DAMAGE TO CARROTS BY *ROTYLENCHUS UNIFORMIS*, WITH A DISCUSSION ON THE CAUSE OF INCREASE OF TOLERANCE DURING THE DEVELOPMENT OF THE PLANT

BY

J. W. SEINHORST and JADWIGA KOZŁOWSKA

Institute of Phytopathological Research, Wageningen, the Netherlands, and Institute of Ecology, Warsaw, Poland

The tolerance of carrot to attack by *Rotylenchus uniformis* (Thorne) was about the same at 12° and at 17° to 22°. It increased with increase of the age of the plants, so that tolerance limits (*T*), estimated by fitting curves according to the equation \[ y = m + (1 - m) z^P-T \] (eq. (1)) to the data increased to the threefold value between 4 to 5 weeks after sowing and the end of the experiments (6 to 9 weeks later). Observations on the increase of leaf length suggested that nematode attack reduced the rate of growth of the plants only during a limited period which was probably longer with higher nematode density. Models based on this assumption and on a retardation of the growth of the plants by nematode attack were developed.

The observations on growth and ultimate weights of the plants including those in experiments by Seinhorst & Kuniyasu (1969) were in good accordance with these models. Increase in root density during the development of the plants is considered the cause of the increase in tolerance. Because it is faster at low than at higher nematode densities it causes a deviation from proportionality at low nematode density, of the relation between nematode density and reduction of plant weight, which is expressed in eq. (1) by the use of the term \( z^{P-T} \).

Seinhorst & Kuniyasu (1969) found a much lower tolerance of carrot (*Daucus carota*) to attack by *Rotylenchus uniformis* (Thorne) in an experiment in winter at about 8° than in two experiments in summer at about 18°. Population densities of *R. uniformis* in about half the area of sandy soils in the Netherlands where carrots are grown fairly frequently are within the range that reduced plants weights in the experiment at about 8° in winter (Seinhorst & Kuniyasu, 1969). Therefore it seemed important to investigate whether the low tolerance found in winter was really due to low temperatures or to another phenomenon. To investigate the effect of temperature on the tolerance of carrots to attack by *R. uniformis* experiments were done at 12° and at 17° to 22°. As the results of these experiments did not seem to explain the differences in tolerance at low temperature found by Seinhorst & Kuniyasu (1969), another experiment was done at 12° but with two light intensities, to investigate whether the low tolerance found in winter had been due to lack of light. A temperature below 12° was not available. Neither could differences in daylength be realized. Finally a model of the growth of carrot at different nematode densities was developed to show the relationships between the various observations on the growth and final weights of the plants and nematode density.
Materials and methods

The experiments were done in two growth chambers and in a glass house. One growth chamber was kept at 22° during the sixteen hours per day it was illuminated and at 17° during the remaining eight hours of darkness (further indicated as 17°/22°). The other was kept at 12° continuously and was illuminated during sixteen hours per day. Illumination was by fluorescent tubes producing a light intensity of 15000 lux at 30 cm distance (the tops of the pots). To produce the two light intensities in the second experiment at 12° all the lamps were used in one part of the experiment and only half the lamps in the other part. The glass house was used in August and September. It received daylight only and was kept at about 18°. As the space in the growth chambers was limited the experiments were done with 20 cm long, 2.5 cm wide plastic tubes containing 300 g soil. The sandy soil used had been steam sterilized about six months before use and was mixed with 5% clay powder to improve its moisture holding capacity and fertility.

The nematode population used in the experiment was maintained on cauliflower plants. The nematodes were collected from the soil by elutriation and separated from the small quantity of soil particles in the suspension thus obtained by the (modified) Baermann method (Seinhorst, 1962). Of the clean suspension thus obtained dilution ranges, with densities $a \times 2^x$ were prepared, $x$ being whole numbers 0 to 12. In a first effort these nematode suspensions were sprinkled on the soil, which was mixed a day later and then put in the pots. As this resulted in a great mortality of the nematodes the pots were reinoculated and resown eight weeks after the first sowing. The nematode suspensions were then introduced through a long injection needle. The needle was pushed 10 cm deep into the soil with a wire inside to prevent clogging. Then the wire was pulled out, a syringe with the nematode suspension was mounted on the needle, and the plunger pushed down gently while the syringe was pulled up. In this way nematodes were injected all along the 10 cm long channel left by the needle. Densities found in pots without plants indicated that this inoculation method did not cause great losses of nematodes (Fig. 20). Initial densities in this experiment are considered further to be the sum of the numbers of nematodes introduced by the second inoculation and what remained of the first (20% according to determinations in four pots). Actual densities can be derived from Figs. 3-7. To obtain nematode free controls 30 pots were injected with water removed from the original nematode suspension before the dilution series was made (with the same water).

There were twelve replications per nematode density in the preliminary and the first experiment at 17°/22° (Table I), ten of which were sown to carrots and eighteen replications in the first experiment at 12°, fifteen of which were sown to carrots. In the second experiment at 12° there were 22 pots per density, 20 of which were sown to carrots. Of these 22 pots per density eleven were placed at 15000 lux and eleven at 7500 lux during 6 weeks. Then all pots were placed in a glasshouse at about 18° during another 6 weeks. About fifteen carrot seeds (var. ‘Amsterdamse Bak’) were sown per pot. The number of plants was reduced...