Nematol. medit. (1982), 10: 175-181.

Scottish Crop Research Institute, Invergowrie,
Dundee DD2 5DA, U.K.

# DIFFERENTIAL RESPONSE OF PLANT PARASITIC NEMATODES TO NEMATICIDAL CHEMICALS

by
T. J. W. ALPHEY

Observations from a number of field experiments indicate that soil inhabiting nematodes may differ in their susceptibility to different non-fumigant nematicides. Differences in the level of kill achieved in the field can sometimes be attributed to differences in methods of application or environmental conditions during and following treatment. However, the extent of differences in susceptibility to nematicides in the control of nematodes is uncertain. This work attempts to determine whether different nematode species respond differentially to certain nematicidal chemicals.

## *Materials and Methods*

Soils were collected from four different fields sites in Angus, Scotland. Each soil was selected because it was predominantly infested with one of the following nematodes: *Longidorus elongatus* (de Man) Thorne *et* Swanger, *Rotylenchus robustus* (de Man) Filipjev, *Pratylenchus crenatus* Loof or a mixture of *Trichodorus cylindricus* Hooper and *T. similis* Seinhorst. Each soil was mixed to ensure an even distribution of nematodes and samples taken to assess the initial population densities. The soils were each divided into five aliquots to which the following treatments were applied: aldicarb (Temik, 33.6 kg/ha), benomyl (Benlate, 44.8 kg/ha), oxamyl (Vydate, 56 kg/ha), quintozene (Botrilex, 448 kg/ha) and untreated. Granules were mixed into soil which was used to fill five 22 cm pots and then sown with a rye grass (*Lolium perenne*)/clover (*Trifolium repens*) mixture. All pots were maintained, in a randomised design, in a frost-free glasshouse and watered when necessary. Soil cores were taken with a cheese-corer to give a composite sample of 200 g from each pot at 22 wk, 44 wk and 66 wk after treatment and the nematodes were extracted by a modified wet-sieving and decanting technique. For analysis data were transformed by the expression $\log_e (x + 1)$.

## *Results*

Numbers of nematodes, with the exception of *L. elongatus*, in untreated control soils were decreased within 22 wk, possibly due to starvation or as a result of damage suffered during the initial disturbance and mechanical mixing of the soils. Subsequently the numbers of nematodes in the untreated pots increased (*P. crenatus, R. robustus*, trichodorids), or were at least maintained (*L. elongatus*) (Fig. 1a - d).

The numbers of *P. crenatus* were decreased in comparison to untreated controls by aldicarb and oxamyl 22 wk after treatment and did not increase during the remainder of the experiment. Benomyl had little effect on the numbers of *P. crenatus* and in the quintozene treatment numbers of *P. crenatus* increased considerably between 22 wk and 66 wk (Table I).

In the soil containing trichodorid nematodes the numbers at 22 wk were decreased significantly, in comparison to the controls, only by aldicarb. By 66 wk the numbers of trichodorid nematodes had not increased in the aldicarb treated soil, in comparison to the untreated control, and in quintozene treated soil numbers were also significantly less than those in untreated soil (Table I). The numbers of trichodorid nematodes in the benomyl treated soils increased between 22 wk and 66 wk.

The numbers of *L. elongatus* were initially decreased by all chemical treatments (Table I), but only quintozene maintained control throughout the experiment.

Oxamyl and quintozene had decreased the numbers of *R. robustus* by 22 wk but again only quintozene maintained control for 66 wk.

Analysis of the data showed a significant ($P = 0.001$) interaction between chemicals and nematode species.

