Fine-root biodegradation measurements in controlled OxiTop system

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ABSTRACT

Degradability of fine roots (d≤ 2 mm) of Norway spruce (*Picea abies*) at moderate and high soil copper concentrations was studied in a laboratory incubation experiment. The OxiTop (WTW) system used enables to assess soil respiration by measuring O_2 consumption of samples. Soil was collected in a fertile Norway spruce forest site. Fine roots were picked out of soil, weighed and cut in 0.5-1.0- mm pieces. The treatments were 'soil', 'soil + roots', 'soil + roots + Cu 100 (mg kg^{-1})', and 'soil + roots + Cu 500 (mg kg^{-1})'. The amendment with Cu100 increased respiration up to 160% compared with the 'soil + roots' treatment. Estimates of root biodegradation (O_2 consumed per carbon content of the sample) were 16% ('soil + roots'), 45% ('soil + roots + Cu 100'), and 31% ('soil + roots + Cu 500'). The preliminary results suggest that the amendments with Cu increased microbial respiration and had an enhancing effect on the fine root decomposition. The OxiTop system may perform as a useful and feasible means for studying plant litter degradation under variety of controlled conditions.
KEYWORDS: fine-root degradability, copper, laboratory incubation, OxiTop, soil microbial respiration

INTRODUCTION

Fine roots are one of the main sources of C to the soil. The quality of the roots and the environmental conditions for decomposition control the amount and dynamics of carbon is accumulation in soil organic matter and/or respiration. High levels of heavy metals, e.g., copper, may inhibit soil microbial processes, and thus increase the accumulation of soil organic matter (Sauvé 2006). The OxiTop (WTW) method has proved highly reliable in biodegradation measurements (Vähäoja etal 2005), although not yet used in root studies. The objective of this study was i) to estimate the suitability of OxiTop system for laboratory degradation of fine root litter, and ii) to compare short-term decomposition of fine roots at different levels of Cu exposition.

METHODS

Soil was taken from the 0-10 cm humus layer in a 27-years old Norway spruce stand, South-East Estonia (N 58° 16′, E 27° 16′), in Gleysol. Fresh soil samples were sieved through 2 mm sieve to remove debris and coarse roots. The fine roots with diameter ≤2 mm were sorted out (not washed) and weighed. The roots were cut in approximately 0.5-1.0-cm pieces. The contents of total C and N, inorganic C, acid detergent (AD) cellulose, AD lignin, water, Cu, and loss on ignition (440°C) were measured in the roots and in the soil.

An experimental design of four treatments with three replicates was applied to estimate short-term microbial degradation of fine roots and putative inhibition of copper on the degradation. Levels of Cu were chosen as the target value of 100 mg kg^{-1} (satisfactory), and 500 mg kg^{-1}, the industrial limit value, stated by the Estonian Ministry of Environment in 2004. The treatments were: soil, soil + roots, soil + roots + Cu100, and soil + roots + Cu500. The distribution of fine roots in the soil + roots treatments corresponded to 65 g roots kg^{-1} soil (dw/dw). Twelve 1L OxiTop (WTW) bottles were filled to about 1/5 of volume with the prepared soils (dw 40.8-47.9 g per bottle). Each bottle was provided by a beaker containing 30ml 2M NaOH for absorbing the CO_2 to be evolved during soil respiration. After closing the bottles air-tight, the OxiTop sensor-heads were started, to measure the change of pressure caused by the consumption of O_2 (the CO_2 being eliminated by absorption). During the incubation period the temperature was set to 20°C (28 days), 24°C (8 days), and 30°C (12 days).

Means were compared by Kruskal-Wallis ANOVA at $p< 0.05$.

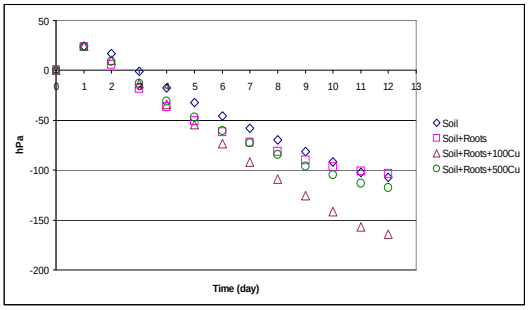
RESULTS

Table 1 shows the initial characteristics of the soil and roots. During the 48 days of incubation the dry weight of soil and soil-root mixtures remained unchanged in all treatments.

Table 1. Characteristics of soil and fine roots at the start of the experiment

Variable	Soil	Roots	Variable	Soil	Roots
$pH_{(H2O)}$	4.2	-	Water content %	62.7	54.9
Conductivity$_{(H2O)}$ (µS cm^{-1})	91.5	-	LOI %	43.3	91.1
Total C %	24.7	49.2	AD cellulose %	9.0	19.2
Inorganic C %	<0.1	0.1	AD lignin %	20.9	49.9
Total N %	1.0	0.8	Cu (mg kg^{-1})	3.2	5.8

The temperature was held successfully constant only at 30°C, while the lower temperatures held instable. Respiration (Figure 1.1) was most intense in the treatment of soil + roots + Cu100. Calculated values of fine roots degraded during the incubation were 16% in the treatment of soil + roots, 45% in the soil + roots + 100Cu, and 31% in the soil + roots + 500Cu. AD cellulose and AD lignin contents had decreased in the substrates of soil + roots + Cu100, while they had increased in the other treatments (Figure 1.2).



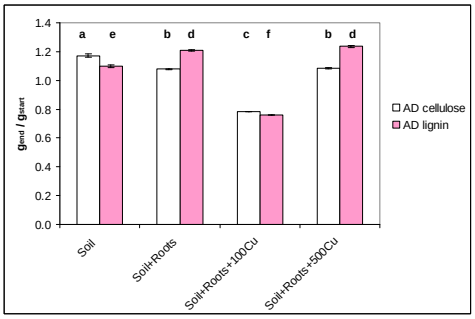


Figure 1.1. Changes in pressure during the incubation phase at the temperature 30°C. Each symbol represents the mean of n=3. Figure 1.2. Changes in AD cellulose and in AD lignin contents in the incubated substrates, compared as the mean ratios of initial to final values ±1SE (n=3). The letters a, b, c and d, e, f show respective significant differences at $p < 0.05$.

DISCUSSION

Constant temperature during the incubation period is important as the pressure would respond immediately to changes of temperature. The results of this experiment were influenced by the relatively high temperature used due to the absence of cooling. The AD cellulose and AD lignin decomposed significantly, showing a dynamic character of these components. The concentrations of Cu used, did not inhibit respiration and decomposition of fine roots, rather the opposite. The conditions applied in this experiment were somewhat extreme, and likely caused shifts in the microbial communities. The OxiTop system proved however, suitable for using it in further root decomposition studies.

REFERENCES

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