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FINE ROOT DYNAMICS ON TWO DRAINED PEATLAND SITES

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Total fine root biomass was 397 g/m^2 at an afforested and fertilized tall sedge fen (VSN), and 529 g/m^2 at a tall sedge pine fen (VSR). The studied sites were located on the Lakkasuo mire complex in central Finland. The greater biomass on the VSR site could be a result of its lower nutrient status compared to that of the fertilized VSN site. Total root production during May–September 1991 was 178 g/m^2 at the VSN site and 242 g/m^2 at the VSR site when all significant increments in the living and dead root biomasses were summed up. Almost half of the fine root biomass was renewed during the summer.

Keywords: Biomass, drainage, ground vegetation, necromass, *Pinus sylvestris*, production

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INTRODUCTION

Fine root dynamics appear to play a very important role in carbon and nutrient cycling in many forest ecosystems on mineral soils. Fine root production may account for 5 to 75% of the annual biomass production of a tree stand (e.g. Harris et al. 1977, Grier et al. 1981, Keyes & Grier 1981, Fogel 1985, Santantonio & Santantonio 1987, Persson 1992). The detrital input to the soil through fine roots may be greater than that through the above-ground compartments of trees.

On peat soils, drainage increases biomass production and shifts it from the ground vegetation to the tree layer (e.g. Reinikainen et al. 1984, Vasander 1990). Simultaneously, the importance of root systems as biomass and litter producers may increase. After drainage, the decomposition of organic matter increases due to improved aeration and probably also because the litter produced is more readily decomposable.

The aim of our study is to determine fine root (Ø ≤10 mm) biomass and production in two Scots pine (*Pinus sylvestris*) stands growing on drained peatlands.

MATERIAL AND METHODS

Study sites

The material for this report was collected from two sample plots on the Lakkasuo mire complex in central Finland (61°48´N, 24°19´E, 150 m a.s.l.). Both sample plots are located in the drained (1961) part of the mire. The sample plot on tall sedge fen (VSN) was fertilized and afforested after drainage while the stand on the tall sedge pine fen (VSR) was naturally regenerated before drainage. The 1992 tree stand volume was 123 m^3/ha on the VSN site and 150 m^3/ha on the VSR site. The corresponding stem numbers/ha were 3 860 and 2 370.

Methods

Living and dead fine root biomasses were determined once a month during the summer using the core method. Forty peat cores (24 cm^2) were taken systematically on each plot from the 0–10 cm and 10–20-cm layers. Sampling started in May 1991 and will continue to 1993. The material for this report was collected in 1991. The depth to the water table and soil temperature were monitored regularly on the plots.

Root production has been estimated using two methods, both of which are based on the fluctuations in the living and dead fine root biomasses during the growing season.

Method I

$$\text{Production} \geq \sum_{j+1}^{k} (\Delta B)^{+}{}_{j}$$

where k is the number of sampling times during the investigation −1; $(\Delta B)^{+}{}_{j}$ are observed positive values of the living biomass change from the jth to the j+1th sampling.

Method II

Production was calculated by balancing transfers in living and dead root biomass compartments according to the decision matrix presented by Fairley and Alexander (1985) (Table 1).

In the first case, all fluctuations were used in the calculations. In the second case, only significant (Duncan's test, $p < 0.05$) fluctuations were used. Decomposition measurements were not available at the time of writing this report and therefore all the production estimates presented are underestimates.

RESULTS AND DISCUSSION

Root biomass

The average living root biomass during May–September 1991 was 397 g/m^2 for the VSN site and 529 g/m^2 for the VSR site (Fig. 1). Field layer vegetation accounted for 30% of the total living root biomass on both plots. The greater Scots pine root biomass of the VSR site could result from the greater depth to the water table or lower site fertility compared to that of the fertilized VSN site. Improved aeration in the surface peat is known to increase the amount of roots (Heikurainen 1955a, Paavilainen 1966), and poor nutrient status of soil to increase the accumulation of biomass into the below-ground compartments of trees (Keyes & Grier 1981). The differences in the structure of the tree stand is a less probable explanation for the difference in root biomass because the stand development on both sites has reached the stage when the root system is assumed to be fully developed and production compensates for mortality (Kalela 1955, Heikurainen 1955b).

The average dead root biomass was 141 g/m^2 for the VSN and 224 g/m^2 for the VSR site. The biomass of dead field layer vegetation roots was greater than that of dead Scots pine roots. The ratio of living to dead roots was lower for field layer vegetation than for Scots pine. This could be the result of either higher mortality or lower decomposition rate of field layer vegetation roots compared to Scots pine roots. The ratio of living to dead Scots pine roots was greater than that in Scots pine stands on mineral soils (e.g. Persson 1980). However, on peat soils high living to dead root ratios have been observed (Finér 1991). This would suggest that either the root mortality rate is lower or that the decomposition rate is higher in peat soils than in mineral soils.

The living biomass of the <2 mm diameter Scots pine roots culminated in August, when the soil temperature was the highest and the depth to the water table was the greatest. There was no clear pattern in the fluctuations of the other root compartments during the summer.

Table 1. Decision matrix illustrating the equations used for estimating fine root production (P). The appropriate quadrant is chosen according to the change in the live and dead standing biomasses (B) during the interval between two sampling dates. Annual estimates are calculated by summing the estimates from all sampling intervals within the year (Fairley & Alexander 1985).

