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Root demography of asparagus

A report prepared for the

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CROP & FOOD RESEARCH
Mana Kai Rangahau

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1 EXECUTIVE SUMMARY

- 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 cutting management; and to facilitate more efficient use of fertilisers.

- 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 there is very little information 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 were monitored weekly using an underground observatory (rhizotron) located near Hastings. From 1994 to 1997 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 and 10 September to 26 November 1996. We also commenced a detailed analysis of data accumulated on both plots since August 1994.

- Root populations varied a great deal through each season, with most new roots produced in the month or so after harvesting. Only one third of the roots counted were below 20 cm depth.

- There was considerable turnover of the fine roots. On average, new root production was equivalent to 1.35% of the population per day, whereas death was equivalent to 1.3% per day. This implies asparagus is well adapted for fertile soil conditions.

- Our 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.

- Asparagus roots are quite resistant to dry soil conditions - there was no relationship between soil water potential and root growth or death rates.

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2 INTRODUCTION

In asparagus, structural roots bear the responsibility for storing nutrients needed for future growth of spears and fine roots. The fine roots 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.

In Hawke's Bay we have constructed an underground observatory (rhizotron) that is the only one of it's kind in the Southern Hemisphere. The rhizotron and its associated equipment enable us to make precise, non-destructive measurements of root systems throughout the year. We are using the rhizotron in this project.

The project commenced in August 1994, and it is intended to run over at least a further year. This length of time is essential for us to define the annual and seasonal variations in root activity against a background of climatic variations from year to year and increasing age of the crop.

3 METHODS

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, 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 a side). Each compartment is approximately 1.2 m wide, 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 have used two complementary techniques to measure roots.

First, we measured 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 counted the number and condition of roots that cross the longitudinal lines between each cross line. To do this we used a borescope fitted with a video camera. We classify roots as brown or white, fine or structural (>3 mm diameter). We also used the minirhizotron data to measure the life-spans of individual roots.

Second, we made tracings of the roots present behind the clear plastic windows, using clear acetate sheets (A4) and coloured pens. The soil depth ranges we measured were 6-36, 49-79, and 93-123 cm. We used these tracings to provide a simple means of identifying patterns in root growth down the soil profile and to check the patterns measured with the minirhizotrons.

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

4 RESULTS TO DATE

In this report we concentrate on the measurements made using minirhizotrons.

The *net* change in the root population was least in winter and early spring (i.e. the first third of each year). The population grew quickly in late spring and early summer, and decreased in autumn. Only one third of the roots counted were below 20 cm depth.

Generally - but not always - there were fewer roots on the harvested plants compared to the unharvested plants.

Relative growth rate in both the harvested and unharvested plants varied sharply between and within seasons (Figure 2). In both years, the relative growth rate seemed to be decreased by the spear harvest. Irrespective of the time of year, there was always some root growth somewhere in the soil profile. Unlike the shoots, the root system did not have a dormant period.

On average, new root production was equivalent to 1.35% of the population per day.

Relative growth rate was only weakly affected by soil temperature (Figure 3). This was true of both the harvested and unharvested plants. Furthermore, we could see no relationship between relative growth rate and soil water potential (results not shown).

There were marked variations in relative death rates within and between seasons (Figure 4). However, there were no consistent differences between relative death rates on the harvested and unharvested plants. This contrasts to the situation for relative growth rate.

On average, root death was equivalent to about 1.3% of the population per day.

Soil temperature did affect relative death rate (Figure 5). The relationship was not simple, and it is clear that other factors are also influencing the rate of root death. Again though, there was no obvious influence of soil water potential.

The annual rates of root turnover decreased as the crops grew older (Table 1). This is a surprising result, and one that should be checked in the coming season. If confirmed, it has important ramifications for attempts to model the growth of asparagus crops, because it implies a substantial change in the plants "priorities" as plantings mature.

Table 1: Changes in the mean annual rates of root production and death.

