THE BIOLOGY OF HETERODERA CAROTAE

BY

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The biology of Heterodera carotae was investigated under laboratory and field conditions in Italy. Juveniles emerged from cysts all the year round and in greatest numbers (37.6-40.6%) at 15-20°C. Egg hatch was also substantial at 5-10°C, but negligible at 25°C. The age of carrot plants affected hatch and most juveniles (67-80.4%) emerged in root leachate from 5-7 week old carrots. Forty six per cent of the eggs from the egg masses were still viable at the end of the summer, but in November only 7% of the eggs in soil were eggs from egg masses. Invasion of carrot roots by juveniles occurred over a range of temperatures from 8 to 20°C, but no nematode development was observed at 8°C. Heterodera carotae required 26 and 36 days to develop females and cysts at 20°C, when 260 and 360 day degrees above 10°C, respectively, had accumulated. Second stage juveniles appeared within egg masses and cysts after an accumulation of 510 and 570 day degrees above 10°C, respectively. Two generations can be completed by the nematode during a carrot growing season and no nematodes invade carrot roots in summer.

Keywords: Carrot cyst nematode, hatching, development, life cycle, Italy.

Since the carrot cyst nematode, Heterodera carotae Jones, was first reported in England (Jones, 1950a), remarkable yield losses have also been observed in other European countries (Oudinet, 1968; Vallotton, 1980). In Italy severe damage by H. carotae is frequently seen in three of the four major carrot (Daucus carota L.) growing areas. Despite this, information on several aspects of the nematode’s biology was poor. Jones (1950b), Ambrogioni (1971), and Vallotton (1983) stated that two generations could be completed by the nematode in England and Italy, and one to four in Switzerland. Winslow (1955) and Greco (1981) found that root exudates of carrot were a prerequisite for the hatch of the eggs contained within cysts. However, information on the hatch of H. carotae as affected by different temperatures, plant age, and time of year was lacking and the effects of temperature and sowing time of carrots on the life cycle of H. carotae had not been elucidated. Investigations have therefore been undertaken since 1972, under laboratory and field conditions, to provide more insight into the biology of this nematode.

MATERIALS AND METHODS

Effects of temperature on hatching. Cysts were extracted with a Fenwick can from wet soil taken at the end of October from a heavily infested field at Margherita di Savoia (Province of Foggia), in which carrot had been harvested.
in February. Batches of 200 cysts were incubated (Greco et al., 1982) for 2 weeks in tap water at 15°C, and then for 8 weeks in root leachate of 2 week old carrots, prepared as described below, at 5, 10, 15, 20 or 25°C ± 1. Cysts were pre-incubated in water because in this period hatch during the first 2 weeks is usually poor. Emerging juveniles were counted and the root leachate renewed weekly. There were five replicates at each temperature. The cysts were crushed at the end of the experiment to estimate the numbers of unhatched eggs remaining and thereby calculate percentage hatch.

**Effects of root leachates from carrots of different ages on hatching.** Twenty 12 cm diam. clay pots were filled with steam sterilized sandy soil, sown with carrot cv. Selection 92, and maintained in a glasshouse at 18-23°C. About 40 plants per pot were allowed to grow. Root leachates were collected by drenching these pots after 3 days and 1, 2, 3, 5 and 7 weeks. Five batches of 200 cysts, extracted from the soil as above, were incubated in each of the root leachates for 10 weeks at 15°C ± 1 to determine percentage hatch. Since hatch in water is poor (Greco, 1981) no water control was used.

**Hatching from cysts collected throughout the year.** Cysts used in this investigation were extracted from soil taken from a heavily infested field at 20 day intervals over a one year period, beginning 16 October 1981. In this field previous carrots had been harvested 8 months earlier. Five batches of 200 cysts each were incubated for 9 weeks in root leachate of 5-7 week old carrots at 15°C ± 1, and percentage hatch estimated.

**Hatching from egg masses collected from field soil.** This experiment was designed to study whether eggs from egg masses remained viable until a new carrot growing season. Five batches of 100 egg masses were collected by processing field soil in September with a Fenwick can. Carrots had been harvested in February from this field. The egg masses were then incubated for 6 weeks at 20°C ± 1 in root leachate of 30 day old carrots to estimate percentage hatch.

**Investigation on the basal development temperature.** The aim of this experiment was to establish basal temperature development for the nematode. Twenty plastic pots containing 170 cm³ of a steam sterilized sandy soil, were sown with carrot cv. Selection 92 in a glasshouse at 20-25°C and thinned after one week to 10 plants per pot. When the seedlings were 2 weeks old, 2,400 second stage juveniles were added to each pot. Four pots were then transferred to each of the five growing cabinets set at 8, 10, 12, 15 and 20°C. Two weeks later the roots of the plants were washed free of soil and comminuted for 30 s in a blender. The water suspension was then diluted to 50 ml and the nematodes in two aliquots of 5 ml each counted and assigned to developmental stages. Any enlarged second stage juveniles were also recorded.

**Investigation of development at 20°C.** The aim of this experiment was to establish the temperature requirements for *H. carotae* in day degrees. Fifty-six plastic pots with 10 plants of 2 week old carrot were inoculated with 3,000 juveniles, and transferred to a growing chamber in which the soil temperature