Mode-of-action of the carbamate nematicides cloethocarb, aldicarb and carbofuran on *Heterodera schachtii*. 2. Systemic activity

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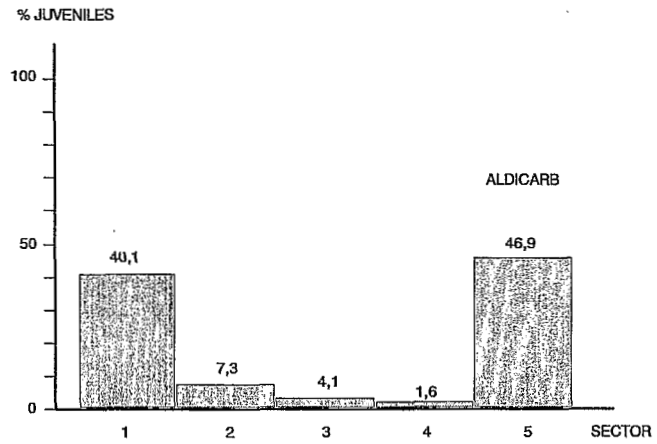
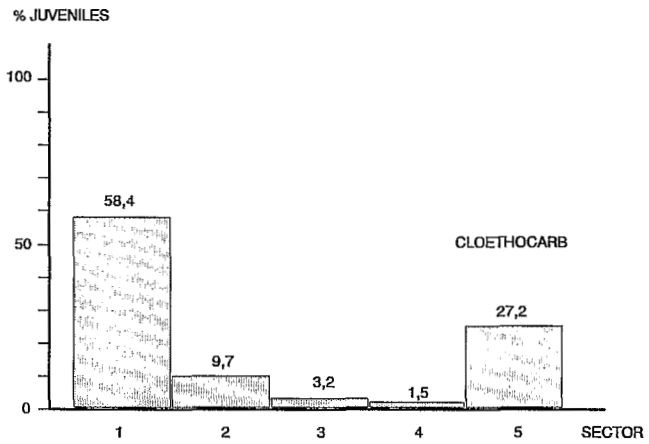
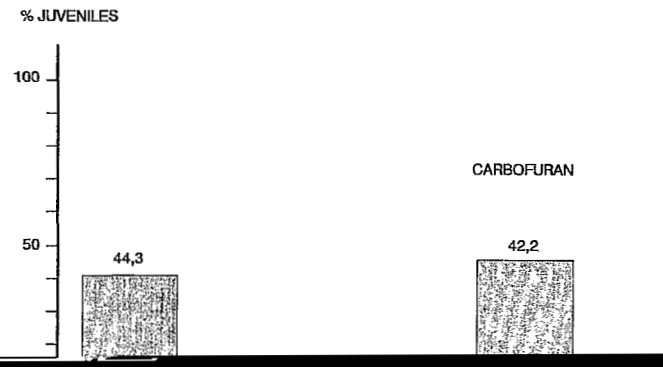
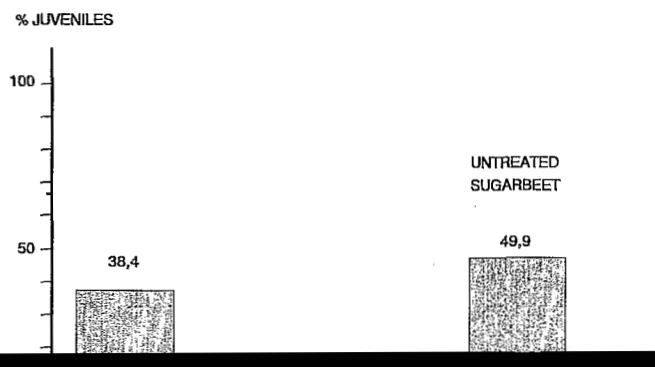
SUMMARY

The systemic activity of cloethocarb (Lance®), aldicarb (Temik®) and carbofuran (Curaterr®) against *Heterodera schachtii* in