	Mean relative growth rate (% per day)[1]	Growth as % of mean population [1]
1994-95	1.9	480
1995-96	1.3	300
1996-97 (to end of April)	0.9	210

[1] mean for both compartments

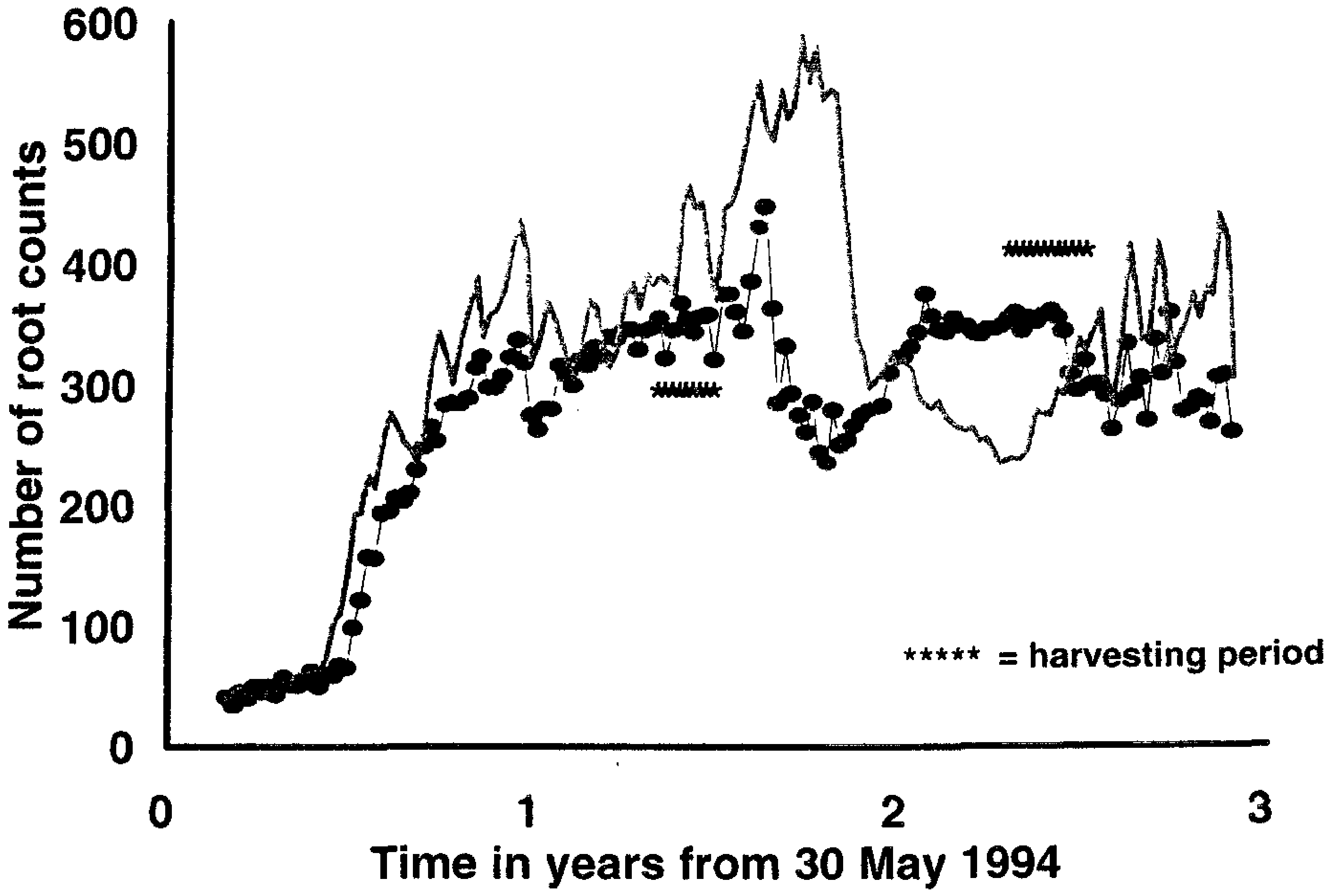

Figure 1: Root counts at 20, 68 and 110 cm depth. Note time is given in years from 1 June 1994 - one division (¼ of a year) corresponds to a season (e.g. 0.25 to 0.5 years was spring 1994). —●— = harvested plants, —— = unharvested plants.

