5.2	1.6	2.7

Different indexes indicate statistically significant differences

Table 2. Nutrition status on particular variants

Nutrient	Limit		Variant			
	deficit	optimum	C – control	Ce	T – tablets	P – powder
N	1.3	1.50	1.33	1.11	1.23	1.27
P	0.12	0.15	0.20	0.18	0.19	0.18
K	0.40	0.60	0.51	0.54	0.50	0.46
Ca	0.20	0.30	0.30	0.30	0.30	0.31
Mg	0.07	0.10	0.07	0.07	0.075	0.09

much more prominent in the extreme year 2003. The SILVAMIX application lowered the relatively small plantation mortality, but the Cererit fertilization caused the multiple increased dying of young plants. This was caused probably by the unbalanced nutrition, which will be discussed further. Similar effects (of the SILVAMIX effects on one side and of the site non-corresponding liming on the other) were documented also at the study of beech plantations in higher elevations (Remeš et al. 2004).

On the control variant, the plantations did show quite good nutrition state, with only the N and Mg being on the sufficiency limits (Table 2). The substratum of spread windrows content relatively sufficient amount of particular nutrients, only the nitrogen and deficient bases could be lost in the moulds of rows during excessive N-mineralization (Binkley 1986). All fertilizers lowered the N-contents of needles, due to the increased growth and dilution effect probably – the Cererit variant caused the extreme lowering leading to high deficiency. Similar, but not critical trend did show the P-contents. The K and Ca contents were not affected at all; the Mg nutrition was increased over deficiency limit by the SILVAMIX application. Positive effect of SILVAMIX application was confirmed also from colour changes of leaves, which were minimal in trees after SILVAMIX application, while variants of Cererit showed about 60–80% and control plots about 50% of trees with colour change symptoms.

Particular fertilizers so showed much differentiated effects and the pre-fertilization site and nutrition analysis and the corresponding fertilizer selection seem to be critical points for the treatment success.

CONCLUSIONS

After the site degradation by the bulldozer preparation, spreading of windrows can represent a good way to conserve accumulated organic matter for the forest ecosystem. This substrate is more convenient for the tree species roots then the scarified mineral soil, but it is still far from the optimum state. Heavy nutrition deficiencies and problems with plantation growth can occur. Fertilization can represent a suitable way to support young trees. The first results confirmed the necessity of the selection of site convenient fertilizer and fertilization method. The SILVAMIX variants released the nutrients in the plant available form during a long period. The complex, but rapidly soluble Cererit caused nutrition problems of the plantations. The growth rate was accelerated using proper fertilization, the mortality of plantations was decreased and the colour changes were almost eliminated. The fertilization

potential has to be studied in the future more for its favourable effects in different cases.

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Hnojení smrkových porostů vysázených na rozhrnutých valech v Krušných horách

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ABSTRAKT: Příspěvek dokumentuje výsledky sledování vlivu přihnojení na růst a vývoj výsadeb hospodářských dřevin (SM) na rozhrnutých valech po buldozerové přípravě v Krušných horách. Na typickém stanovišti (kolem 850 m n.m., LT 7K4, půdy typu kambizemí až kryptopodzolů) byl sledován vliv komplexního průmyslového hnojiva Cererit a pomalu rozpustného hnojiva SILVAMIX. Meliorační hmoty byly aplikovány hned při výsadbě a sledování prozatím trvalo dva roky (2002–2003). Kromě růstu kultur byla sledována mortalita a stav výživy. Přihnojení SILVAMIXEM mělo za důsledek zvýšení přírůstu a snížení mortality výsadeb, přestože stav výživy byl ovlivněn minimálně. Na druhé straně Cererit vykazoval spíše negativní dopad – sice mírné zvýšení přírůstu, ale nepříznivé ovlivnění výživy a vysoce zvýšenou mortalitu. Volba vhodného způsobu přihnojení a vhodného hnojiva je proto při podobných zásazích zásadní záležitostí.

Klíčová slova: Krušné hory; příprava stanoviště; růst dřevin; hnojení; výživa dřevin; SILVAMIX

Rozhrnování valů vytvořených při tzv. buldozerové přípravě stanoviště představuje druhou fázi obnovy lesních ekosystémů s využitím buldozerů v Krušných horách. V první etapě byly buldozery využity k vytvoření valů pro mechanizovanou obnovu lesa v prostoru mezi nimi na stanovištích po rozpadu lesních porostů v důsledku imisní zátěže. To vedlo k výrazné degradaci lesních stanovišť, neboť odstraněné holorganické vrstvy představovaly rozhodující zdroj živin a disponibilní prostor pro jemné kořeny dřevin. Na daných stanovištích byly založeny porosty náhradních dřevin, které jsou v současné době vhodné k rekonstrukci. Valy jsou přitom opětovně rozhrnovány s využitím buldozerů, což vede k pokrytí zhruba jedné třetiny plochy porostů zbytky organické hmoty. Tento substrát je často ochuzen nadměrnou mineralizací a následnými ztrátami živin (zvláště dusíku)

a představuje diferencovaně vhodné prostředí pro vývoj kořenových systémů. Příspěvek dokládá vliv hnojení různými typy hnojiv (Cererit, SILVAMIX) na růst a prosperitu výsadeb smrku na typické lokalitě.

Účinky různých druhů hnojiv (rychle rozpustný komplexní Cererit a pomalu rozpustný SILVAMIX v práškové i tabletované formě) byly sledovány na lokalitě Boleboř, na stanovišti charakterizovaném LT 7K4, půdním typem kryptopodzol a nadmořskou výškou 860 m. Lokalita byla připravena v roce 2001, výsadba smrku ztepilého (buk byl likvidován klimatickými extrémy a zvěří) a přihnojení byly uskutečněny na jaře 2002 (schéma plochy je na obr. 1). Sledoval se přírůst výsadeb, jejich mortalita, barevné změny jehličí a stav výživy.

Vliv hnojení je patrný ve velice krátké době a projevuje se příznivě ve vztahu k novým výsadbám. SILVAMIX zvýšil výrazně přírůst výsadeb, a to i v klimaticky mimořádně extrémním roce 2003 (tab. 1). Rovněž téměř eliminoval mortalitu, barevné změny a udržel relativně vyrovnaný stav výživy výsadeb (tab. 2). Naproti tomu aplikace Cereritu vedla spíše k nevyvážené výživě, menšímu ovlivnění přírůstu a zejména ke zvýšené mortalitě. Vhodná volba hnojiva a způsobu aplikace tak zásadním způsobem ovlivňuje úspěch opatření chemické meliorace stanoviště.

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