Root demography of asparagus

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New Zealand Asparagus Council

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Mana Kai Rangahau

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1 EXECUTIVE SUMMARY

- The objective of project 1994/12 is to quantify the annual and seasonal turnover of structural and fine roots of asparagus. The distribution of root ages in a crop affects the crop's responses to stresses and to inputs such as fertilisers. Root turnover can be very fast in some species, but no data are available for asparagus. This work underpins applied research on asparagus management. It is a long-term project that is closely linked to Attempts to model the growth of the crop.

- Root growth and death are monitored weekly, using an underground observatory (rhizotron) located near Hastings.

- Growth into the subsoil was very rapid. Within one year of establishment there were roots at 100 cm depth.

- There was little root growth until early spring. Fine roots did not grow upwards from the crowns until mid-summer, and there were few roots in the top 15 cm soil before then. This suggests that unless there is heavy rainfall and the fertilisers are very soluble, fertiliser applications during spring and early summer may not be very effective. More research is needed on the interactions between fertiliser timing and effectiveness.

- There was a decrease in structural roots in spring. Protracted harvesting periods could reinforce this trend and have a substantial detrimental effect on fine root numbers later in the season.

2 INTRODUCTION

In asparagus, structural roots store nutrients needed for the future growth of spears and fine roots. The fine roots are responsible for most of the water and nutrient uptake, and their ability to do this changes with age. The distribution of root ages in a crop influences the crop's responses to stresses and to inputs such as fertilisers.

Information on the patterns of growth and death of asparagus roots is potentially very valuable. For example, it should allow the identification of strengths and weaknesses in the growth physiology of asparagus on which to focus further research on plant breeding and crop management. Furthermore, if there are clear seasonal variations in root activity within the topsoil, then more efficient means of using fertilisers could be devised. Unfortunately, technical difficulties in studying roots have caused crop scientists to concentrate mainly on above-ground processes. Relatively little is known about the production and longevity of asparagus roots.

New technology (especially borescopes and video cameras) has meant it is easier to study roots in the field. Recent experiments using this technology on other crops have shown that fine root systems can be much more dynamic than previously thought. An underground observatory (rhizotron) constructed in Hawke's Bay is the only one in the Southern Hemisphere. The rhizotron and associated equipment allow precise, non-destructive measurements of root systems throughout the year. The rhizotron has been used in this project.

The objective of this project (1994/12) is to quantify the annual and seasonal turnover of structural and fine roots of asparagus. The approach used is demographic, viewing root systems mainly as populations. The approach allows a direct measurement of the ages of roots, and quantification of their turnover rates. Root lengths can also be calculated from the data, as needed. The project is closely linked to attempts to model the growth of the crop (Project 1994/16).

3 METHODS

The project is intended to run over at least two years. This length of time is essential for a study of the annual and seasonal variations in root activity.

The experiment is situated at the Hawke's Bay rhizotron near Hastings. The rhizotron is basically a rectangular pit, 15 m long by 2 m wide x 2 m deep. It has reinforced, clear plastic walls. The walls are insulated; an insulated roof rises to only 5 cm above ground level. The rhizotron is divided into 24 compartments (12 each side). Each compartment is about 1.2 m wide, and contains a planting bed 2 m long arranged at 90° to the rhizotron wall. The soil is a Mangateretere silt loam.

Crowns of Jersey Giant were planted in three rhizotron compartments in September 1993. Planting depth was 15 cm. The plants established well. About 25% of the plants proved to be female: they were not weeded out. Spears were not harvested in this first year of the experiment. So far, detailed measurements have been made on roots in two of the compartments.

Two complementary techniques are used. First, roots behind the clear plastic windows are traced using clear acetate sheets (A4) and coloured pens. The soil depth ranges measured are 6-36, 49-79, and 93-123 cm. These tracings are used to calculate the life expectancies of individual roots at different times of the year. Originally it was also intended to measure root lengths on these tracings, but the time requirements and costs of computerised image analysis were too great. More efficient methods of analysis are still being devised.

Second, roots in the bulk soil are measured using perspex tubes ('minirhizotrons') that penetrate 1 m horizontally into the soil behind the rhizotron windows. The minirhizotron tubes were installed carefully to avoid disturbing the soil around them. There are three minirhizotron tubes in each compartment (at depths of 18, 61 and 105 cm). On the outside of each tube are three longitudinal lines with cross lines at 5 cm intervals. The number and condition of roots that cross the longitudinal lines between each cross line are counted using a borescope fitted with a video camera. Roots are classified as brown or white, fine or structural (>3 mm diameter). Root measurements are made weekly. The numbers of live spears or shoots above the soil surface are also counted.

4 RESULTS TO DATE

The minirhizotron results are summarised in Fig. 1. Fig. 2 gives an impression of the growth behind a rhizotron window.

