THE POPULATION DYNAMICS OF *HETERODERA TRIFOLII* IN A MANAWATU PASTURE

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ABSTRACT

Changes in numbers of all stages of clover cyst nematode, *Heterodera trifolii*, in white clover roots and in soil were studied in a white clover/ryegrass permanent pasture. Soil samples were taken with a soil corer at fortnightly intervals between March 1999 and March 2001. There were two distinct cycles of *H. trifolii* invasion and development in a year. Distinct peaks in numbers of J2 in soil were seen in late winter and again in late summer, followed by peaks in J2 numbers in roots, possibly reflecting optimum soil temperatures in spring and autumn. The numbers of females peaked 2-4 weeks after those of J2 in roots. No distinct peaks were found in the numbers of new and old cysts. Amounts of clover root in cores were generally higher in autumn and in spring. Numbers of all stages of *H. trifolii* and weights of clover root tended to be lower in 2000 than in 1999.

Keywords: population dynamics, *Heterodera trifolii*, white clover, ryegrass, pasture.

INTRODUCTION

Clover cyst nematode, *Heterodera trifolii* Goffart parasitises clovers throughout New Zealand (Skipp & Christensen 1983; Mercer & Woodfield 1986) causing a general root malfunction and an accompanying depression of nitrogen fixation (Yeates et al. 1977) and foliage growth by white clover (*Trifolium repens*) (Watson et al. 1985; Yeates et al. 1975). Understanding the variation in population densities of plant-parasitic nematodes is one of the key requirements for a control programme. Seasonal variation in plant and soil nematode populations has been correlated with variation in environmental factors such as soil temperature and soil moisture. In New Zealand, Yeates (1973) and Yeates and Risk (1976) reported that there were two generations per year of this nematode in the field. The objective of this study was to monitor stages of a clover cyst nematode (CCN) population throughout the year and to determine population peaks in the Manawatu.

MATERIALS AND METHODS

Soil sampling

Clover cyst nematode population densities were studied at AgResearch Grasslands, Fitzherbert West, Palmerston North, New Zealand, using soil core samples taken fortnightly from March 1999 to March 2001. Four separate samples (85 mm in depth and 45 mm in diameter) were taken at each time, one from each quarter of a paddock of permanent white clover/ryegrass pasture (12.1 x 11.7 m) on Manawatu silt loam soil. At the same time, three soil core samples (75 mm in depth and 25 mm in diameter) were taken randomly from the paddock for gravimetric determination of moisture content. Daily soil temperatures (10 cm depth, 0900 h) were obtained from AgResearch Grasslands, Palmerston North, and fortnightly arithmetic means were calculated.

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Extraction of CCN second stage juveniles (J2)

J2 were extracted from each soil core (approximately 134 ml of soil) in a shallow tray using a method described by Whitehead and Hemming (1965). The extract was examined in a Doncaster dish under a dissecting microscope. Numbers of J2 were recorded and means and standard errors of the four samples expressed as numbers of J2 per 100 ml soil.

Extraction of females and cysts

After extraction of J2, soil from each core was transferred from the tray to an elutriation tower (Wood & Foot 1977). Females and cysts were recovered from the overflow in a 150 µm mesh sieve and emptied into a Doncaster dish. Elongate adults were classed as females and the cysts were sorted into yellowish and brown/black classes, corresponding to new and old cysts respectively using a dissecting microscope. Numbers of each type were recorded and expressed as mean numbers per 100 ml soil.

Staining of the CCN stages in roots

White clover roots were retained in a 1 mm mesh sieve in the overflow from the elutriation tower. They were washed, stained, weighed and held in acidified glycerol for 3 days to remove excess stain in plant tissue (Byrd et al. 1983) before counting J2. Numbers were expressed as mean numbers of J2 per g of wet weight of roots.

All results are expressed as a four assessment running average of the fortnightly assessments to allow a more ready comparison of seasonal population changes.

