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Root demography of asparagus

A report prepared for the

New Zealand Asparagus Council

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CROP & FOOD RESEARCH
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1 EXECUTIVE SUMMARY

1. The objective of this project is to quantify the annual and seasonal turnover of structural and fine roots of asparagus.

2. The distribution of root ages in a crop affects its responses to stresses and to inputs like fertilisers. In other species, root turnover can be very fast. But no data are available for asparagus.

3. 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.

4. Root growth and death are monitored weekly using an underground observatory (rhizotron) located near Hastings. In 1995/96 we monitored intensively two plots of cv. Jersey Giant that had been planted in September 1993. One plot was unharvested, and the other was harvested from 26 September to 21 November 1995. We also commenced a detailed analysis of data accumulated on both plots since August 1994.

5. There was little *net* change in the root population during winter and early spring. The number of roots increased rapidly in late spring and early summer, and then decreased in autumn.

6. However, root numbers fluctuated greatly over intervals of two-four weeks, and, irrespective of the time of year there were always some roots growing and some dying in the soil profile. Unlike shoots, the asparagus root system did not have a dormant period during winter.

7. There was considerable turnover of fine roots. Over a one-year period, half of the fine roots survived for 28 days or less. Thicker, structural roots survived longer - half of them survived for 49 days. The annual turnover rates for the fine roots are the largest ever reported.

8. Preliminary results suggest that spear harvesting can substantially depress fine root populations later in the season, although this result needs to be checked in other seasons.

2 INTRODUCTION

In asparagus, structural roots bear the responsibility for storing nutrients needed for future growth of spears and fine roots. Although the fine roots may be only a few percent of the total dry mass of the crop, they are responsible for most of the water and nutrient uptake. The distribution of root ages in a crop influences the crop's responses to stresses and to inputs like fertilisers.

This project was developed on the premise that information on the patterns of growth and death of asparagus roots should enable us to identify strengths and weaknesses in the crop's growth physiology that we can address in further research on plant breeding and crop management. Furthermore, if there are clear seasonal variations in the activity of roots within the topsoil, then we could devise more efficient means of using fertilisers.

Unfortunately, very little is known about the production and longevity of asparagus roots. Recent experiments on other crops have shown that fine root systems can be much more dynamic than previously thought. In Hawke's Bay, we have constructed an underground observatory (rhizotron) that enables us to make precise, non-destructive measurements of root systems throughout the year. We have made use of the rhizotron in this project.

The objective of this project is to quantify the annual and seasonal turnover of structural and fine roots of asparagus in order to identify strengths and weaknesses in asparagus growth physiology that we can address in further research on plant breeding and crop management. It should also enable us to develop more efficient means of using fertilisers. We have taken a demographic approach - looking at root systems mainly as populations. Our approach enables us to look directly at the ages of roots and quantify their turnover rates. Information on root lengths can also be calculated from our data as needed.

This is a long-term project that commenced in August 1995. Here we report on results obtained in year two of the project. Results from year one were reported in June 1995. An overview of both years was provided at the New Zealand Asparagus Council's Research Seminar, Christchurch, 22 May 1996.

3 METHODS

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

In September 1993 we planted crowns of Jersey Giant in three rhizotron compartments. Planting depth was 15 cm. The plants established well. About 25% of the plants proved to be female - these were not weeded out. In this first year of the experiment we did not harvest spears. So far we have made detailed measurements on roots in two of the compartments. One compartment has never been harvested. Spears were harvested from the other compartment from 26 September to 21 November 1995.

We are using two complementary techniques to measure roots.

First, we make tracings of the roots present behind the clear plastic windows, using clear acetate sheets (A4) and coloured pens. The soil depth ranges we measure are 6-36, 49-79, and 93-123 cm. We are using these tracings to provide a simple means of identifying patterns in root growth down the soil profile.

Second, we measure roots in the bulk soil using perspex tubes ('minirhizotrons') that penetrate 1 m horizontally back into the soil behind the rhizotron windows. The minirhizotron tubes were carefully installed to avoid disturbing the soil around them. In each compartment there are three minirhizotron tubes (at 18, 61 and 105 cm depths). On the outside of each tube are three longitudinal lines with cross lines at 5 cm intervals. We count the number and condition of roots that cross the longitudinal lines between each cross line. To do this we use a borescope fitted with a video camera. We classify roots as brown or white, fine or structural (>3 mm diameter). We also use the minirhizotron data to measure the life-spans of individual roots.

Root measurements are made weekly. We also count the number of live spears or shoots above the soil surface.

4 RESULTS TO DATE

1. There was little *net* change in the size of the root population during winter and early-spring (Fig. 1). The population grew quickly in late spring and early summer, and decreased in autumn.

