*Acta Agrophysica, 2001, 51, 51-55*

# DEVELOPMENT OF *BETULA PENDULA* SEEDLINGS GROWING ON THE SILESIA STEELWORKS DUMPING GROUNDS IN KATOWICE

*I. Franiel*

Department of Ecology, University of Silesia
Jagiellońska 28, 40-032 Katowice, Poland

A b s t r a c t. Zinc-lead waste dumps belong to the type of industrial waste areas which are unyielding to natural reclamation techniques. Heterogeneous composition of waste results in numerous complex physical and chemical processes causing serious air and water pollution in the surrounding areas. Moreover, industrial waste is characterized by high concentration of heavy metal compounds and other toxic substances which constantly affected all living organisms exposed to them. The present research shows the results of research aimed to establish degree of the sensitivity of *Betula pendula* seedlings to the adverse conditions of zinc-lead waste from the "Silesia Steelworks" in Katowice. Two kinds of substrate, i.e. slag and post-flotation waste was placed in pot cultures (17 cm in top diameter) and for each kind of waste a different soil variant was applied: (I) dump soil, (II) dump soil fertilized with NPK fertilizer, (III) dump soil covered with a 2.5 cm layer of garden soil, (IV) dump soil mixed with peat. In the experiment each variant of the soil type was used in 3 pots (repetitions). Additionally, pots with garden soil were used as control. Each pot received 25 seeds. The seeds of *Betula pendula* growing on smelter waste dumps had been collected in the vicinity of the dumps. At the end of the experiment, the seedlings were counted and the leaf colouring, height, root length of each seedling was measured. The results of the experiment showed that the most favourable soil type for *Betula pendula* seedlings were variants Nos (III) and (IV).

K e y w o r d s: *Betula pendula*, seedlings, reclamation, post-floatation and smelter wastes.

## INTRODUCTION

The need for natural reclamation of zinc heaps is urgent, particularly since the concentrations of heavy metals and other toxic substances are high there. Complex physico-chemical tests of the soil and physiological and ecological studies of plants are necessary to improve and facilitate reclamation techniques used on the dumping grounds. Physiological and ecological research can be done with pot seedling cultures. The present paper attempts to show the results of research aimed at establishing the degree of sensitivity of *Betula pendula* seedlings to adverse conditions of the zinc waste dump.

## MATERIALS AND METHODS

Two kinds of substrate (soil), i.e. slag and post-floatation waste, were brought to the laboratory of the Faculty of Biology and placed in pots (17 cm in top diameter). A general characteristics the of waste is shown in Table 1 [2].

**Table 1.** Granulometric composition of zinc-lead waste (by the Prószyńskis method) and chemical analysis of zinc-lead waste

| Soil type | Depth (cm) | Size distribution of the soil samples (%) | | Grain size (mm) distribution (%) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | >20 mm | 20-1 mm | 1-0.1 | 0.1-0.05 | 0.05-0.02 | 0.02-0.006 | 0.006-0.002 | <0.002 |
| Smelt waste dump | 0-50 | 11.7 | 73.1 | 74 | 14 | 7 | 2 | 1 | 2 |
| Post-floatation dump | 0-50 | 16.5 | 2.5 | 63 | 28 | 4 | 2 | 1 | 2 |

| Soil type | Depth (cm) | pH | | N | C | $SO_3$ | $N\text{-}NH_3$ | $N\text{-}NO_3$ | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $H_2O$ | KCl | (%) | | mg/100 g | | | | |
| Smelter waste dump | 0-50 | 7.2 | 6.9 | 0.006 | 0.02 | 0.18 | 1.03 | 0.16 | 11.4 | 1.2 |
| Post-floatation dump | 0-50 | 7.3 | 7.0 | 0.001 | .0.07 | 0.019 | 0.94 | 0.48 | 4.3 | 0.76 |

In each of these categories of dumping grounds, a different soil variant was applied:

I. dump soil

II. dump soil fertilized with NPK fertilizer

III. dump soil covered with a 2.5 cm layer of garden soil

IV. dump soil mixed with peat (50% pot volume).

In variant No. II, a full dose of pure NPK fertiliser was applied, i.e. 400 kg per ha with carbamide (100 kg per ha.), superphosphate (200 kg per ha.) and potassium salt (100 kg per ha.) [3]. It was calculated that one pot should receive 0.227 g of carbamide, 0.452 g of superphosphate and 0.227 g of potassium salt. Eight days before seed planting, the soil was fertilized with superphosphate and potassium salt. Carbamide dosage was applied in two stages: the first half of the prescribed amount was applied 2 days before planting, the second in July.

The seeds of the *Betula pendula* trees growing on the smelter waste dumps had been collected in the vicinity of the dumps. Then, the *Betula pendula* seeds were tested for the following properties: seed purity, germination capacity, germination energy (Table 2).

