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Effect of dolomite fertilization on nutritional status of seedlings and soil properties in forest nursery

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Abstract

The aim of the study was to determine the effect of dolomite fertilization on the properties of soils in the forest nursery and to determine the nutritional status of two species seedlings: the common beech (*Fagus sylvatica* L.) and pedunculate oak (*Quercus robur* L.) The study was carried out in the area of a forest nursery in the Polanów Forest District (northern Poland). Mineral fertilization with dolomite in the amount of 2200 kg/ha was applied on the experimental plots. One and two years after the fertilization, soil properties were evaluated and the the amount of nutrients in the leavesof seedlings was determined. The pH, C and N content, content of exchangeable basic cations, mineral nitrogen forms and enzymatic activity were determined in the soil samples. The content of macro and microelements was determined in the leaves of the tested species. The study conducted confirmed the beneficial effect of applied dolomite fertilization. Fertilization reduced acidification, increased Mg content and improved enzyme activity. In the case of both species, an improvement in the nutritional status was recorded one and two years after fertilization. A positive effect of the conducted fertilization was a decrease in the manganese content in beech and oak leaves. There was a significant correlation between the content of manganese in the leaves of the studied species and the content of magnesium in the soils. The enzymatic activity reacts to changes in the soil environment caused by dolomite fertilization.

1. Introduction

The soil sorption complex serves as a reservoir of nutrients that are released into the soil solution from where they are available to plants. The appropriate soil pH, cations exchange capacity and base saturation must be maintained for optimal macro and microelements uptake in forest nurseries (van den Driessche, 1984). In forest nurseries, especially those on a larger scale, intensive and long-term use leads to the risk of so-called "soil fatigue" (Szołtyk, 2006). Biological imbalance, also manifested in the unfavorable domination of bacteria over mycorrhizal fungi (Sienkiewicz, 2009), subsequently leads to a reduction in the quality of seedlings being produced (Aleksandrowicz-Trzcińska, 2004). In order to prevent this, a number of activities are carried out to improve the properties of the substrate in forest nurseries (Szołtyk and Hilszczańska, 2003). One of the basic revitalization treatments for soil is simply regulating its pH, which consists of acidification or liming. Acidification is necessary when the long-term application of organic materials with high pH values (e.g. low peat, excessively limed compost, multi-component fertilizers) leads to soil alkalization (Szołtyk, 2006). In the second case, when soil acidifies due to the leaching of calcium into the deeper layers, its absorption by plants, or its binding by certain mineral fertilizers, liming is necessary.

Acidity determines many processes taking place in soils, affects the processes of soil organic matter transformation, nutrient circulation, development of living organisms, resulting in the amount and quality of biomass obtained (Błońska et al., 2016b). Excessively low pH can be dangerous for plants as it limits the availability of nutrients, and additionally leads to excessive absorption of aluminum (Al), manganese (Mn), and ferrum Fe, which may have a toxic effect on plants (Walendziak and Szołtyk, 1992). Acidification is associated with alkaline cations leaching from soils, especially calcium (Ca) and magnesium (Mg). Alkaline cations are replaced by aluminum, hydrogen and manganese, which appear in soil solution in excessive amounts as the pH decreases. Mineral fertilization, especially liming, is used to reduce soil acidity by increasing pH and concentration of exchangeable calcium and magnesium (Błońska et al., 2017; Januszek et al., 2020; Saarsalmi et al., 2014, 2011). The use of liming by changing the pH of the soil plays a key role in regulating the mineralization of organic matter, N transformation, nitrification and denitrification (Bolan et al., 2011). Liming of acidic soils has a positive effect on microbiological biomass (Badalucco et al., 1992), fertilization usually strongly favors the accumulation of organic residues which increases soil microbiological biomass (Luo et al., 2015). The structure and functions of microbial communities are key drivers of soil biogeochemical cycles and general soil quality (Nannipieri et al., 2018). Measurements of the activity of extracellular enzymes involved in the circulation of nutrients originating from organic compounds provide information about the biogeochemical cycles (Adamczyk et al., 2014). Several common hydrolytic enzymes contribute to the C cycle (β-D-cellobiosidase, β-Glucosidase, β-Xylosidase), N cycle (N-acetyl- β-Glucominidase), P cycle (phosphatase) and S cycle (arylsulphatase), their main function is degradation of cellulose, hemicelluloses and chitin (Parvin et al., 2018). Hu et al. (2014) results suggest that a balanced application of fertilizer nutrients has positive effects on multiple soil chemical parameters, which in turn enhances enzyme activity.