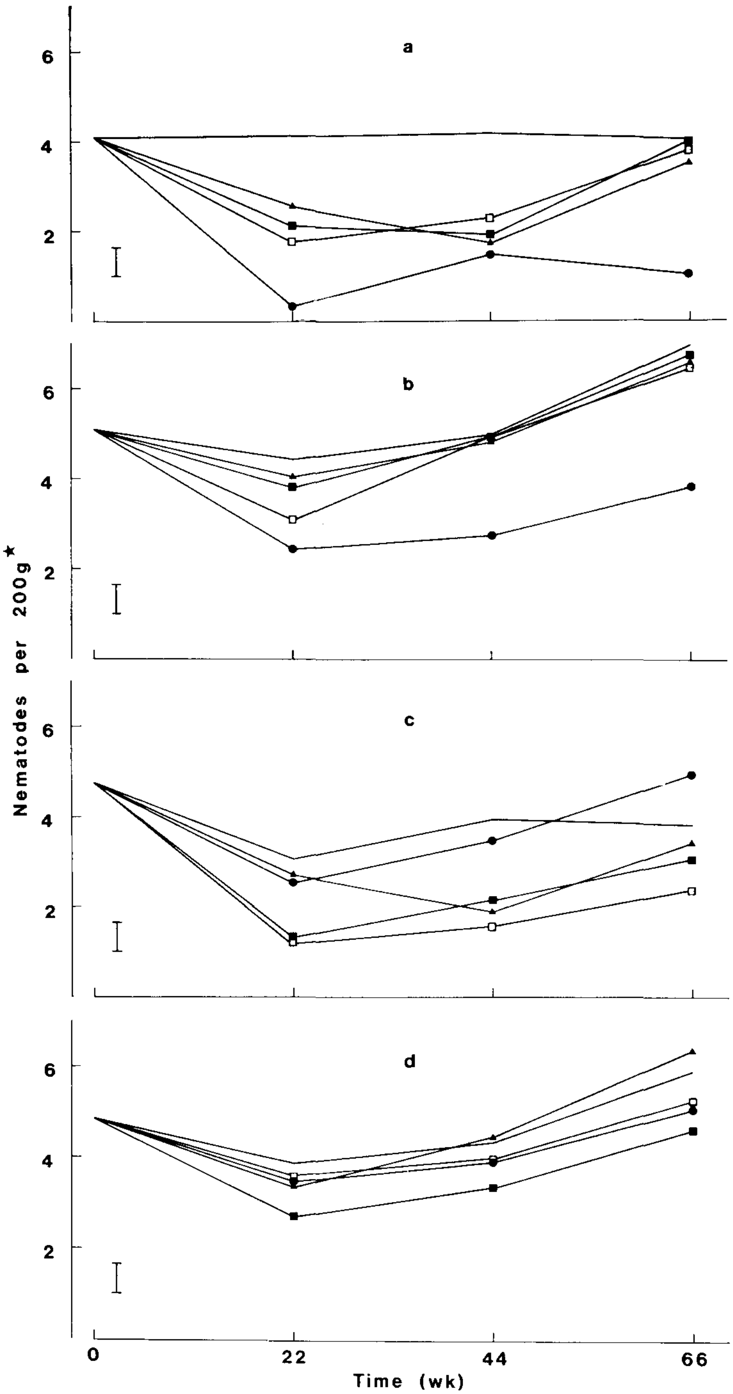


Fig. 1 - Effect of four nematicidal chemicals on population size of (a) *Longidorus elongatus*, (b) *Rotylenchus robustus*, (c) *Pratylenchus crenatus*, and (d) trichodorids (*Trichodorus cylindricus* + *T. similis*). Treatments: ■——■ aldicarb; ▲——▲ benomyl; □——□ oxamyl; ●——● quintozene; —— untreated. Bar represents L.S.D. (P = 0.05).
* Numbers of nematodes per 200 g soil transformed by the expression $\log_e (x+1)$.

Table I - *Percentage change of species with respect to untreated controls by four nematicidal chemicals.*

| | | Percentage change in population | |
|---|---|---|---|
| | | 22 wk | 66 wk |
| *L. elongatus* | aldicarb | −87*** | − 7 |
| | benomyl | −81*** | −45 |
| | oxamyl | −92*** | −24 |
| | quintozene | −98*** | −96*** |
| *R. robustus* | aldicarb | −48 | −27 |
| | benomyl | −33 | −34 |
| | oxamyl | −75*** | −44 |
| | quintozene | −87*** | −96*** |
| *P. crenatus* | aldicarb | −85*** | −51* |
| | benomyl | −30 | −32 |
| | oxamyl | −90*** | −79*** |
| | quintozene | −40 | +223*** |
| Trichodorids | aldicarb | −71*** | −72*** |
| | benomyl | −42 | +51 |
| | oxamyl | −25 | −49 |
| | quintozene | −35 | −56* |

*, **, *** Significantly different from the untreated controls at P = 0.05, 0.01, 0.001 respectively. Significance determined on transformed means.

## *Discussion*

In this pot experiment, under glasshouse conditions, the nematodes studied differed in their susceptibility to the nematicidal chemicals tested. The patterns of control of *L. elongatus* and *R. robustus* were similar but contrasted with that for *P. crenatus* (Fig. 1). The pattern of control of trichodorid nematodes was intermediate.

The numbers of *L. elongatus*, trichodorids and *P. crenatus* 22 wk after treatment were decreased, in comparison to the untreated controls, by the systemic carbamate pesticide aldicarb. However, after 66 wk significant control was found only in the trichodorid and *P. crenatus* soils. Oxamyl, also a carbamate nematicide, initially decreased numbers of all nematodes with the exception of trichodorids, but after 66 wk only numbers of *P. crenatus* were significantly lower than those in the untreated pots. Furthermore, control by the fungicide quintozene also produced a differential effect. Quintozene decreased numbers of *L. elongatus* and *R. robustus* better than either of the nematicides and maintained control throughout the experiment. However, quintozene failed to control *P. crenatus*, the population density of which increased considerably during the period of the experiment.