(1) Total numbers of roots (all depths)

So far there have been three distinct phases (Fig. 1a):

- there was little net change in the root population from late winter until mid-spring, then
- the number of fine roots increased, and in structural roots decreased until late spring (November), then
- the number of both fine and structural roots increased rapidly at least until late autumn (May).

The amount of root death over winter is not yet known.

(2) Variations down the soil profile

Root growth and death has varied greatly with soil depth (Fig. 1b,c,d).

- Growth into the subsoil was very rapid. Within one year there were fine roots at 100 cm depth.
- Very few structural roots grew and remained below about 50 cm.
- Soil depth affected the timing of the peaks and troughs in the numbers of structural roots.
- Growth upwards from the crowns was slow until January 1995 (Fig. 2).

4.1 Implications of results so far

- Unless there is heavy rainfall and the fertilisers are very soluble, fertilisers applied during spring and early summer may not be very effective because until mid-summer there are only a few roots in the top 15 cm of soil. More research is needed on the interactions between fertiliser timing and effectiveness.
- The decrease in the number of structural roots in spring suggests that protracted harvesting periods could have a substantial detrimental effect on fine root numbers later in the season. Structural roots of course act as the source of subsequent fine root growth.

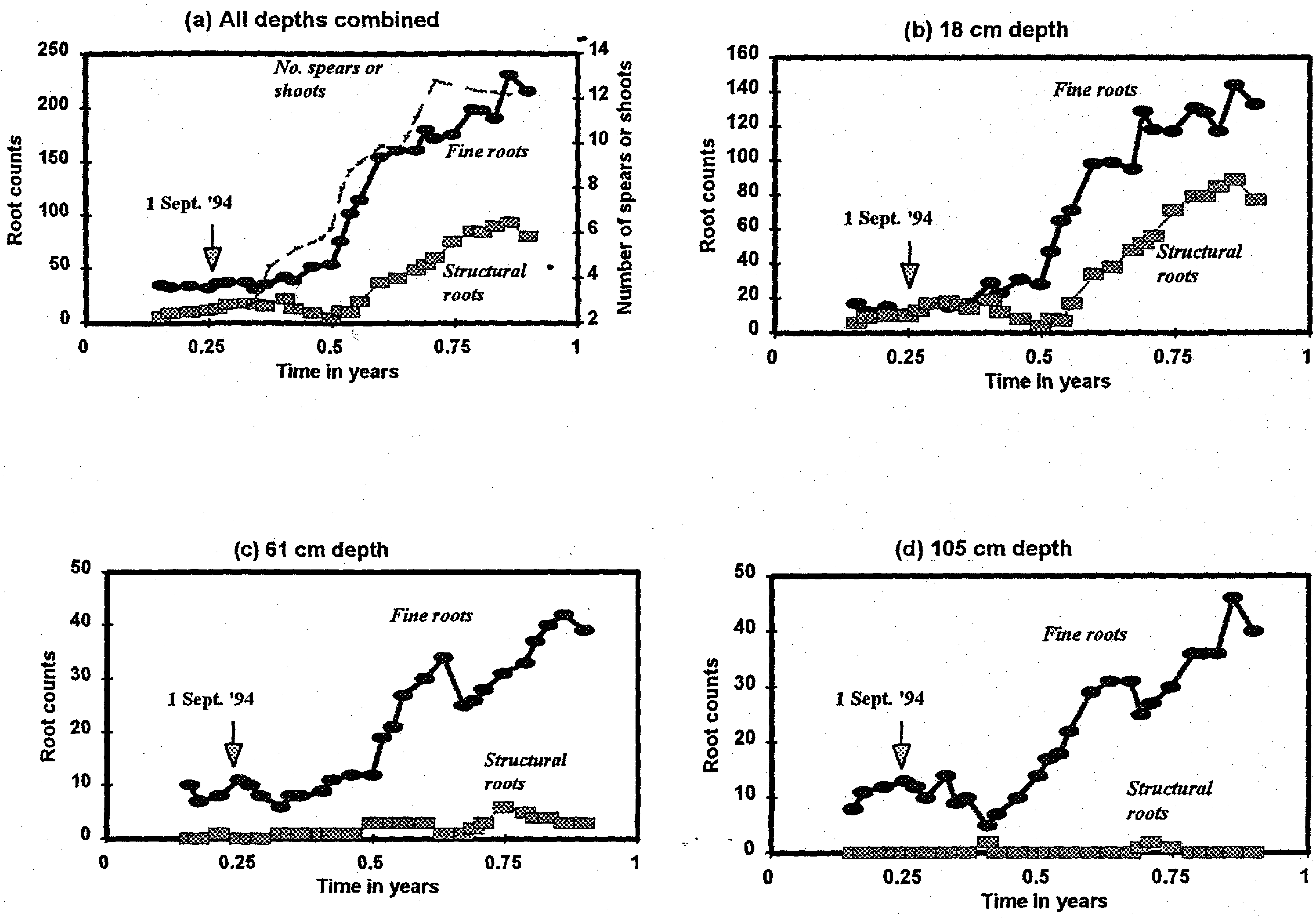

Figure 1: Numbers of roots counted with the minirhizotrons. Note that (a) also shows the number of spears or shoots per plant. The time is given in years from 1 June 1994 - one division (0.25 of a year) corresponds to a season (e.g., spring).