Differences in the reaction of the soil to liming can be caused by the amount, form and frequency of application, as well as the composition of the applied fertilizer, and other factors such as climate, environmental conditions, type of humus and chemical properties of the soil can strongly influence the effect of liming treatments (Schaaf and Hüttl, 2006). In Polish forest nurseries, it is recommended to use dolomite lime containing 20% MgO, which is supposed to compensate for the deficiencies of magnesium common in nursery production (Szołtyk, 2006).

So far, few studies have been conducted on the effect of dolomite fertilization on the properties of nursery soils and the content of micro and macro nutrients in the assimilation apparatus of tree seedlings. The aim of our study was to determine the effect of dolomite fertilization on the properties of soils in forest nurseries. The basic properties of soils and the activity of extracellular enzymes involved in the transformation of C, N, P and S were used to assess the effect of fertilization on nutritional status of seedlings. Additionally, the amount of nutrients in the leaves of seedlings as a result of dolomite fertilization was determined.

2. Materials and methods

2.1. Study area and experimental design

The study was carried out in the area of a forest nursery in the Polanów Forest District (northern Poland). The study area is characterized by the following meteorological conditions: the average length of the growing season is 230 days, the average temperature during the growing season is 13°C and the average precipitation during this period is 300 mm. The study areas were dominated by Cambisols (IUSS Working Group WRB, 2015). The study covered two species, i.e., common beech (*Fagus sylvatica* L.) and pedunculate oak (*Quercus robur* L.).

Twelve plots of dimensions 20x10 m were selected for the study. Soils on the research plots were characterized by a similar share of sand fraction 45%, silt 49% and clay 6%. Six plots were grown with beech, on the next six with oaks. Mineral fertilization with dolomite in the amount of 2200 kg/ha was applied on three plots with beech and three plots with oak (Table 1). The applied fertilizer was characterized by granulation up to 2 mm. The remaining 6 plots were control plots (3 control plots with beech and 3 control plots with oak). Fertilization was carried out in October 2017, and soil and plant material samples for laboratory analyses were taken in August 2018 and 2019. The fertilizer in the form of granules was spread evenly over the test plots. From each plot, soil samples from five points for analyses were collected. Soil samples were taken from a depth of 0–15 cm. The oak and beech seeds were sown pointwise. In addition, plant material for laboratory analysis was collected from each plot. Oak and beech leaves were taken from 30 seedlings on each research plot. One-year (2018) and two-year (2019) seedlings were collected for laboratory analyzes. The seedlings for the analyzes were selected randomly from the research plots. All leaves were separated from each seedling, dried and ground.

2.2. Laboratory analysis

In the soil samples, the particle-size distribution was determined using the laser diffraction (Analysette 22, Fritsch, Idar-Oberstein, Germany), pH was analyzed in distilled water using the potentiometric method, as well as the content of total nitrogen (N) and organic carbon (C) content were measured using LECO CNS True Mac Analyzer (Leco, St. Joseph, MI, USA), including the calculation of the C/N ratio. Exchangeable calcium, potassium, magnesium were determined after extraction in 1M ammonium acetate by an ICP (ICP-OES Thermo iCAP 6500 DUO, Thermo Fisher Scientific, Cambridge, U.K.). In the samples with natural moisture the forms of mineral nitrogen NH_4-N and NO_3-N in 2M KCl soil extracts by FIAstar 5000 were determined.

For the determination of enzymatic activity fresh samples of natural moisture were sieved through a sieve (ø 2 mm) and stored at 4°C until analysis. The activity of extracellular enzymes (β-glucosidase (BG); β-D-cellobiosidase (CB); xylanase (XYL); N-acetyl-β-D-glucosaminidase (NAG); phosphatase (PH) and arylsulphatase (SP)) were determined using fluorogenically labelled substrates (Pritsch et al., 2004; Sanaullah et al., 2016; Turner, 2010) (Pritsch et al., 2004; Turner 2010; Sannaullah et al., 2016). Fluorescence was measured on a multi-detection plate reader (SpectroMax) with excitation at 355 nm and emission at 460 nm wavelengths.