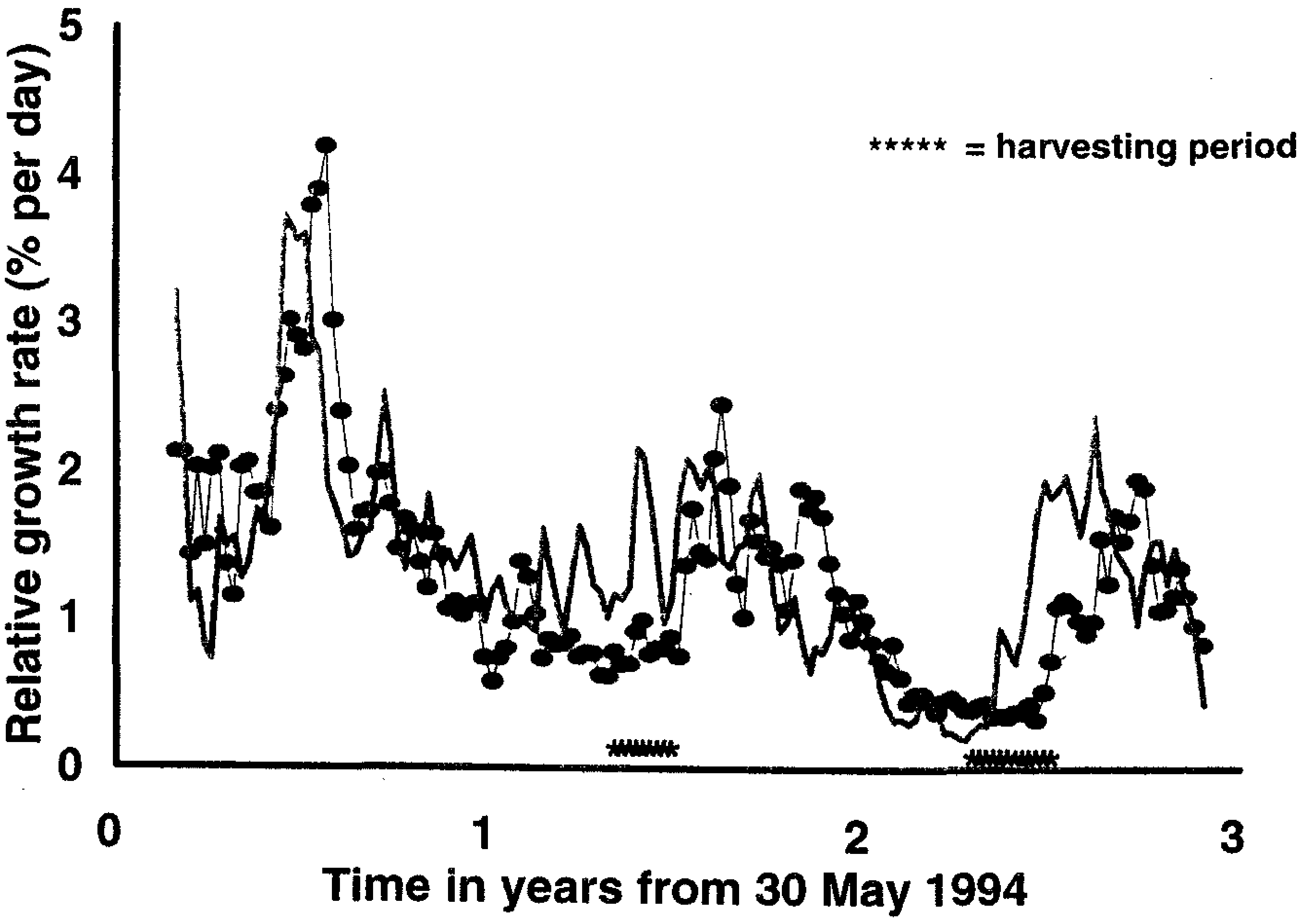

Figure 2: Growth rate of the root population vs time. Note that the results are expressed as a relative growth rate. —●— = harvested plants, —— = unharvested plants.

