The effect of crop rotation of six forest tree species on peat-bark substrate enzymatic activity

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Abstract

The paper focuses on the effect of a nine-year utilisation of the peat-bark substrate and crop rotation of six main forest tree species on changes in the substrate enzymatic activity during successive rotation cycles.

The study was conducted in the forest nursery in the years 1989-1997. Seedlings of Scots pine Pinus sylvestris, Norway spruce Picea abies, European larch Larix decidua, pendentive oak Quercus robur, common beech Fagus sylvatica, and silver birch Betula verrucosa were grown on peat-bark substrate. The activity of soil enzymes: betaglucosidase, invertase, urease, asparginase, acid phosphatase and dehydrogenases was assessed. The succession of three 3-year crop rotation cycles with species following each other according to the rotation plan was subject to observations.

The obtained results have confirmed recent suppositions that the tree species and their rotation modify soil enzymatic activity. The enzymatic activity of the peat-bark substrate changed after each three-year crop rotation cycle and decreased with time. After the second crop rotation cycle the activity of betaglucosidase, urease, asparginase was found to be lower, and the activity of invertase and dehydrogenases - higher. After three crop rotation cycles the positive effect of appropriate species rotation on the enzymatic activity of the substrate was noted.

Introduction

A long-term utilisation of soil in forest nurseries causes considerable changes in the soil environment. Soil in forest nurseries changes its properties resulting from processes mainly connected with the physiology of root systems of seedlings such as nutrient uptake by the grown species causing "soil weariness" and degradation, secretion of metabolic substances from the roots to the soil and their accumulation, quantitative and qualitative changes in populations of rhizosphere organisms as well as with the phenomenon of allelopathy and the effect of individual seedling species on soil.

Fungi, bacteria, actinomycetes and algae are microorganisms living in the soil. Their number and composition depend on type of soil, depth and moisture, as well as on the content of oxygen, organic and mineral elements and temperature. The enzymes released from the cells of microorganisms in the soil environment take active part in processes of decomposition and synthesis. The enzymes are the product of metabolism and catalysts of these processes and thus they decide about the decomposition rate of the organic matter (Trojanowski 1973, Russel 1974, Burns 1978, 1982).
Activity of enzymes in the soil is used to assess the general activity of soil microorganisms and the effectiveness of biochemical processes in the soil. The activity of enzymes responsible for the most important biochemical reactions should be analysed to describe changes caused by a long-term use of the soil and crop rotation.

Mineralisation of the organic matter is of paramount importance in sustaining soil fertility as it returns available nutrients to plants. High reduction in soil organisms and even disappearance of microorganism communities is reflected in the inhibition of biochemical processes involved decomposition and mineralisation of the organic matter. Recent studies aimed to detect soil enzymatic activity posed by stress factors such as industrial pollution, use of mineral fertilisers and composts (Januszek 1993, Olszowska 1999, Garcia-Gil et al. 2000). There is still lack of studies on soil enzymatic activity in forest nurseries.

The aim of this study was to determine the effects of peat-bark substrate utilisation during a nine-year period as well as the succession of six forest tree species on changes in the substrate enzymatic activity during successive crop rotation cycles. The experiment was conducted in a forest nursery in the years 1989-1997. Seedlings were grown on seedbeds filled with the substrate in the foil greenhouse. The activity of soil enzymes: betaglucosidase, invertase, urease, asparagine, acid phosphatase and dehydrogenases was assessed.

Methods

The experiment was established in the Zwierzyniec Forest Subdistrict, Skierniewice Forest District. The area is situated in the region II - European Lowland, in the transition climatic zone under strong influence of the continental climate. The growing season is 190 - 220 days, mean temperatures in January from -2 to -3 °C, mean temperatures in July from 17.5 to 18.5 °C, precipitation - ca 500 mm, period of frosts 3 - 3.5 months.

The foil greenhouse was used for the experiment to limit the number of uncontrolled factors that might have affected the results.

Seedbeds on which seedlings of the selected tree species were grown were prepared prior to the experiment. One hundred twenty plots separated from each other, were used in the experiment. The dimensions of each seedbed were: length - 1 m, width - 0.5 m, height - 0.3 m. The substrate was peat-bark at the proportion 1:1. Broken pine bark was mixed with peat from raised bog. Each seedbed was filled with 0.15 m³ of the substrate. The substrate was proved suitable for the production of seedlings of the species used in the experiment as demonstrated by Gorzelak (1986, 1998).

Main forest species, Scots pine Pinus sylvestris, Norway spruce Picea abies, European larch Larix decidua, pendulate oak Quercus robur, common beech Fagus silvatica, and silver birch Betula verrucosa grown in forest nurseries were used in the experiment. Three 3-year crop rotation cycles with species succeeding each other were subject to observations. This corresponded to complete permutation with the set exclusion - the same element by the same that make up thirty variants.

The experiment was conducted in three-year crop rotation cycles with the same species shifted every three years. The designed three crop rotation cycles are shown in Table 1:

- first crop rotation cycle (1989 - 1991), the first three years aimed at “substrate weariness” by growing the same species on the same plots, year after year,
- second crop rotation cycle (1992 - 1994), a three-year succession of all species from the first cycle grown one after another,
- third crop rotation cycle (1995 - 1997), recurrent three-year succession of each species: the species return to the same plots on which they were grown in the first rotation.

The activity of the following soil enzymes in substrates was assessed:

- betaglucosidase - using the jodometric method to assess enzymatic activity (in ml of Na₂S₂O₃ in 1 g of soil) (Russel 1972),
- invertase (beta-fructofuranosidases) - using the jodometric method to assess enzymatic activity in (ml of Na₂S₂O₃ in 1 g of soil) (Russel 1972),
- urease - using the calorimetric method to assess enzymatic activity in (mg of NH₃ in 10 g of soil)

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