In the leaves samples, the concentration of macro and microelements was determined by an ICP (ICP-OES Thermo iCAP 6500 DUO, Thermo Fisher Scientific, Cambridge, U.K.). Dried samples of leaves were mineralized in a mixture of HNO_3 and

Table 1
The chemical composition of dolomite used for fertilization

Ca %	Mg	Fe	Mn	Mo	B	Zn	Cu
21.5	10.9	1.5	0.1	0.02	0.02	0.005	0.003

$HClO_4$ (3:1). Carbon (C) and nitrogen (N) in the leaves samples were measured with an elemental analyzer (LECO CNS TrueMac Analyzer (Leco, St. Joseph, MI, USA)).

2.3. Statistical analysis

The normality of a variable distribution was checked. Tukey HSD test was used to evaluate the differences in the mean values of the soil properties and nutrients content in the assimilation apparatus between variants treatments. Spearman's correlation coefficients for the activity of soil enzymes, selected soil characteristics and nutrition of seedlings were calculated. The principal component analysis (PCA) method was used to evaluate the relationships between soil properties and seedling characteristics. Differences with $P < 0.05$ were considered statistically significant. All analyses were performed using Statistica 12 software (StatSoft 2012).

3. Results

Higher pH was recorded in soils fertilized with dolomite in the first and second year of the study (Table 2). In the first year after dolomite application, significantly higher pH was recorded on plots with oak. In the second year of the study, significantly higher pH was recorded on plots with oak and beech (Table 2). In the case of carbon content, the effect of fertilization was recorded in the first year of the study in soils with oak. No significant increase in nitrogen content was recorded in soils fertilized with dolomite (Table 2). As a result of the fertilization, a significant increase in the content of alkaline cations, especially calcium and magnesium, was recorded. In the case of calcium, a significant increase in the content was recorded in plots with oak and beech in the second year of the study, and in the case of magnesium, a significant increase in the content was recorded both in the first and second year of the study, in soils with oak and beech (Table 2). In the case of phosphorus content, the effect of fertilization was less visible. The ammonium nitrogen content did not change after fertilization with dolomite. In the case of nitrate nitrogen, an increase in the content was recorded in the first year of the study in soils of beech plots (Table 2).

In case of enzymatic activity, the effect of fertilization is visible in the first and second year of the study. In the first year of the study there was no statistically significant increase in the activity of the enzymes studied (Table 3). In the second year of the study, the differences between the enzymatic activity of fertilized and control plot soils were more pronounced. In the case of BG, CB and NAG, a statistically significantly higher activity was recorded in the fertilized soils in the second year of the study, regardless of the species (Table 3).

The effect of fertilization is visible in the nutrition of oak and beech seedlings (Table 4). In the case of carbon and nitrogen, there was no statistically significant increase in the assimilation apparatus of the studied species. A similar effect was observed in the case of calcium, potassium, phosphorus and copper contents. A significant increase as a result of dolomite fertilization was recorded for magnesium content. A higher magnesium content was recorded in beech and oak leaves growing on soils of fertilized plots (Table 4). Manganese content in leaves of the tested species decreased as a result of the fertilization. In the case of beech, a significantly lower manganese content was recorded in the first and second year of the study, in the case of oak, the manganese content was significantly lower in the second year of the study (Table 4).

The enzymatic activity of the soils studied strongly positively correlated with soil pH and nitrate nitrogen content in the soil (Table 5). Additionally, a strong, positive relationship between the majority of the studied enzymes and the content of magnesium in leaves of the studied species was recorded. In the case of CB and XYL activity, the relationship with potassium content in leaves was recorded (Table 5). Figure 1 shows the correlation between the content of manganese in the leaves of the tested species and the content of magnesium in soils. The PCA analysis confirms the effect of dolomite fertilization on the

