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THE DEVELOPMENT OF *Betula pendula* ROTH. SEEDLINGS AND THEIR USEFULNESS FOR RECLAMATION OF A ZINC SMELTER DUMP

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Introduction

The zinc waste dumps belong to the type of industrial waste areas which are found difficult for natural reclamation techniques. The heterogeneous composition of the waste results in numerous complex physical and chemical processes causing serious air and water pollution in the surrounding areas. The first stage in waste dump reclamation is the initiation of soil forming processes on the dump. They can be accelerated by adding organic matter [GASIDŁO, GORGOŃ 1999]. Complex physico-chemical tests of soil as well as physiological and ecological studies of plants are necessary to improve and facilitate the reclamation techniques used on the dumping ground [PATRZAŁEK 1990; HARABIN, WRONA 2000]. The present paper attempts to show the sensitivity of *Betula pendula* ROTH. seedlings to the adverse conditions of the zinc waste dump. Additionally, pollen vitality and seed germination capacity of *Betula pendula* were tested before the preparation of the pot cultures experiment. These properties were taken into consideration in the evaluation of the results, since they affected the processes under analysis.

Materials and methods

The research was done on post-floatation sludge-silt waste which was found in Katowice, east of the „Silesia" Steelworks, in the northern section of Rów Wełnowiecki. The post-floatation sludge-silt waste dump (33 m high) is composed of waste originating from complex zinc and lead ore enrichment processes, i.e. dolomites, clays, and extremely toxic silts, containing floatation reagents and other compounds used to accelerate a selective floatation process. The pH value of the waste was 8.4 [PROJEKT TECHNICZNY...].

The seeds of 10 trees of *Betula pendula* growing on the zinc smelter sludge-silt waste grounds had been collected in the vicinity of the dump. Additionally, seeds of 10 birch trees from non-polluted region (Mirów – 60 km in north-east direction from Katowice) were used as a control group.

For the pot cultures sludge-silt waste was brought to the laboratory of the

Faculty of Biology and placed in 24 pots (17 cm in top diameter). In each pot a different soil variant was applied:

I – sludge-silt waste (D1, M1 symbols)
II – sludge-silt waste mixed with peat (50% pot volume) (D2, M2 symbols)
III – sludge-silt waste covered with 2.5 cm layer of garden soil (D3, M3 symbols)
IV – garden soil as a control type (D4, M4 symbols)

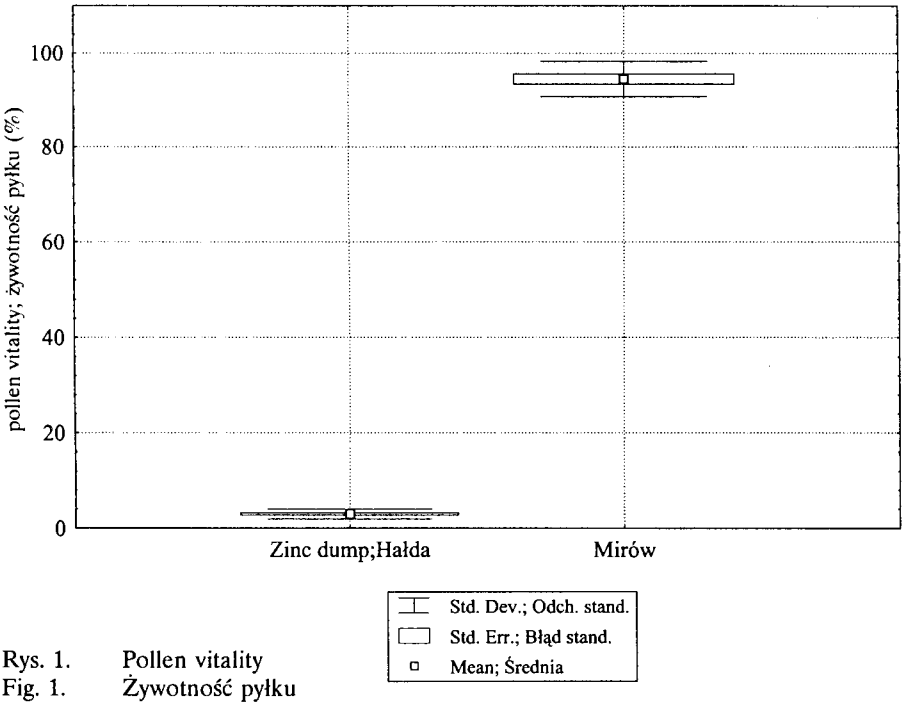
In this paper the following abbreviations were used: D – for seeds of the trees growing on zinc waste dump, M – for seeds of the trees growing in Mirów. In the experiment, each soil variants were used in three repetitions, and in August 2000 each pot received 25 seeds. In the course of the experiment, the appropriate level of soil humidity and light was maintained. At the beginning of the vegetation season, pollen vitality of *Betula pendula* [FRANIEL 1999; ZAUFAL 2000] and then germination capacity of seeds [SUSZKA et al. 2000] were tested. As soon as the germination occurred, the numbers of growing and surviving seedlings were noted systematically once in a week. On terminating the experiment at the end of July 2001, the seedlings were counted and the shoot height and root length were measured.