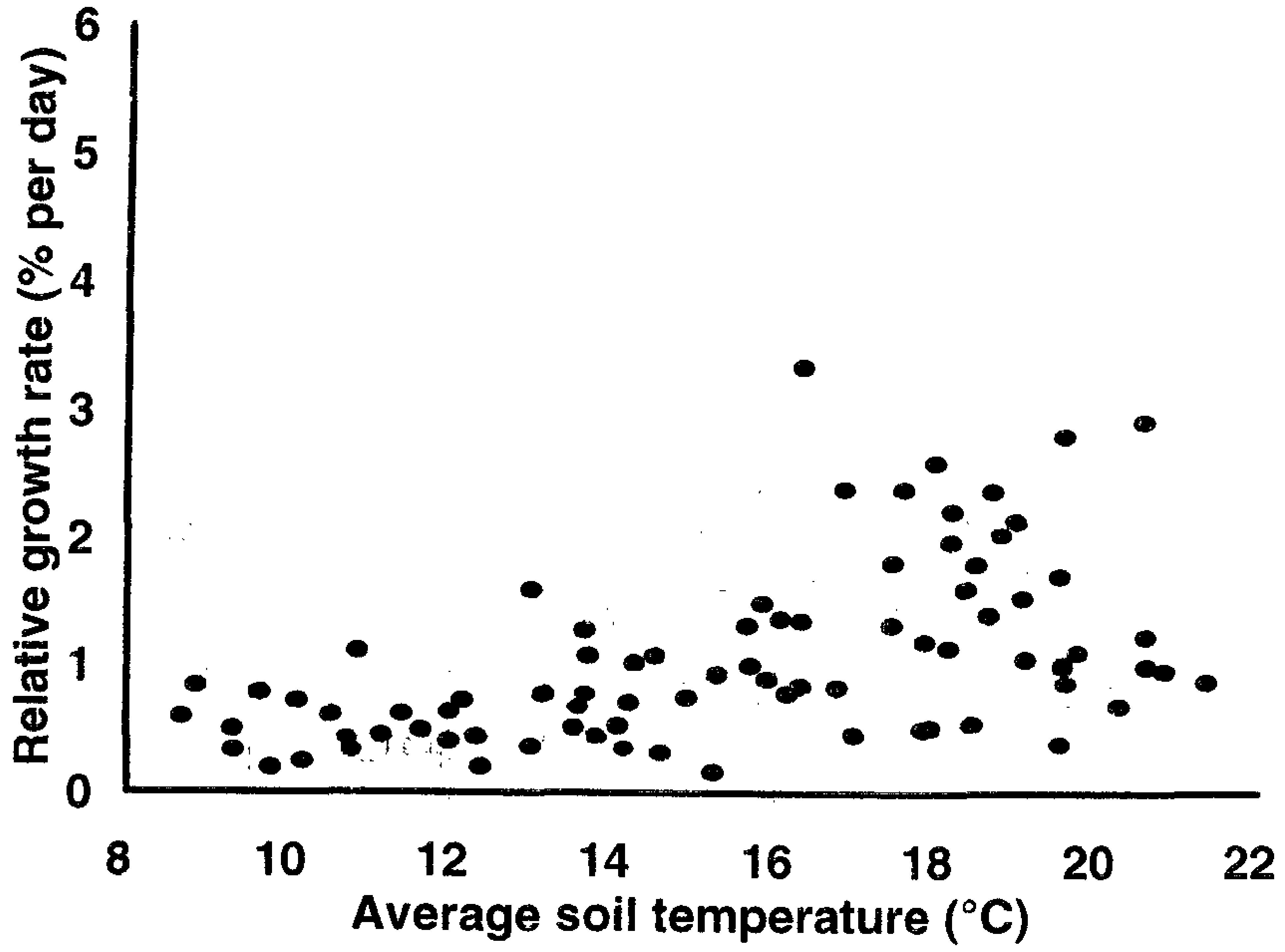

Figure 3: Growth rate of the root population as affected by soil temperature. Note that the results are expressed as a relative growth rate. ● = harvested plants, □ = unharvested plants.