% JUVENILES
100
50
0
ALDICARB
40,1
7,3
4,1
1,6
46,9
1
2
3
4
5
SECTOR


% JUVENILES
100
50
0
58,4
CLOETHOCARB
9,7
3,2
1,5
27,2
1
2
3
4
5
SECTOR


% JUVENILES
100
50
CARBOFURAN
44,3
42,2


% JUVENILES
100
50
UNTREATED
SUGARBEET
38,4
49,9

The sand-block was moistened with tap water and incubated for 48 h to allow a root diffusate gradient to form. Approximately, 1000 *H. schachtii* J2 in 100 µl tap water were then pipetted onto sector 1. The sand-block was saturated with tap water and the Petri dish containing the sand-block sealed. An additional treatment without sugarbeets acted as a control. The experiment was terminated 5 days after nematode inoculation. The distributions of juveniles in the sand-block sectors of the different treatments were compared with one another using a χ^2-test. The percentage of J2 which penetrated the roots in sector 5 based of the total number which reached sector 5 was calculated as the penetration rate.

GROWTH AND DEVELOPMENT

Sugarbeets cv. Kawemono were raised in PVC pots containing 250 ml sand until the emerging second leaf pair was developed. Each pot was then inoculated with 5000 *H. schachtii* juveniles. After 3 days the roots were washed under running tap water to remove any J2 adhering to the root surface.

The sugarbeets were re-potted into PVC pots containing 250 ml steam-sterilized field soil without nematodes. Cloethocarb, aldicarb and carbofuran were added at an application rate of 1 g/m row and the control plants remained untreated.

The plants were placed in a greenhouse at 20 ± 5 °C with 16 h supplemental illumination using sodium vapor

compared to the untreated sugarbeet controls. The distribution pattern of the cloethocarb treatment was also significantly different from that in the treatment without sugarbeet. Cloethocarb treated plants also had lower numbers of nematodes in sector 2-4 and high percentages in 1 and 5 than in the control.

Aldicarb and carbofuran treated sugarbeet seedlings had J2 orientation patterns that were not statistically different from the untreated sugarbeets (Fig. 1). The penetration rate in cloethocarb treated sugarbeets was significantly lower than the penetration rate in untreated roots, whereas it was not significantly different from the penetration rates for carbofuran or aldicarb (Table 1). The penetration rates for aldicarb and carbofuran were not significantly different from that of the untreated control. Therefore, cloethocarb treated sugarbeets not only disrupted J2 orientation, but also had an inhibitory effect on penetration. By contrast, treatments with aldicarb and carbofuran did not alter J2 orientation nor inhibit penetration.

Table 1

Heterodera schachtii penetration rates in sand-block orientation chambers as influenced by carbamate treated sugarbeet.