Results and discussion

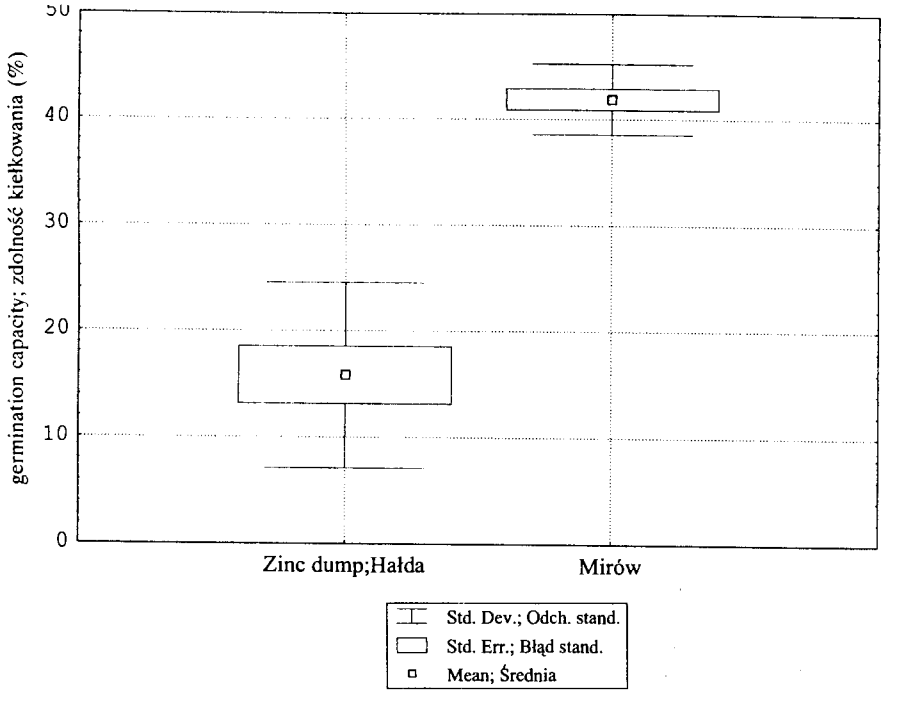
The successful growth of plant seeds is stimulated not only by the quality of embryo sac and pollen, but also weather conditions during the period of pollination. The present author's research into the vitality of pollen on agar medium in laboratory conditions has shown that capability of pollen vitality is considerably diminished (by 70–80 percent) on the waste dump soil in comparison with the Mirów site. The research by HOULE [1992] proved that pollen structure is susceptible to various factors of the environment, especially acid rain precipitation and UV radiation. The properties of the habitat should not be ignored either as they exert considerable influence on the male reproductive organ. If the stigma has received a relatively high number of pollen grains, the potential competition of pollen tube may bring about the growth of better seeds and consequently, seedlings. The dump seeds are characterized by low germination capacity. The deteriorating quality of plant seedlings may have been caused by inhibitors activated in the seed itself, or by a distorted reproductive stage in parent plants.