Table 2
Basic properties of the studied soils

Year of study	Study variant	pH H_2O	pH KCl	C %	N	C/N	Ca mg·100g^{-1}	Mg	K	P mg·kg^{-1}	N-NH_4	N-NO_3
I	D Beech	5.07±0.05^a	4.07±0.05^a	2.06±0.17^a	0.15±0.01^a	14.1±0.1^a	23.0±1.9^a	2.6±0.3^a	7.7±0.2^a	81.9±27.9^b	2.1±0.1^a	11.8±0.1^a
	C Beech	4.92±0.13^a	3.89±0.10^b	2.36±0.22^a	0.16±0.02^a	14.7±0.5^a	21.8±0.6^a	1.2±0.1^b	7.5±0.3^a	128.4±6.0^a	2.2±0.0^a	12.1±0.4^a
	D Oak	5.13±0.05^a	4.19±0.14^a	1.99±0.03^b	0.14±0.01^a	14.7±1.1^a	22.4±2.8^a	2.4±0.2^a	9.4±0.3^a	97.6±14.0^a	3.8±1.2^a	13.9±1.1^a
	C Oak	4.81±0.10^b	3.81±0.07^b	2.44±0.12^a	0.16±0.01^a	15.7±1.0^a	20.5±0.7^a	1.3±0.1^b	7.8±0.3^a	108.1±18.8^a	2.9±0.6^a	12.4±1.5^a
II	D Beech	5.30±0.10^a	4.20±0.10^a	2.20±0.01^a	0.10±0.00^a	15.5±0.2^a	36.5±8.1^a	3.6±0.5^a	7.9±0.1^a	76.5±9.9^b	6.5±0.4^a	25.4±4.2^a
	C Beech	5.00±0.17^b	4.00±0.08^b	2.30±0.14^a	0.10±0.01^a	15.7±0.4^a	21.0±5.2^b	1.5±0.3^b	6.2±0.5^b	107.2±7.7^a	6.9±0.3^a	7.5±3.7^b
	D Oak	5.20±0.07^a	4.20±0.11^a	2.33±0.09^a	0.16±0.02^a	14.3±0.7^a	32.3±5.1^a	5.0±0.3^a	8.6±0.3^a	97.3±11.4^a	7.8±0.8^a	18.4±5.2^a
	C Oak	4.82±0.17^b	3.94±0.14^b	2.24±0.07^a	0.15±0.01^a	15.4±0.8^a	14.1±3.1^b	1.8±0.4^b	5.4±0.3^b	101.6±6.2^a	6.4±0.4^a	10.5±2.8^a

mean ± SD; D – plots after fertilization; C – control plots; small letters in the upper index of the mean values mean significant differences between study variants
średnia ± SD; D – działki po nawożeniu; C – wykresy kontrolne; małe litery w górnym indeksie średnich wartości oznaczają znaczne różnice między wariantami badania

Table 3
Enzyme activity of study soils

Year of study	Study variant	BG nmol MUB·g⁻¹d.s.·h⁻¹	CB	XYL	NAG	PH	SP
I	D Beech	33.51 ±8.36[a]	6.00 ±1.12[a]	3.38 ±0.67[a]	20.46 ±6.76[a]	275.21 ±48.13[a]	1.16 ±0.61[a]
	C Beech	26.17 ±5.96[a]	4.91 ±0.42[a]	2.79 ±0.88[a]	16.92 ±2.56[a]	257.36 ±52.26[a]	0.69 ±0.27[a]
	D Oak	27.37 ±8.36[a]	7.04 ±1.68[a]	4.14 ±1.13[a]	20.93 ±3.65[a]	327.05 ±121.81[a]	0.95 ±0.25[a]
	C Oak	26.11 ±9.14[a]	5.36 ±1.56[a]	3.51 ±0.68[a]	15.40 ±4.67[a]	197.02 ±17.38[a]	0.75 ±0.20[a]
II	D Beech	42.24 ±4.62[a]	8.53 ±1.89[a]	3.92 ±1.03[a]	25.18 ±4.46[a]	379.16 ±68.89[a]	1.37 ±0.65[a]
	C Beech	28.79 ±6.39[b]	5.06 ±0.86[b]	2.45 ±1.18[a]	15.96 ±4.29[b]	223.91 ±106.99[a]	0.66 ±0.26[a]
	D Oak	38.08 ±5.85[a]	9.64 ±2.90[a]	4.22 ±1.47[a]	28.07 ±6.48[a]	391.01 ±132.17[a]	1.95 ±1.04[a]
	C Oak	25.18 ±4.22[b]	5.21 ±0.32[b]	2.60 ±1.13[a]	16.07 ±3.80[b]	203.77 ±43.95[a]	0.87 ±0.72[a]

Explanations: mean ± SD; D – plots after fertilization; C – control plots; CB – β-D-cellobiosidase, XYL – xylanase, NAG – N-acetyl-β-D-glucosaminidase, BG – β-glucosidase, PH – phosphatase and SP – arylosulphatase; small letters in the upper index of the mean values mean significant differences between study variants

Table 4
The content of macroelements and selected microelements in beech and oak seedlings