Treatment	*Penetration rate*

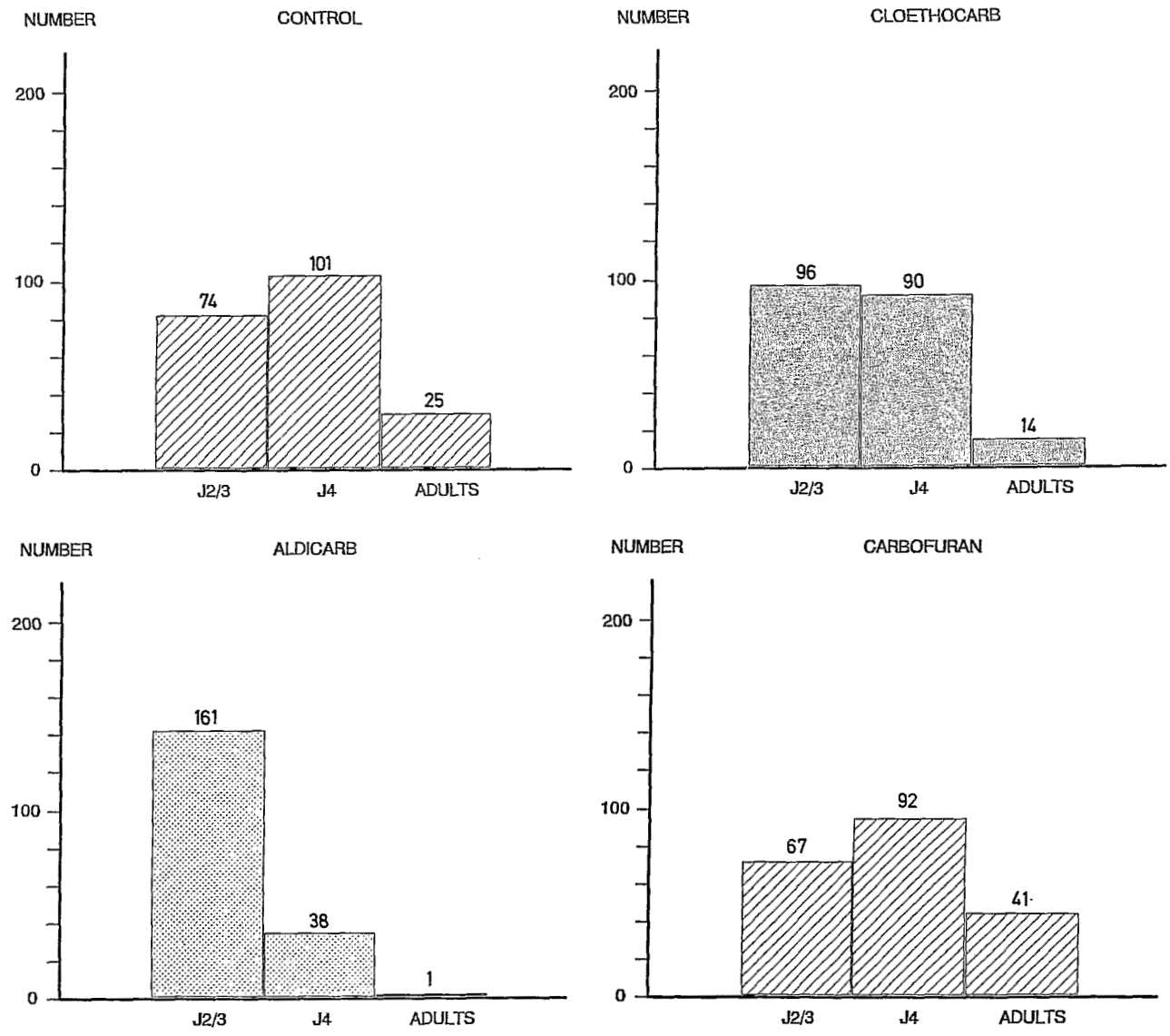


Fig. 2. Frequency distributions of *Heterodera schachtii* developmental stages in untreated sugarbest roots as well as in roots treated with cloethocarb, aldicarb and carbofuran. Distributions significantly different following the χ^2-test are indicated by different bar patterns; mean of eight repetitions.

volume classes from 1-3 and 3-5 $\mu^3 \times 10^5$ and a lower percentage in all remaining classes. The highest percentage of small volume nematodes was caused by aldicarb.

The carbamates affected nematode development (Fig. 2) and nematode growth (Fig. 3) to the same degree. A distribution of volume classes calculated for each *H. schachtii* developmental stage showed that the volume distribution for J2/J3 and J4 was influenced by the carbamates in the same way as the distribution of the developmental stages. On the other hand, the distributions for the volume classes of adult *H. schachtii* did not differ from one another.

Discussion

Carbamate nematicides, which are absorbed by the plant roots and translocated in the plant (Nelmes, Trudgill & Corbett, 1973; Riebel & Beitz, 1976; Steele,