The research shows that significant differences exist between zinc heap and Mirów region in pollen vitality and germination capacity (Fig. 1, Fig. 2). The germination of seeds and survival of seedlings for both populations of *Betula pendula* was characterized by certain regularities. In each of the two birch populations of seeds the germination started and culminated at different times. It was closely related to specific soil variant. In the pot culture the survival time of the seedlings was at its optimum in the soil variant III and IV (2, 3 months), and was the shortest in the soil variant I (1 week); after the stated periods of time the seedlings began to die off. The soil type 2 was characterized by an intermediate survival time (1 month).

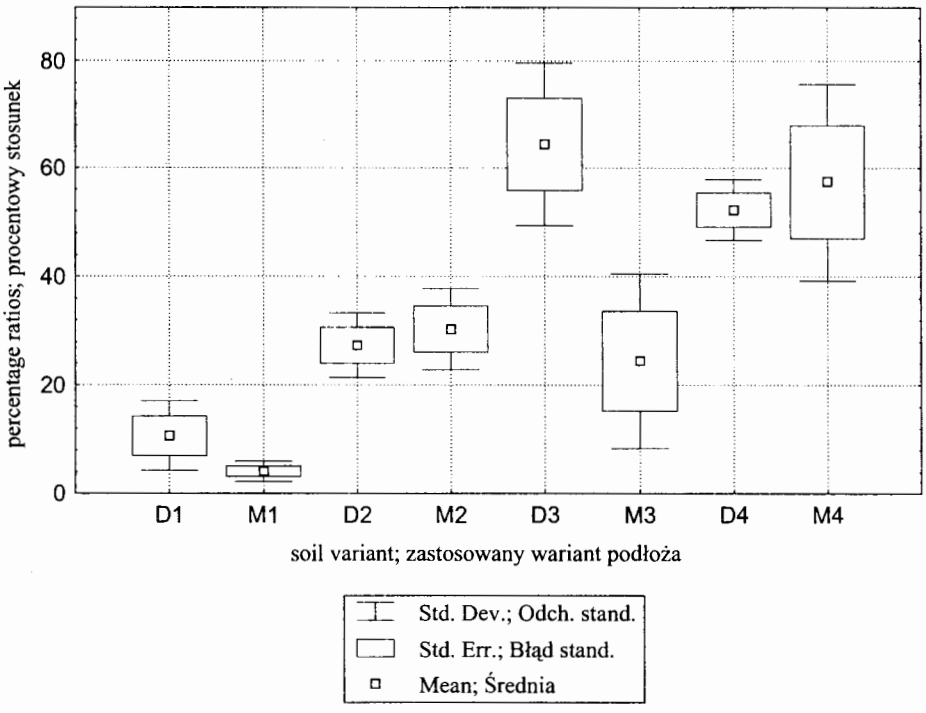
Fig. 3 shows the percentage ratio of numbers of seedlings surviving during the experiment to their maximum numbers. Tab. 1 shows the average seedling heights and root lengths.



Rys. 1. Pollen vitality
Fig. 1. Żywotność pyłku



Rys. 2. Germination capacity of seeds (%)
Fig. 2. Zdolność kiełkowania nasion (%)



Rys. 3. Percentage ratio of surviving seedlings to their maximum number
Fig. 3. Procentowy stosunek liczby siewek przeżywających do ich maksymalnej liczby

Table 1; Tabela 1

Average seedling heights/root lengths (cm)
Średnie długości siewek: część nadziemna/podziemna (cm)

Species; Gatunek	Post-floatation dump; Hałda			
	I	II	III	IV
Betula pendula	0/0	1,7/1,4	2,1/1,1	1,5/0,7
	Mirów			
	0/0	0,7/1,3	3,1/1,9	3,8/1,7

I, II, III, IV – variants of soil; zastosowany wariant podłoża

The experiment showed positive results for seedlings from seeds of birch trees from dump site growing on the variant II of soil and for seedlings from seeds of *Betula pendula* trees from Mirów growing on soil variants III and IV. variant I of soil showed absence of seedlings in experiment at the end of July 2001.