Year of study	Study variant	C % d.m.	N	Ca	Mg	K	P	Mn mg·kg⁻¹ d.m.	Cu
I	D Beech	45.95±1.05[a]	2.21±0.12[a]	0.70±0.10[a]	0.10±0.03[a]	0.67±0.02[a]	0.17±0.02[a]	2323.00±623.05[b]	15.86±0.19[a]
	C Beech	46.75±0.59[a]	2.17±0.05[a]	0.64±0.08[a]	0.06±0.01[a]	0.60±0.03[b]	0.16±0.01[a]	5888.25±239.75[a]	14.81±1.30[a]
	D Oak	46.41±2.12[a]	2.36±0.12[a]	0.50±0.03[a]	0.13±0.02[a]	0.82±0.04[a]	0.21±0.01[a]	1651.00±240.60[a]	16.81±0.19[a]
	C Oak	46.31±0.59[a]	2.22±0.03[a]	0.60±0.07[a]	0.09±0.01[b]	0.76±0.13[a]	0.20±0.01[a]	1940.50±302.42[a]	15.13±1.30[a]
II	D Beech	46.18±0.70[a]	2.19±0.12[a]	0.55±0.08[a]	0.24±0.05[a]	0.81±0.02[a]	0.19±0.01[a]	904.08±410.45[b]	16.52±1.76[a]
	C Beech	47.27±0.64[a]	1.95±0.13[a]	0.72±0,10[a]	0.08±0.01[b]	0.71±0.08[a]	0.17±0.01[a]	5522.00±931.11[a]	16.70±2.33[a]
	D Oak	46.78±1.14[a]	2.28±0.12[a]	0.53±0.07[a]	0.28±0.13[a]	0.79±0.05[a]	0.21±0.02[a]	740.63±137.72[b]	20.56±1.45[a]
	C Oak	46.50±1.80[a]	2.16±0.13[a]	0.55±0.05[a]	0.11±0.01[b]	0.60±0.16[a]	0.20±0.00[a]	2184.67±129.22[a]	19.53±1.88[a]

mean ± SD; D – plots after fertilization; C – control plots; small letters in the upper index of the mean values mean significant differences between study variants

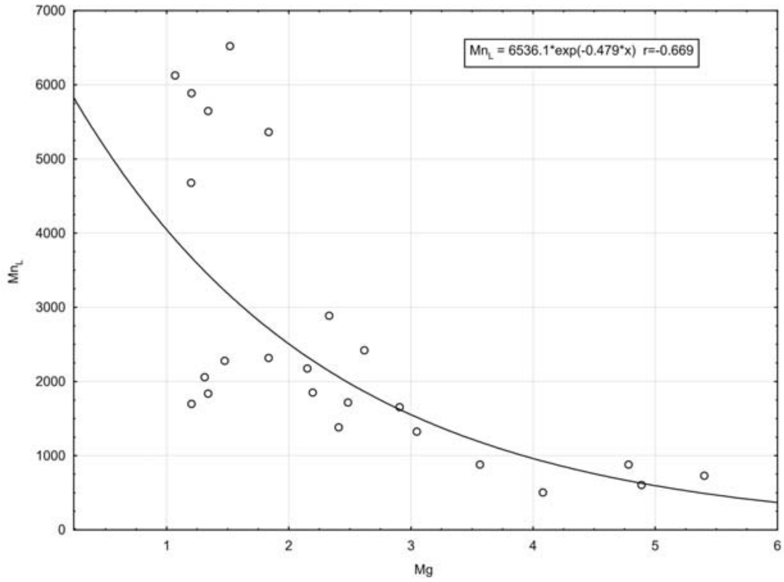
Table 5
Correlations between the activity of soil enzymes and selected soil characteristics and nutrition of seedlings

	pH H_2O	C	N	$N\text{-}NO_3$	$N\text{-}NH_4$	N_L	Mg_L	K_L	P_L	Ca_L
BG	0.783*	0.080	0.309	0.507*	0.313	0.135	0.544*	0.258	0.056	0.083
CB	0.817*	0.052	0.241	0.667*	0.307	0.401	0.803*	0.541*	0.413*	–0.297
XYL	0.334	–0.155	–0.093	0.298	0.039	0.186	0.297	0.432*	0.304	–0.373
NAG	0.641*	–0.104	0.198	0.632*	0.214	0.487*	0.694*	0.310	0.311	–0.214
PH	0.661*	–0.342	0.041	0.689*	0.049	0.370	0.478*	0.136	0.097	0.040
SP	0.811*	–0.002	0.311	0.658*	0.230	0.256	0.584*	0.278	0.217	–0.018