2. The size of the fine root population differed between the cut and the uncut crops (Fig. 1). For reasons we do not yet understand, there appeared to be more fine roots, and fewer structural roots, present on the uncut crop compared with the cut crop before the cutting treatment was imposed. After cutting, the difference in fine roots became very large indeed. There were more fine roots in the uncut crops. This result needs to be checked in future seasons. We suggest that the same treatments are imposed for a further year, and then they are swapped so that the previously uncut crops are cut and vice versa.

3. In both compartments the root population fluctuated greatly over intervals of two-four weeks, and irrespective of the time of year, there were always some roots growing and some dying in the soil profile (Fig. 2). Unlike shoots, the asparagus root system did not have a dormant period during winter.

4. There was tremendous turnover of the fine roots. Over a one-year period, before we imposed the harvesting treatments, half of the fine roots survived 28 days or less (Fig. 3). The thicker structural roots survived longer - half of them survived 49 days. The annual turnover rates for the fine roots may be the largest ever reported - total fine root growth per annum was about 3.5 times the maximum net size of the root population.

5. In year one we noticed very little root growth above crown depth until mid-summer. In year two any such effects were much less conspicuous, although data analysis is still proceeding.

6. Clearly, the root system is much more dynamic than previously thought. This implies that it is very sensitive to changes in soil conditions. More research is needed on the interactions between soil conditions (especially temperature and nutrient concentrations) and asparagus root dynamics.