**Table 2.** Germination characteristics of *Betula pendula* seeds

| Germination characteristics of seeds | Zinc-lead dump | Unpolluted area (60 km SW from Katowice) |
|---|---|---|
| Seed purity (%) | 24.0 | 30.0 |
| Germination capacity (%) | 10.4 | 36.8 |
| Germination energy (%) | 21.6 | 31.6 |

In the experiment, each of the soil types (I, II, III, IV) were used in three pots (repetitions) for both categories of waste. Additionally, pots with garden soil were used as a control group. In the course of the experiment, an appropriate level of soil humidity and light (2000 lx, 16 h per day) was maintained. The *Betula pendula* seeds were planted on April 2nd 1998; 25 seeds in each pot. As soon as germination started, the number of growing and surviving seedlings was noted systematically once a week. At the end of the experiment, in the end of September, the seedlings were counted and the following measurements were taken:

- number of live seedlings in each pot,
- leaf colouring of seedlings in each pot (in accordance with the five-degree scale: 1- deep green, 2 - green, 3 - light green, 4 - yellowish-green, 5 - others (i.e. grey) [1],
- height of each seedling,
- root length.

## RESULTS AND CONCLUSIONS

The number of seedlings that survived on the date of the experiment end, their maximum numbers throughout the observation time, and the percentage ratio of these two sets of values are shown in Tables 3 and 4. The average seedling height and root length are shown in Table 5; Table 6 presents data on leaf colouring.

The contaminants accumulated in the soil considerably diminish seed quality and tend to cause a considerable decrease in generative reproduction rates (Table 2).

In the pot culture the seedling survival time was at its optimum in the soil type III (86 days), and was the shortest in the soil types I, II (13 days); after the above

**Table 3.** The maximum number of live seedlings and the number of seedlings on the date of experiment end

| Number of seedlings | Soil variant | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | | | II | | | III | | | IV | | | Control | | |
| | Replications | | | | | | | | | | | | | | |
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| | Smelter waste dump | | | | | | | | | | | | | | |
| *Betula pendula* | 25 | 5 | 0 | 25 | 4 | 0 | 25 | 19 | 8 | 25 | 8 | 2 | 25 | 8 | 3 |
| | Post-flotation dump | | | | | | | | | | | | | | |
| | 25 | 6 | 0 | 25 | 4 | 0 | 25 | 11 | 2 | 25 | 7 | 2 | | | |

**Table 4.** Percentage ratios of the numbers of seedlings surviving on the date of the experiment end to their maximum numbers

| | Soil variants | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | Control |
| Seedlings *Betula pendula* | Smelter waste dump | | | | |
| | 0 | 0 | 42.1 | 25.1 | 37.5 |
| | Post-flotation dump | | | | |
| | 0 | 0 | 18.1 | 28.5 | |

**Table 5.** Average seedling hight in cm [a] and root length in cm [b]- [a/b]

| | Soil variants | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | Control |
| Seedlings *Betula pendula* | Smelter waste dump | | | | |
| | 0/0 | 0/0 | 1.3/1.7 | 1.5/2.3 | 3.1/2.7 |
| | Post-flotation dump | | | | |
| | 0/0 | 0/0 | 0.7/1.6 | 0.4/1.3 | |

**Table 6.** Leaf colouring (scale 1-5)

| | Soil variants | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | Control |
| Seedlings *Betula pendula* | Smelter waste dump | | | | |
| | 0 | 0 | 2 | 3 | 1 |
| | Post-flotation dump | | | | |
| | 0 | 0 | 2 | 3 | |

time periods the seedlings began to die off. The soil type IV was characterized by a medium survival time (34 days).

Soil types III and IV of the smelter dump soil were the optimum for the seedlings, whereas soil type I and II were most adverse. For the post-floatation dump soil only the soil type IV was better than type III. As far as germination (including survival rate and quality of pot cultures ) is concerned, soil type IV was the best for both categories of dump soil, whereas soil type III was the optimum for germination and survival rates rather than for the physical condition of seedlings. *Betula pendula* seedlings were eventually absent from the soil types I and II. It is not clear why a full fertilizer dose had a negative influence on germination and plant survival. One possible explanation is a destructive impact of a single full NPK dose. The results from a one-season pot experiment showed that seed planting methods at dump reclamation are not advisable unless germinating seeds have specific conditions for growth.

## REFERENCES

1. **Brzywczy-Kunińska Z., Rutkowska B.:** Odporność drzew i krzewów na dwutlenek siarki oraz wyniki badań traw. Zesz. Nauk. Inst. Gospodarki Komunalnej, 8, 92-98, 1964.
2. **Franiel I.:** Concentrations of heavy metals (Pb, Zn, Cd) in the biomass of selected tree species growing on "Silesia steelworks dumping grounds in Katowice. Acta Biol. Sil., 28(45), 59-67, 1996.
3. Projekt techniczny rekultywacji przejściowej zwałowiska nr 44 odpadów pohutniczych ZM Silesia w Katowicach. (mimeographed), 1988.