*$p < 0.05$; N_L, Mg_L, K_L, P_L, Ca_L – content in the leaves of the tested seedlings

properties of the soils studied and on the nutrition of beech and oak seedlings (Fig. 2 and 3). In the case of beech plots, the PCA analysis explains more than 69% of the variability of the features tested. Soils of fertilized plots clearly separate from those of control plots. Soils of control plots without fertilization are characterized by high manganese content, low pH, lower content of nutrients, especially magnesium (Fig. 2). In the case of plots with oak, the PCA analysis explains more than 69% of the variability of the features tested (Fig. 3). Similarly as in the case of plots with beech, the soils of plots fertilized with dolomite with oak clearly differ in properties compared to those of control surfaces.

Fig. 1. Relationship between Mn (mg·kg⁻¹ d.m.) content in seedlings leaves and Mg content (mg·100g⁻¹) in soil



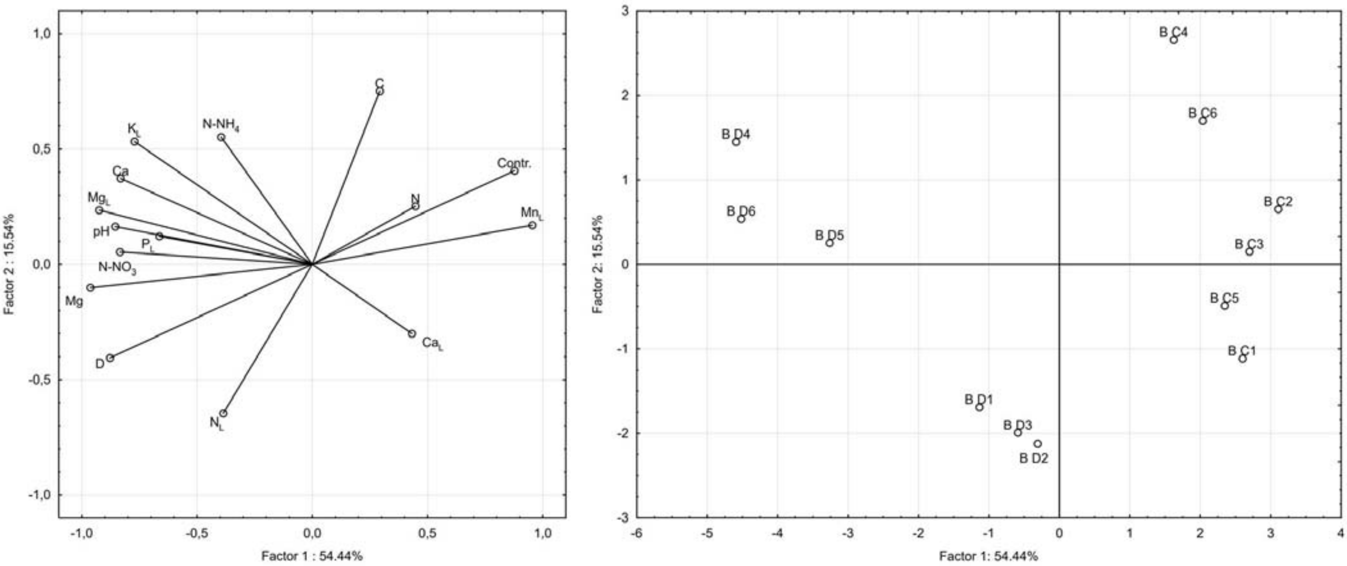


Fig. 2. PCA analysis showing the effect of dolomite fertilization on soil properties and nutrition of beech seedlings

