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# Root Production And Turnover In *Populus* Grown Under Elevated $CO_2$ Using A Free Air Enrichment System POPFACE.

M. Lukac, C. Calfapietra and D. L. Godbold

*Key words:* root, *Populus*, auger, ingrowth core, elevated $CO_2$, POPFACE

## Abstract

Rising levels of atmospheric $CO_2$ may change root production, root turnover and ecosystem carbon balance. In order to quantify these possible alterations over longer time period and at an ecosystem level a novel technique of air $CO_2$ enrichment was applied to a plantation of three fast growing *Populus* species. Root production and turnover were measured both by auger and ingrowth coring methods. Two years into the experiment both methods applied show increased production of fine and coarse roots under elevated $CO_2$ conditions for all three clones utilised. These results suggest that future levels of atmospheric $CO_2$ will have to be taken into account when constructing a carbon budget of an ecosystem.

## Introduction

With rising level of atmospheric $CO_2$ and its potentially large effect on green plants (Tingley *et al.*, 2000) many questions concerning ecosystems' response remain unanswered. When considering the capacity of plants to sequester carbon the key components determining the fate of assimilated carbon may remain unseen – the belowground systems of roots (Norby and Jackson, 2000). A number of studies have evaluated the effect elevated $CO_2$ has on root growth (Ceulemans and Mousseau, 1994; Taylor *et al.* 1994; Godbold *et al.*, 1997; Rogers *et al.* 1999). Their findings indicate that elevated atmospheric $CO_2$ leads to increased biomass production accompanied by greater proportion of C allocated belowground. However, majority of published studies report on experiments carried out with seedling in greenhouses or growth chambers. Extrapolating these finding to an ecosystem level is of limited value.

POPFACE experiment (for more detail see Miglietta *et al.* 2001) aims at assessing the response of whole ecosystem to elevated $CO_2$. Commercial *Populus* plantation was exposed to ambient and elevated atmospheric $CO_2$ conditions for 3 years.

The objective of this paper is to report on the belowground response of *Populus* trees in the first 2 years of the experiment. In particular, findings on root production and root turnover are discussed.

## Materials and methods

Three *Populus* species: *P.alba, P.nigra* and *P.euramericana* (I-214) were chosen for this experiment because of their fast growth facilitating early canopy closure. Sampling was carried out in 6 plots evenly spaced within 9 ha of I-214 plantation located in Central Italy (42°37' N, 11°51'E). Each circular plot of 20m in diameter was divided into 3 sections occupied by plants of single species planted at 1m x 1m spacing. Elevated (550ppm) $CO_2$ concentration in 3 of the plots was provided by a novel Free Air Carbon Enrichment (FACE) technique. Remaining 3 plots were used as controls with ambient air CO2 concentration.

All trees were planted in early June 1999, roots sampling campaigns were carried out in November 1999, March, July and November 2000. Standing root biomass was measured by auger method with 7 cm core diameter at 2 depths: 0-20cm and 20-40cm. Fine root production estimate was obtained by use of ingrowth cores (4cm diam., 40cm depth) wrapped in nylon mesh with 1mm openings. Both types of cores were manually washed on site shortly after extraction, roots were collected in paper bags, dried at 60C for 7 days and weighed.

## Results and Discussion

Along with other studies (Rogers *et al.* 1994, Berntson and Bazzaz, 1996) we observed an enhancement of root growth under elevated CO2 conditions. All 3 clones showed greater total root biomass in FACE plots in top 40 cm of soil. Increase of root biomass was 28% for *P.alba*, 89% for *P.nigra* and 80% for *P.euramericana* on average over all sampling points.

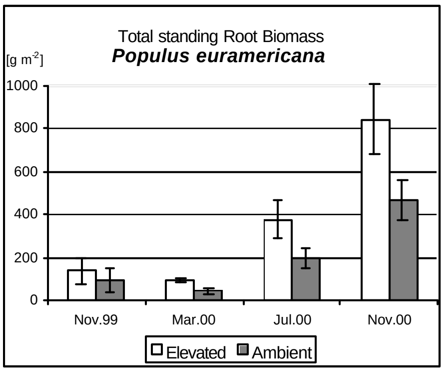


*Figure 1.* Total root biomass of *P.euramericana*

Enhanced growth of *Populus* root biomass was already detectable when the first sampling was carried out in Nov 99 as Figure 1 illustrates for *P.euramericana*. However, statistically significant difference between ambient and elevated CO2 treatments was observed only for *P.nigra* in Jul 00 (**) and Nov 00 (*) and for *P.euramericana* in Nov 00 (*).

Analysis of vertical distribution of roots showed increased allocation of biomass into deeper soil horizon (20-40cm) under elevated $CO_2$ conditions for *P.alba* and *P.nigra*, from 23% to 36% and from 20% to 39% respectively. Ratio of deeper horizon biomass over total measured (0-40cm) for *P.euramericana* (37%) did not change with $CO_2$ treatment.

Ingrowth core measurement showed a corresponding increase of fine root production. Elevated $CO_2$ treatment enhanced fine root growth of *P.alba* by 56%, *P.nigra* by 97% and *P.euramericana* by 73%. Similarly to total root biomass, statistically significant difference between the treatments was observed only for some of the measurements. Pattern of relatively greater investment into roots grown in FACE plots is again visible from the onset of the experiment (Figure 2 for *P.euramericana*).

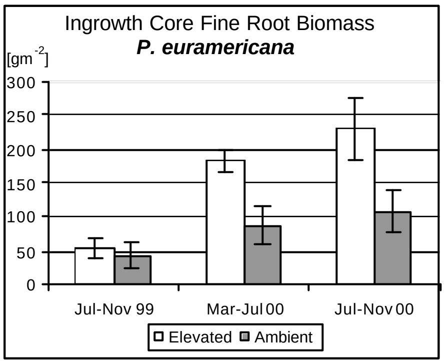


*Figure 2.* Ingrowth Core Fine Root Biomass

Annual fine root production data can be utilised for estimating root turnover when compared to maximum standing crop (Gill and Jackson, 2000). Calculated root turnover of more than $2yr^{-1}$ for all 3 clones is probably an overestimation caused by ingrowth coring method utilised. Even though, a relative comparison of FACE versus control is still valid. This indicates faster fine root turnover under elevated $CO_2$ conditions by 53%, 23% and 84% respectively for *P.alba*, *P.nigra* and *P.euramericana*.

Given such an early stage in the development of this plantation, uneven spatial distribution of roots might explain high variability between the measurements. Despite this drawback, results presented in this report are in line with widely accepted fact that elevated air $CO_2$ conditions lead to greater belowground biomass investment.

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