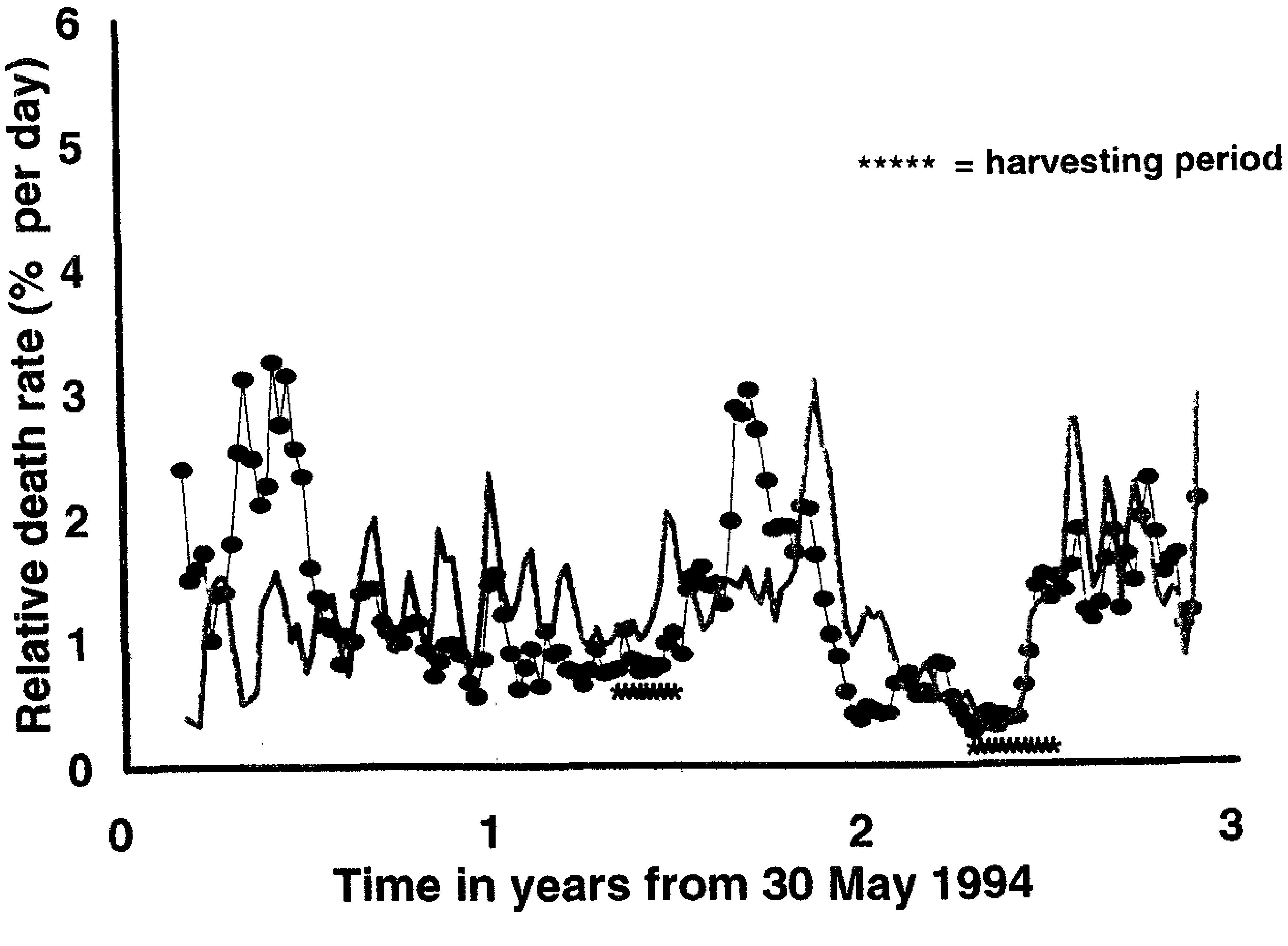

Figure 4: Relative death rate of the root population vs time. —●— = harvested plants, —— unharvested plants