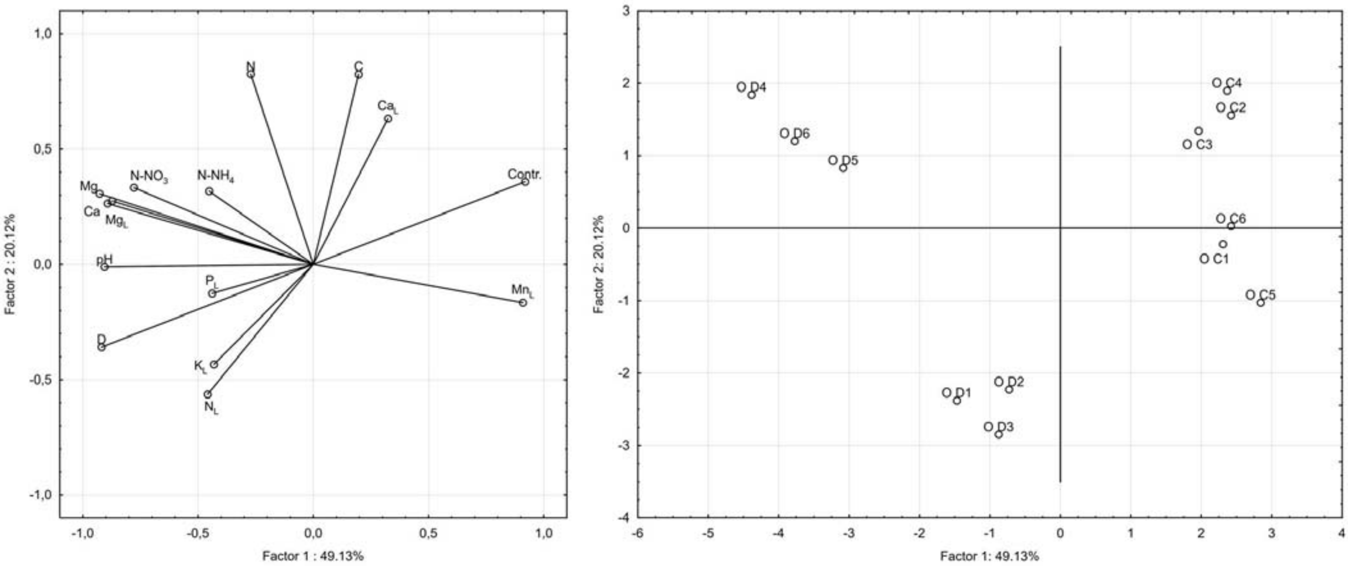


Fig. 3. PCA analysis showing the effect of dolomite fertilization on soil properties and nutrition of oak seedlings

4. Discussion

Our study demonstrated a positive effect of dolomite fertilization on the forest nursery soil at a dose of 2200 kg/ha. The fertilization caused an increase in soil pH and an increase in the content of exchangeable calcium and magnesium, which became apparent in the second year after fertilizer application. Dolomite is a common mineral fertilizer, which is used to deacidify soil and increase the abundance of alkaline cations, especially magnesium (Błońska et al., 2015). Dolomite is a fertilizer from which components are slowly released (Yang et al., 2012). The use of slowly released fertilizer containing macro- and micronutrients is more favorable for improving nutrient deficiencies than rapidly soluble fertilizers (Flückiger and Braun, 1995). An additional effect of applying dolomite fertilization was an increase in soil enzymatic activity. In our study we found an increase in the activity of β-glucosidase, celobiosidase and N-acetyl-β-glucosaminidase, which became apparent in the second year after fertilization. An increase in activity was probably caused by an increase in soil pH. Previous study proved that soil pH strongly influences enzymatic activity (Błońska et al., 2016b). Each soil enzyme has a specific pH range for optimal activity. At optimal pH, the enzymes are more stable. A change in the concentration of H^+ ions in the soil affects the dynamics of the enzymes, degradation of the substrate and change of cofactor through ionization and solubility properties (Tabatabai, 1994). Liming and the associated change in pH may affect the distribution of fungal and bacterial biomass in the soil (Bååth et al., 1992) and thus the enzyme activity. Previous studies proved that a decrease in pH leads to an increase in the percentage of fungi. The composition of the bacterial communities is closely defined by soil pH, higher pH is accompanied by increasing of soil bacterial (Rousk et al., 2010). It can be assumed that another reason for an increase in enzymatic activity of the studied soils may be the influence of root systems of seedlings, which reacted positively to the applied fertilization. The studies by Gianfreda (2015) and Loeppmann et al. (2016) showed that the interaction of root systems and their secretions have a very significant impact on the activity of soil microorganisms and their enzymes, especially in rhizosphere zones. Root-related microorganisms are often considered to be the main producers of enzymes in the rhizosphere soil, but an important contribution of enzymes can originate from enzymatic proteins produced by plant roots (Chroma et al., 2002).