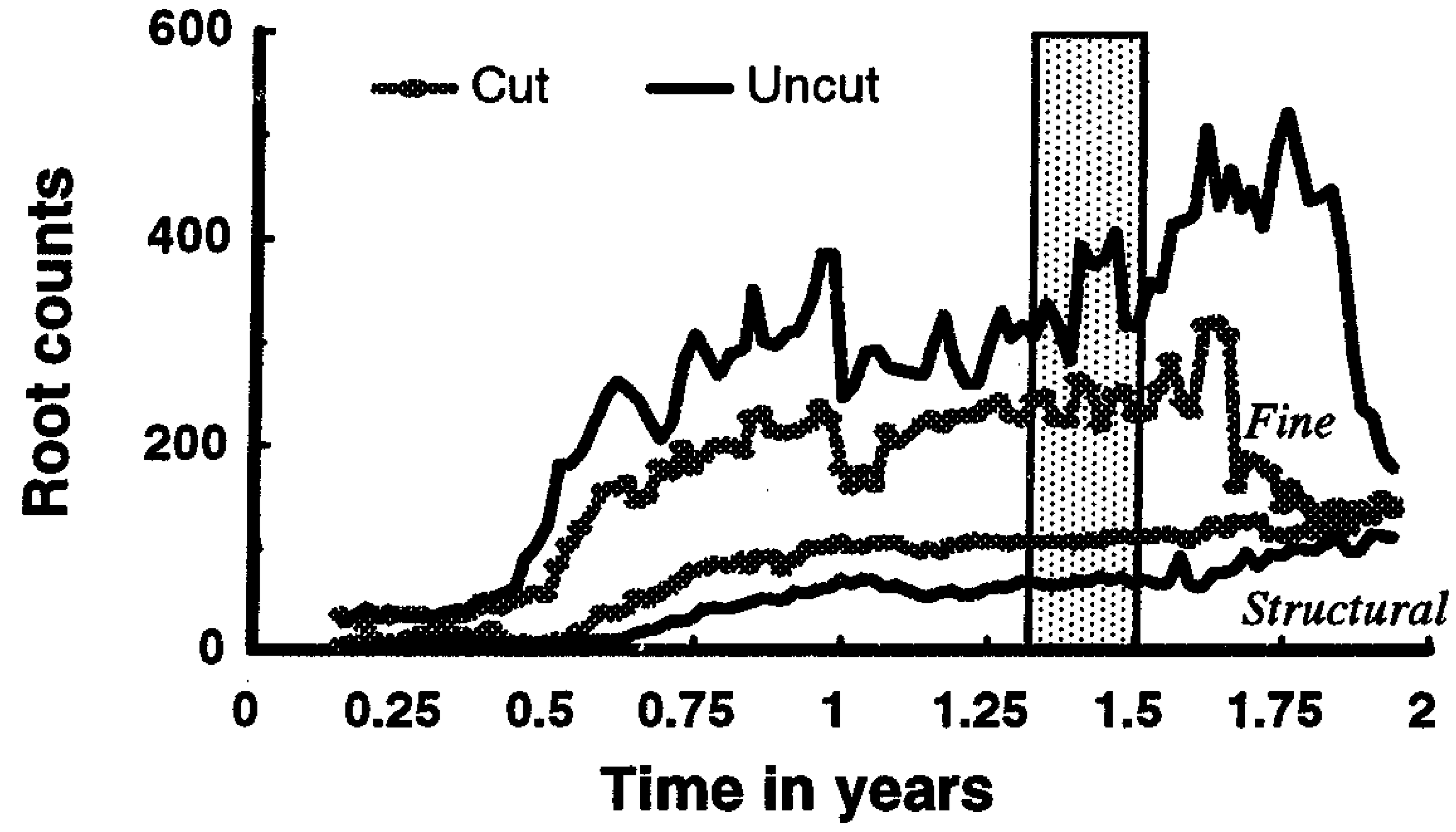

Figure 1 Total numbers of fine and structural roots counted with the minirhizotrons. These are the net populations referred to in the text. Note that the time is given in years from 1June 1994 - one division (0.25 of a year) corresponds to a season (e.g. 0.25 to 0.5 years was spring 1994). The shaded area indicates the period when spears were harvested.

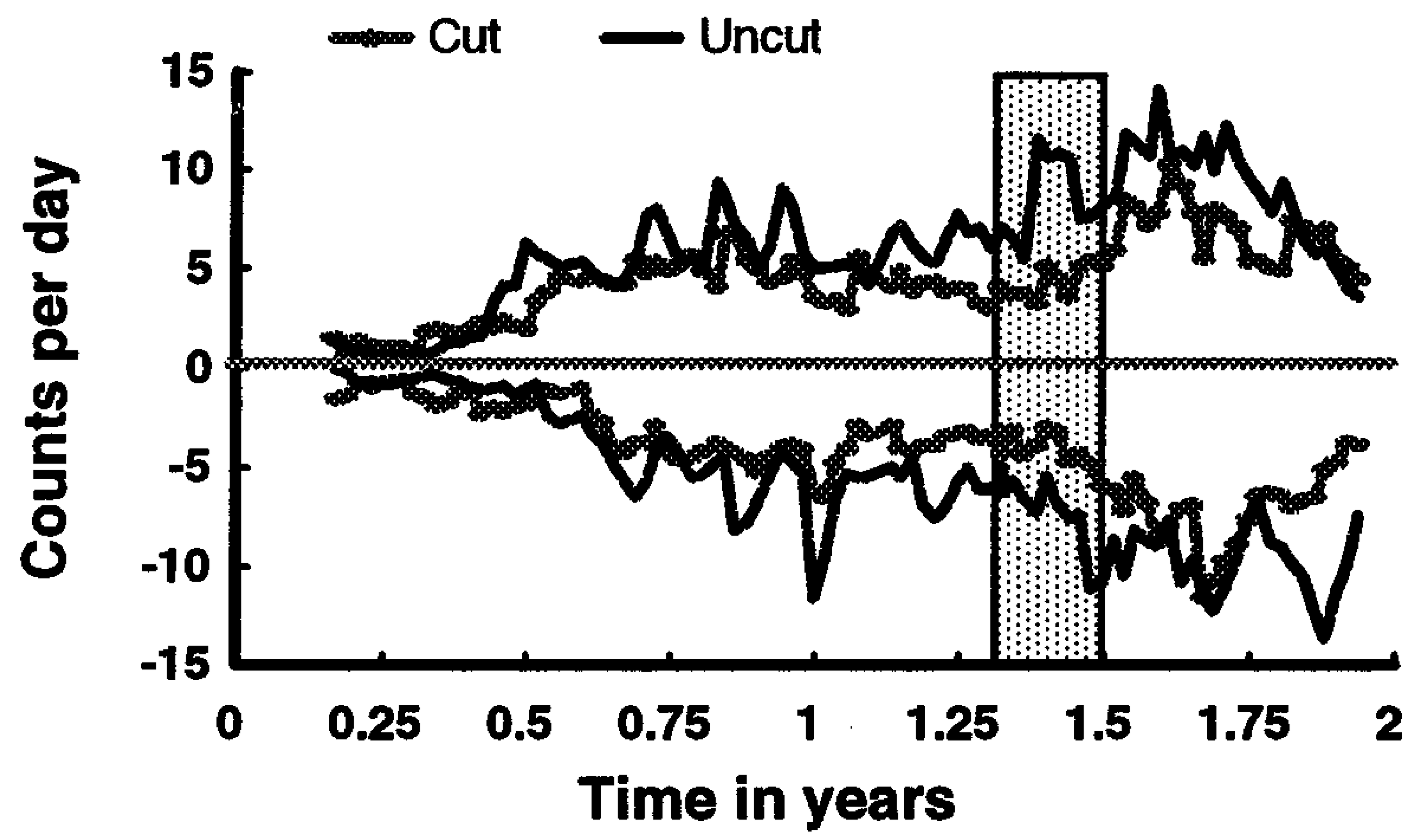

Figure 2 Growth and death rates for the root populations shown in Figure 1. The numbers of fine and structural roots have been combined. Note positive rates (above centre line) are for growth, and negative rates (below centre line) represent death. Legend as for Figure 1.