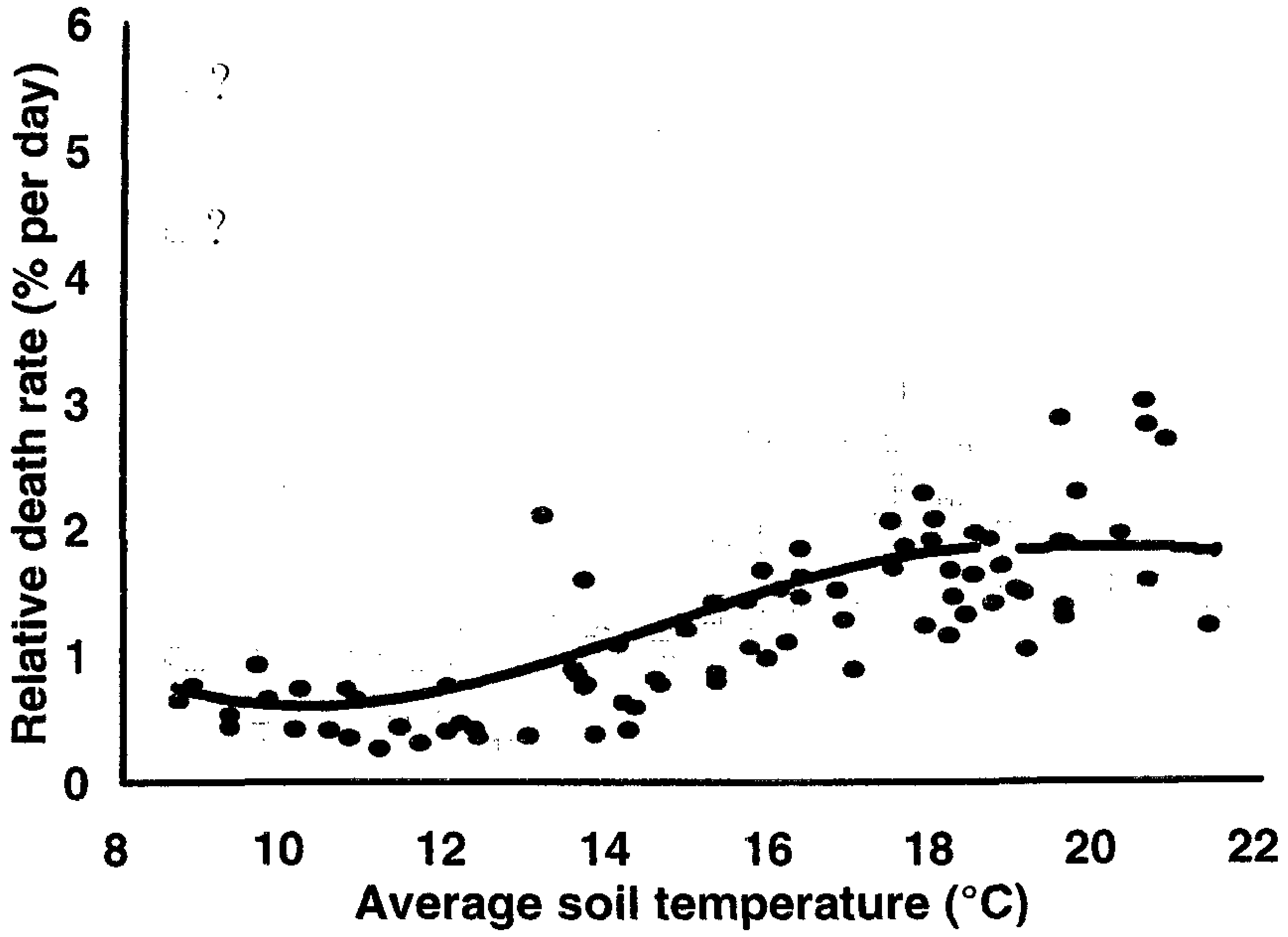

Figure 5: Relative death rate of the population as affected by soil temperature. Note that to date we cannot explain the two outliers marked (?).
—●— = harvested plants, —— unharvested plants.

5 CONCLUSIONS

Root populations vary a great deal through the season, with most new roots produced in the month or so after harvesting. This implies fertilisers will be most effectively taken up by the crop following close up.

The annual turnover rates for the fine roots were among the largest ever reported. This implies asparagus is well adapted for fertile soil conditions.

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.

Asparagus roots are quite resistant to dry soil conditions.

Soil temperature seems to affect root death more than root growth - but other factors may be obscuring any relationship between root growth rate and temperature.

There seems to be substantial changes in the rates of root turnover from week to week. Superimposed on this short-term variability is a gradual, long-term decline in the rate of root turnover.

6 ACKNOWLEDGEMENTS

We thank Graham Mackisack for assistance constructing the rhizotron.