The differential response both to short persistence carbamate nematicides and to long persistence quintozene indicates that the response is not only due to differences in the life cycles or multiplication rates of the nematodes but to the mode of action of the pesticides. Corbett (1974) has discussed the biochemical mode of action of pesticides. Carbamates act by inhibiting the enzyme acetylcholinesterase, which normally hydrolyses the synaptic transmitter acetyl-choline. This action is reversible and organisms may recover when removed from the toxic environment. Short term control of the virus-vector genera by systemic nematicides is well documented. Trudgill and Alphey (1976) have shown that acquisition and transmission of TBRV by *L. elongatus* was inhibited by oxamyl for less than 19 wk following treatment of the soil and Alphey *et al.* (1975) have shown that aldicarb and oxamyl produce only limited control of numbers of trichodorids. Lack of kill by the carbamate nematicides can be explained by their mode-of-action, the short persistence of the chemicals [less than 14 days in soil (Bromilow, 1973)] and the subsequent recovery of nematodes from initial toxic effects. Differences in the susceptibility of nematodes to carbamates may be due to differences in the sensitivity of various cholinesterases present in the species (Lee and Atkinson, 1976), and the vagaries of uptake, metabolism and compartmentalization of the compounds (Corbett, 1974).

The fungicide quintozene (pentachloronitrobenzene) is thought to act by inhibiting chitin synthesis or breakdown (Corbett, 1974) but the persistence of this action is not known. Chitin is found only in the eggshells of nematodes (Lee and Atkinson, 1976) where it gives rigidity to the structure. Therefore it is probable that quintozene would prevent increase in numbers of nematodes by inhibiting egg production but its mode of action against adult nematodes *per se* is unknown. However, previous work has shown that quintozene can be used effectively as a nematicide against *L. elongatus* (Taylor and Murant, 1965 and 1968; Taylor and Gordon, 1970; Trudgill and Alphey, 1976) decreasing numbers and maintaining control over a period of a year, whereas it was not effective in the control of *Pratylenchus* (Trudgill and Alphey, 1976; Trudgill, 1979).

The differential response identified in this work may be due to differences in the ability of the nematodes to withstand periods without food and other nematicide induced stresses, or the relative dependence of the nematodes on the physiological processes affected by the nematicide.

Corbett (1974) discussed the selective action of insecticides and identified five reasons why a compound may not kill an unsusceptible insect but will kill a susceptible one. The reasons included: behaviour patterns which affect contact with the compound; selectivity of uptake of the compound; storage (or secretion) of the compound in the organism away from the site of action; detoxification of the compound by metabolic processes; and possession of a site of action which is not attacked efficiently by the compound. These reasons could be applied to the control of nematodes by nematicides although it is unlikely that the first could be applied to nematodes which co-inhabit treated soil. However, any one or more of the other reasons may contribute to the differential response recorded in this paper.

I thank Mrs. C. Henderson for assistance with nematode counts.

## SUMMARY

In a replicated pot experiment, soils infested with *Longidorus elongatus*, *Rotylenchus robustus*, *Pratylenchus crenatus* or *Trichodorus cylindricus* with *T. similis*, were treated with aldicarb, oxamyl, benomyl or quintozene. Over a period of 66 wk aldicarb and oxamyl failed to decrease numbers of *L. elongatus* and *R. robustus* but did decrease numbers of *P. crenatus*. However, the fungicide quintozene decreased numbers of *L. elongatus* and *R. robustus* but failed to control *P. crenatus*. Control of trichodorids was intermediate. The differential response of the nematodes is discussed.

## LITERATURE CITED

ALPHEY T. J. W., COOPER J. I. and HARRISON B. D., 1975 - Systemic nematicides for the control of trichodorid nematodes and of potato spraing disease caused by tobacco rattle virus. *Pl. Path., 24*: 117-121.

BROMILOW R. H., 1973 - Breakdown and fate of oximecarbamate nematicides in crops and soils. *Ann. appl. Biol., 75*: 473-479.

CORBETT J. R., 1974 - *The Biochemical Mode of Action of Pesticides*. Academic Press, London. New York: 330 pp.

LEE D. L. and ATKINSON H. J., 1976 - *Physiology of Nematodes*. The MacMillan Press Ltd., London and Basingstoke: 2nd Edition, pp. 215.

TAYLOR C. E. and GORDON S. C., 1970 - A comparison of four nematicides for the control of *Longidorus elongatus* and *Xiphinema diversicaudatum* and the viruses they transmit. *Hort. Res., 10*: 133-141.

TAYLOR C. E. and MURANT A. F., 1965 - The use of quintozene (PCNB) as a nematicide. Proceedings of the Third British Insecticide and Fungicide Conference: 514-520.

TAYLOR C. E. and MURANT A. F., 1968 - Chemical Control of Raspberry Ringspot and Tomato Black Ring Viruses in Strawberry. *Pl. Path., 17*: 171-178.

TRUDGILL D. L., 1979 - Control of *Pratylenchus penetrans* and other replanting disorders in raspberry with dazomet. Proceedings 1979 British Crop Protection Conference - Pests and Diseases. *1*: 211-214.

TRUDGILL D. L. and ALPHEY T. J. W., 1976 - Chemical control of the virus vector nematode *Longidorus elongatus* and of *Pratylenchus crenatus* in raspberry plantations. *Pl. Path., 25*: 15-20.

Accepted for publication on 9 July 1982.