RESULTS

There were two distinct peaks in numbers of J2 in soil (Fig. 1a). The peak in August/September 1999 was higher, but of shorter duration than that in July/August 2000. Both peaks occurred 12-14 weeks after soil moisture levels had risen in the autumn and when soil temperatures were low and starting to rise (Fig. 2a). A small summer peak (February/March 2000) occurred during the opposite environmental conditions – falling soil moisture levels and high, but falling temperatures.

The peak numbers of J2 in the soil in August/September 1999 (Fig. 1a) were followed by a corresponding increase in numbers of J2 in the root (Fig. 1b) and then by females in the soil (Fig. 1c). There was a considerable loss in numbers of nematodes between the peak of J2 in the soil (1200/100 ml of soil) (Fig. 1a) and that of the females (70-80/100 ml of soil) (Fig. 1c). There were similar, but smaller increases in numbers of J2 in the roots and of females (Figs 1b & 1c) following the peaks of J2 in soil in February/March and July/August 2000 (Fig. 1a).

There were high numbers of both new and old cysts in April/May/June 1999 (Figs 1d & 1e) prior to the peak of J2 in the soil in autumn 1999 (Fig. 1a). However, the subsequent peaks in numbers of females (Fig. 1c) were not reflected by corresponding peaks in cyst numbers (Fig. 1d). Wet weights of roots in samples (Fig. 2b) did not follow the same pattern as that of numbers of cysts (Figs 1d & 1e).

DISCUSSION

A major peak in numbers of CCN J2 in soil was found in the winter of both 1999 and 2000. A smaller peak was found in January-April 2000 but not in early 2001. Yeates and Risk (1976) also found both a spring peak and an autumn peak of J2 in Southland. While the autumn peak was small in 1974, in 1975 it was as large as the spring peak. In the Wairarapa, Yeates (1973) found spring and autumn peaks of approximately equal size. His study covered one autumn only so possible variability in that peak cannot be assessed. Soil moisture levels in the Southland study (Yeates and Risk 1976) were considerably higher than those in the current and Wairarapa studies (Yeates 1973), with all peaks of J2 numbers at soil moisture levels higher than 30%. However, interpretation of soil moisture needs information on wilting point and water holding capacity components. In all three studies the spring increase in numbers commenced while the soil temperatures were below 10°C and the summer/autumn one when the soil

FIGURE 1: Numbers of CCN in roots and soil in a permanent ryegrass/white clover pasture at Palmerston North from May 1999-March 2001 expressed as a four-fortnight running average. (a) Numbers of J2/100 ml soil, (b) Numbers of J2 per g of wet weight of roots. (c) Numbers of females per 100 ml soil. (d) Numbers of new cysts per 100 ml soil. (e) Numbers of old cysts per 100 ml soil. Bars represent $\pm$ SE.

FIGURE 2: (a) Soil moisture (%) and soil temperature (°C). (b) Wet weight of roots (g) per 100 ml soil core. Measurements were made in a permanent ryegrass/white clover pasture at Palmerston North from March 1999-March 2001 and are expressed as a four-fortnight running average.

temperatures were above 15°C. The J2 assessments in the soil by Yeates (1973) and by Yeates and Risk (1976) were presented as a percentage of total soil nematodes in general, whereas in the current study, they are presented as numbers per 100 ml of soil. Nevertheless, there appears to be good agreement between the three studies, and the general pattern of J2 numbers in the soil would appear similar in the three geographically separated areas of the country where the studies took place.

Numbers of J2 in roots followed a similar pattern to the numbers in soil in all three studies with a 1-2 week delay in both the current study and that of Yeates (1973). Whereas Yeates and Risk (1976) showed that in Southland the pattern of female numbers followed that of J2 in roots with a 1-2 week delay, in the current study and that of Yeates (1973), there was a 2-4 week delay. In the studies of Yeates (1973) and Yeates and Risk (1976) there was a clear relationship between the number of females and the subsequent numbers of cysts. In the current study, there were few new cysts in August-November 2000 following a low number of females in April-October 2000 but the large numbers of females in September-December 2000 were not followed by a correspondingly large increase in new cysts. The reason for this is not known but it could be due to large scale predation on the high numbers of females or to the drop in soil moisture levels which could have made the environment unfavourable for females to mature into cysts.

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