	Live: Increase	Live: Decrease, $\Delta B^{dead} > \Delta B^{live}$	Live: Decrease, $\Delta B^{live} > \Delta B^{dead}$
Dead Increase	$P = \Delta B^{live} + \Delta B^{dead}$	$P = \Delta B^{live} + \Delta B^{dead}$	$P = 0$
Dead Decrease	$P = \Delta B^{live}$	$P = 0$	

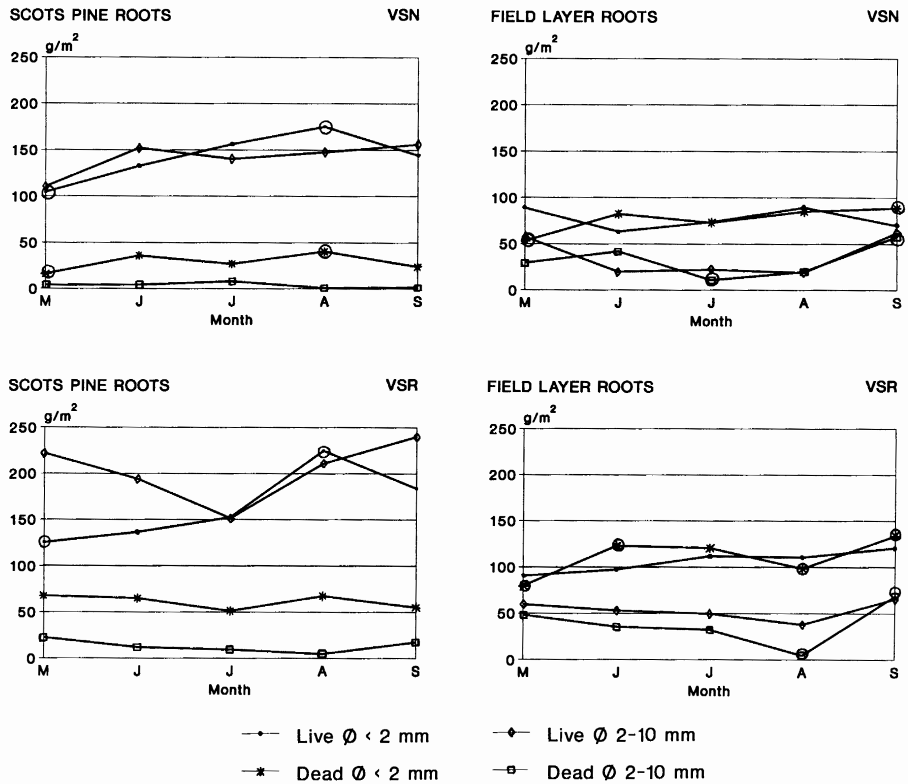

Fig. 1. The development of root biomass of Scots pine and field layer vegetation for the VSN and VSR sites during May–September 1991. Statistically significant biomass increments are shown by cycled symbols.

Production

When all fluctuations in root biomass were used, total root production calculated using method II resulted in values 1.5–1.7 times greater than those calculated using method I (Table 2). When only the significant fluctuations were taken into account, the results were 2.4–2.5 times greater using method II than using method I. In the latter case, the production of field layer vegetation roots was zero using method I.

As was the case with the living and dead root biomass estimates, total root production estimates were greater for the VSR site than for the VSN site. Method II values indicated higher turnover rate (production/living biomass) of field layer vegetation roots than of Scots pine roots provided that the biomass was in steady state on both plots. The high turnover rate of field layer vegetation roots was supported by the fact that the biomass of the dead roots was high compared to that of the living roots. The turnover rates were lower than those measured on Scots pine stands growing on mineral soil in Sweden (e.g. Persson 1980).

The turnover of Scots pine roots <2 mm in diameter seemed to be greater than that of larger roots. The higher ratio between dead and living root biomass of the <2 mm diameter Scots pine roots compared to the larger roots, is in accordance with the result. The turnover of the finest field layer vegetation roots seemed to be lower than that of the larger ones. However, the ratio between the living and dead field layer vegetation root biomass did not differ between the two root diameter classes.

The above-ground production of Scots pine in Fennoscandia varies between 300 and 630 g/m^2 (e.g. Finér 1992). If the above-ground production of Scots pine in the present study is within this range, the pine root production estimates (71–217 g/m^2) would account for 10–40% of total biomass production. This would indicate that the detrital input by Scots pine roots was equal to the needle litterfall (Albrektson 1980).

Table 2. Root production (g m^{-2}) and turnover (production, living biomass) during the summer 1991 calculated with methods I and II (see text). In the first case, all fluctuations in biomass were used and in the second case, only the statistically significant ones were used.

Root fraction	VSN Method I	VSN Method II	VSR Method I	VSR Method II
Case 1 — All fluctuations				
Pine				
<2 mm	70.7	103.9	99.5	115.6
2–10 mm	57.5	58.3	88.7	101.6
Total	128.2	162.2	188.2	217.2
Turnover	0.5	0.6	0.5	0.6
Field layer vegetation				
<2 mm	26.0	38.1	30.3	110.5
2–10 mm	43.3	87.4	27.7	91.7
Total	69.3	125.5	58.0	202.2
Turnover	0.6	1.1	0.4	1.3
Total root production	197.5	287.7	246.2	419.4
Total root turnover	0.5	0.7	0.5	0.8

Root fraction	VSN Method I	VSN Method II	VSR Method I	VSR Method II
Case 2 — Significant fluctuations				
Pine				
<2 mm	70.7	95.0	99.5	99.5
2–10 mm	0.0	0.0	0.0	0.0
Total	70.7	95.0	99.5	99.5
Turnover	0.2	0.3	0.3	0.3
Field layer vegetation				
<2 mm	0.0	35.5	0.0	78.9
2–10 mm	0.0	47.1	0.0	64.0
Total	0.0	82.6	0.0	142.9
Turnover	0.0	0.7	0.0	0.9
Total root production	70.7	177.6	99.5	242.4
Total root turnover	0.2	0.4	0.2	0.6

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