The dump seedlings grown on post-floatation sludge-silt waste covered by a 2.5 cm layer of garden soil have been recorded as having a lower life expectancy than the seedlings on soil with peat, which testifies to the ecological plasticity of the species in relation to the specific environment conditions. This may contri-

bute to the development of specific ecotypes, because in accordance with KREBS [1996] waste dump plant adaptation to soils contaminated with heavy metals is so close that growth may be slowed down if the soil is not contaminated. Laboratory conditions also facilitate better growth. The application of peat (50% pot volume) in the second case (variant II) has reduced unfavourable pH value and increased soil humidity by lessening evaporation, which also contributed to better growth. The swelling impact of dry seeds in waste dump soil may cause further water deficit, which prevents germination.

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Key words: *Betula pendula* ROTH, reclamation, seedlings, zinc smelter dump

Summary

The present paper shows the results of research whose aim was to establish the degree of the sensitivity of *Betula pendula* ROTH seedlings to the adverse conditions of the zinc smelter sludge-silt waste. For the pot cultures post-floatation sludge-silt waste was brought to the laboratory and placed in pots (17 cm in top diameter). In the experiment the following soil variants were used:
I – sludge-silt waste

II – sludge-silt waste mixed with peat
III – sludge-silt waste covered with 2.5 cm layer of garden soil
IV – garden soil as a control type

The seeds of *Betula pendula* trees growing on the post-floatation sludge-silt waste grounds had been collected in the vicinity of the dump. Additionally, seeds of birch from non-polluted region (Mirów) were used as a control group. In the experiment, the soil variants were used in three replicates and each pot received 25 seeds. At the end of experiment, the seedlings were counted and the shoot height and root length were measured. Significant differences exist between zinc heap and Mirów regions in pollen vitality and seed germination capacity. The experiment showed positive results for seedlings from zinc dump seeds growing on the variant II of soil and for seedlings from Mirów seeds growing on variants III and IV of soil.

ROZWÓJ SIEWEK BRZOZY BRODAWKOWATEJ NA HAŁDZIE POFLOTACYJNEJ

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Słowa kluczowe: *Betula pendula* Roth, rekultywacja, siewki, hałda poflotacyjna

Streszczenie

Działalność przemysłowa stanowi największe, a zarazem najuciążliwsze źródło powstawania odpadów. Rekultywacja zwałowisk pocynkowych ze względu na ich toksyczność jest trudna i bardzo kosztowna. Pierwszym krokiem w zabiegach rekultywacyjnych jest zapoczątkowanie na zwałach procesów glebotwórczych. Można je przyspieszyć przez dodanie materii organicznej i odpowiednie nawożenie mineralne. Do badań wybrano brzozę brodawkowatą, gatunek o szerokiej skali ekologicznej przystosowującą tereny niezalesione do zasiedlenia przez inne gatunki. W celu założenia doświadczenia wazonowego do laboratorium Katedry Ekologii sprowadzono odpady z hałdy poflotacyjnej. Doświadczenie obejmowało 24 doniczek i przygotowano następujące warianty podłoża:

I wariant – podłoże z hałdy poflotacyjnej,
II wariant – podłoże z hałdy poflotacyjnej z domieszką torfu,
III wariant – podłoże z hałdy poflotacyjnej przykryte 2,5 cm warstwą gleby ogrodniczej
IV wariant – kontrolny z ziemią inspektową.

Do wysiewu użyto nasion zebranych z 10 drzew rosnących na hałdzie poflotacyjnej oraz z 10 drzew rosnących w Mirowie (nasiona te potraktowano jako materiał porównawczy). Do doniczek o średnicy 17 cm na każdym wariancie podłoża wysiano w trzech powtórzeniach po 25 nasion. Na początku sezonu wegetacyjnego sprawdzono żywotność pyłku, a przed wysiewem nasion poddano je ocenie wartości siewnej. Przy likwidacji doświadczenia pod koniec sezonu wegetacyjnego siewki policzono i zmierzono ich wysokość oraz długość systemu

korzeniowego.

Stwierdzono statystycznie istotne różnice pomiędzy hałdą poflotacyjną, a Mirowem pod względem żywotności pyłku i zdolności kiełkowania nasion. Wykonane doświadczenie potwierdza dobry rozwój siewek pochodzących z nasion z hałdy poflotacyjnej wysianych na II wariancie podłoża i z Mirowa wysianych na podłożach w wariantach III i IV.

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