An additional effect of the fertilization was an increase in nitrogen mineralization, which is proved by an increase in nitrate nitrogen content on the fertilized plots with beech and a clear positive correlation of enzymatic activity with nitrate nitrogen content. The activity of N-acetyl-β-glucosaminidase is considered as an indicator of soil nitrogen mineralization (Ekenler and Tabatabai, 2004). Its increase on plots fertilized with dolomite confirms an increase in soil nitrogen mineralization. A very important effect of the fertilization was a decrease in Mn uptake by seedlings of both beech and oak. In beech leaves, in the first year after fertilization with dolomite, the manganese content decreased about 2.5 times compared to the control, in the second year the manganese content was 6 times lower compared to the unfertilized variant. In the case of oak, the manganese content in leaves significantly decreased in the second year after fertilization and was on average 3 times lower than in the unfertilized variant. There are some reports in the literature on intensive manganese uptake under strongly acidic soil conditions (Marschner, 1995; Porter et al., 2004). In our research, statistically significant differences in the content of Mn in the leaves of oak and beech were noted between the fertilized variant and the control variant, where the soil was characterized by a significantly lower pH. Mn is strongly taken up especially in a magnesium deficiency situation, which may lead, depending on the tolerance of different species, to its toxicity (Millaleo et al., 2010). The reduced uptake of Mn by the cultivated seedlings is, on the one hand, the result of reduced soil acidity, which affects the mobility and bioavailability of Mn. On the other hand, it is an effect of increasing exchangeable magnesium content in the soil. The study conducted confirmed a strong correlation between the Mn content in the leaves of seedlings with the content of exchangeable Mg in the soil. After exceeding the Mg content over 3.0 $mg \cdot 100g^{-1}$, the Mn content in leaves of cultivated seedlings decreased significantly.

5. Conclusions

The applied dolomite fertilization had a positive effect on the properties of the tested soils and the content of nutrients in leaves of the tested species. Dolomite fertilization significantly improves soil pH and exchangeable basic cations content in the soils. Regardless of the species of seedlings, dolomite fertilization improved the nutrition, especially of magnesium. A positive effect of the conducted fertilization was a decrease in the content of manganese in beech and oak leaves. In the assessment of the effects of soil fertilization in forest nurseries, the enzymatic activity of soils can be used, which strongly correlates with the properties of soils and the nutritional status of the young generation of trees. In forest nurseries with soils characterized by too low pH, the application of dolomite fertilization will produce a young generation of appropriately nourished trees.

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Wpływ nawożenia dolomitem na stan odżywienia sadzonek oraz właściwości gleb w szkółce leśnej

Słowa kluczowe

Aktywność enzymatyczna
Nawożenie
Dolomitowanie
Właściwości gleby
Toksyczność manganu

Streszczenie

Celem przeprowadzonych badań było określenie wpływu nawożenia dolomitem na właściwości gleb na szkółce leśnej oraz określenie stanu odżywienia sadzonek dwóch gatunków: buka zwyczajnego (*Fagus sylvatica* L.) i dębu szypułkowego (*Quercus robur* L.). Badania zostały przeprowadzone na terenie szkółki leśnej w Nadleśnictwie Polanów, położonej w północnej części Polski. W celu przeprowadzenia badań założono poletka doświadczalne, na których zastosowano mineralne nawożenie dolomitem w ilości 2200 kg/ha. Rok i dwa lata po wykonaniu nawożenia została przeprowadzona ocena właściwości gleb oraz określenie zawartość składników odżywczych w liściach sadzonek badanych gatunków. W próbkach gleb zostało oznaczone pH, zawartość węgla (C) i azotu (N), zawartość kationów zasadowych, formy azotu mineralnego oraz aktywność enzymatyczna. W liściach badanych gatunków określono również zawartość makro i mikroskładników. Przeprowadzone badania potwierdziły korzystny wpływ zastosowanego nawożenia dolomitem. Wykonany zabieg nawożenia doprowadził do zmniejszenia zakwaszenia, wzrostu zawartości magnezu (Mg) oraz poprawy aktywności enzymatycznej. W przypadku obu gatunków zanotowano poprawę stanu odżywienia zarówno w rok i dwa lata od wykonania zabiegu nawożenia. Pozytywnym efektem przeprowadzonego nawożenia dolomitem było obniżenie zawartości manganu w aparacie asymilacyjnym buka i dębu. Zanotowano istotną korelację pomiędzy zawartością manganu w liściach badanych gatunków, a zawartością magnezu w glebach. Aktywność enzymatyczna gleb reaguje na zmiany właściwości gleb powodowane nawożeniem dolomitem.