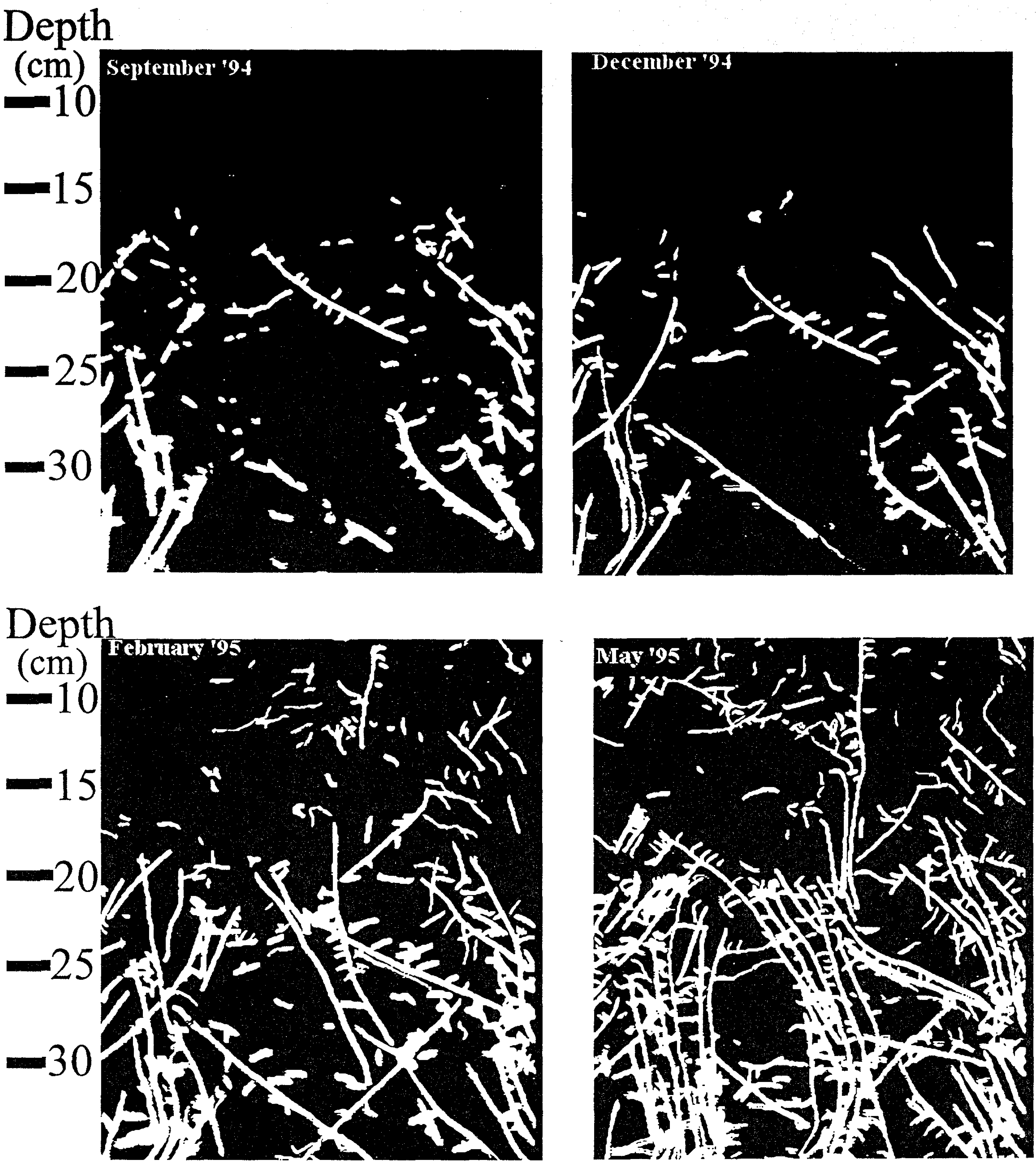

Figure 2: Images of roots present behind one rhizotron window at four dates. Each image was taken in the first week of the month shown. Note that the growth upwards from crown depth (about 15 cm) occurred from early January 1995.

5 WORK IN PROGRESS

- Determining whether the life expectancy of fine roots and structural roots varies with time of year and environmental conditions.
- Examining the proportion of fine roots that develop into structural roots at different times of the year.
- Identifying any interaction between harvesting regimes, fine-root growth, and death (next season).

6 ACKNOWLEDGEMENTS

We thank Graham Mackisack for assistance in constructing the rhizotron.