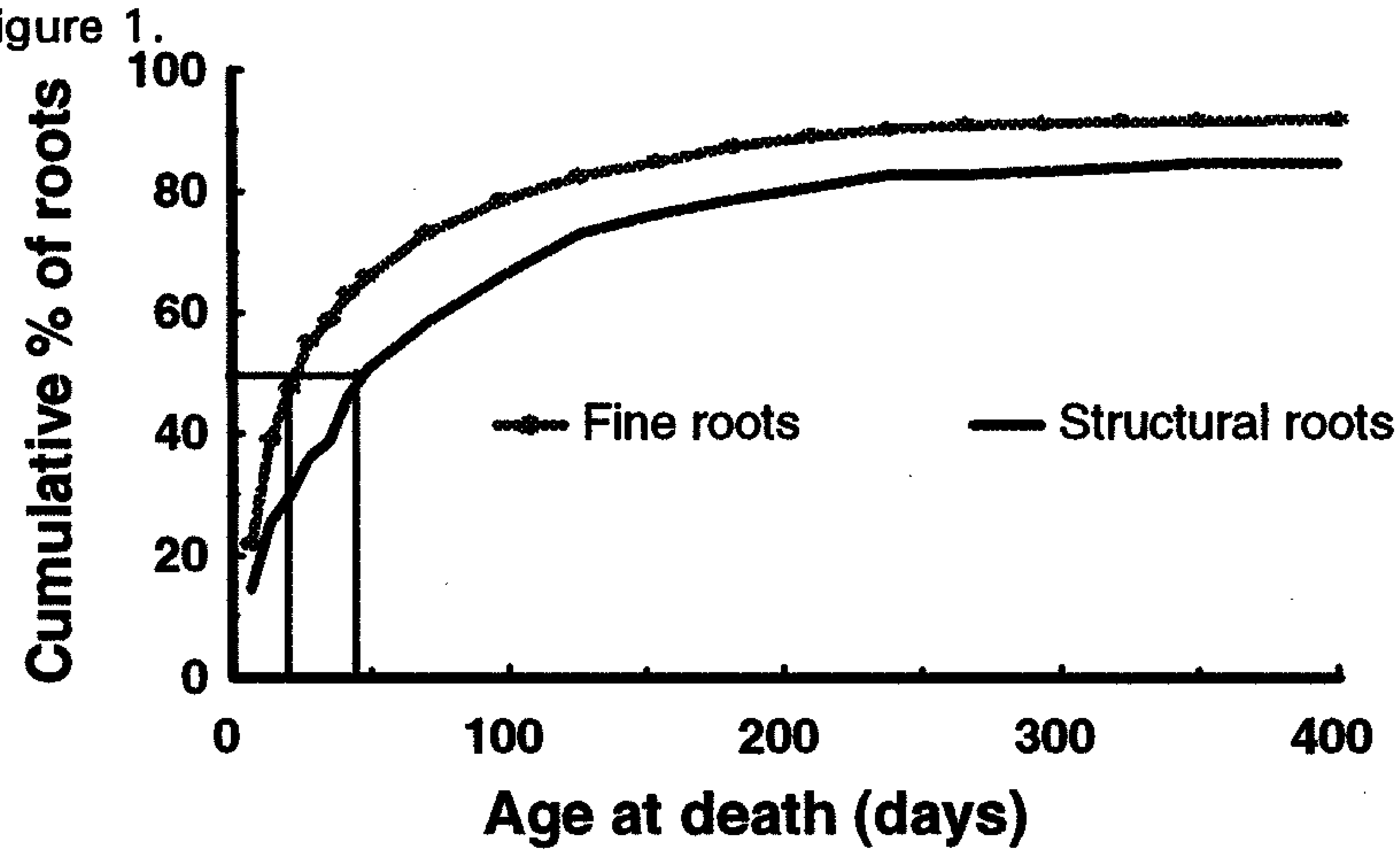

Figure 3 Longevity of fine and structural roots that were first observed on both plots between 31 August 1994 and 31 August 1995 (before the harvesting treatments). Note that 50% of the fine roots died before they reached an age of c. 28 days, whereas 50% of the structural roots died before they were about 49 days old.

5 ONGOING RESEARCH

1. We are still attempting to determine how the life expectancy of fine roots and structural roots varies with the time of year and environmental conditions. This is a massive undertaking - so far we have over half of a million individual observations from the minirhizotrons alone. We have a substantial set of measurements of soil temperature and water potential that needs to be compared to the root population data.

2. Next season we will continue to test how harvesting regimes affect with fine-root growth and death.

6 ACKNOWLEDGEMENTS

We thank Graham Mackisack for assistance in constructing the rhizotron.