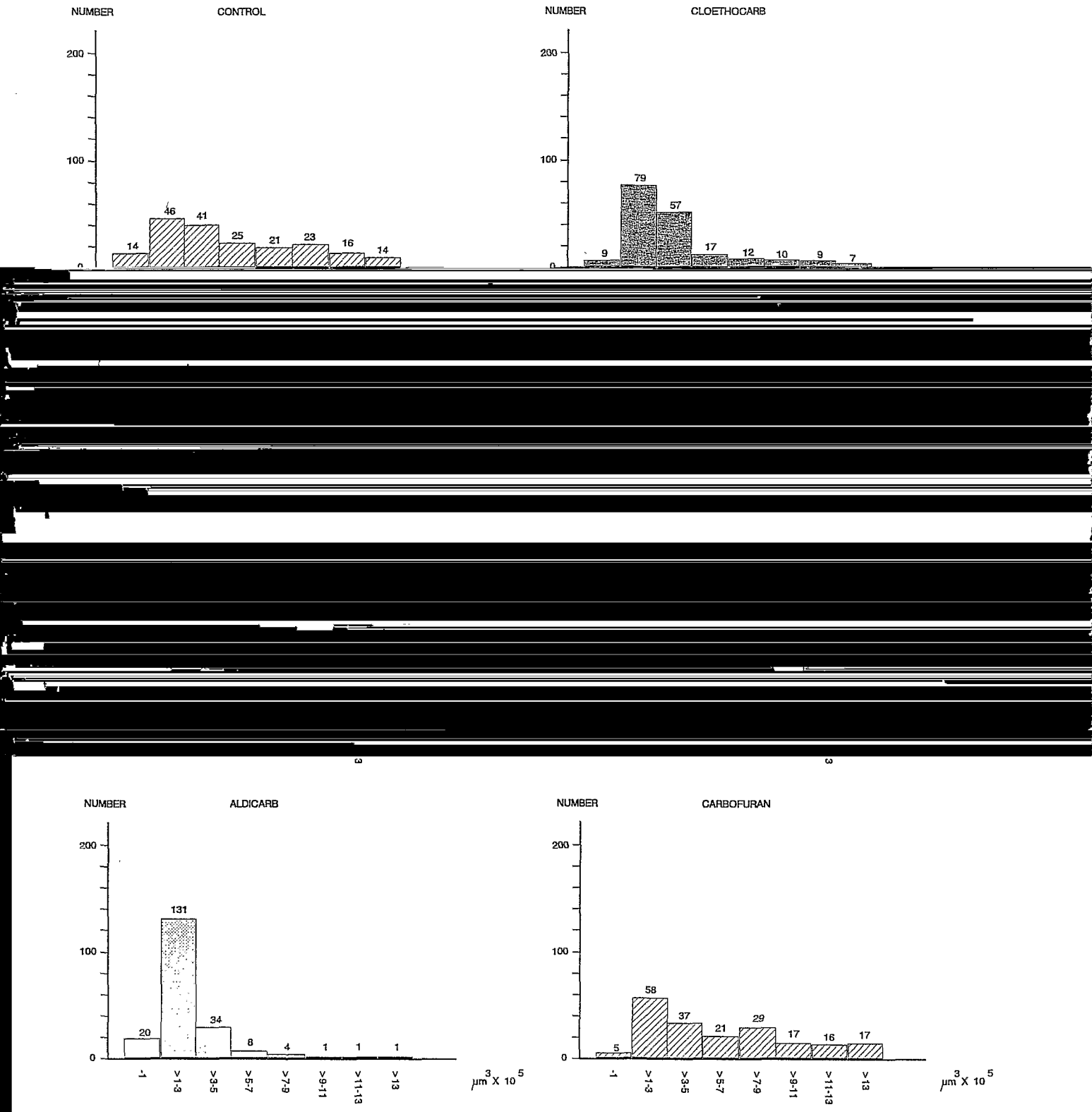


Fig. 3. Frequency distributions of *Heterodera schachtii* volumes of all juvenile stages in untreated sugarbeet roots and well as in roots treated with cloethocarb, aldicarb and carbofuran. (Distributions significantly different following the χ^2-test are indicated by different bar patterns; mean of eight repetitions).

1979; Rouchaud, Moons & Meyer, 1980), trigger processes which alter the composition of substances responsible for nematode attraction to the root or predisposition to root penetration.

treatment with this carbamate causes fewer J2 to migrate into sector 5 than with untreated sugarbeets. This disorientation, however, is not absolute, since more nematodes migrated into sector 5 compared to the

Carbamates taken up by plants after nematode penetration also have an influence on juvenile development and growth in the root. This « curative effect » may be the result of direct toxic action on nematode physiology or to disturbances in nematode nutrition through indirect effects on the activity of the syncytium (Steele, 1976). Such carbamate effects would cause developmental disorders in *H. schachtii* and inhibit the growth of juveniles.

In our studies, treatment of sugarbeet seedlings with aldicarb or cloethocarb after *H. schachtii* penetration caused a retardation in nematode development. More nematodes remained in the J2/J3 stages than in the control. The fact that the size of the individual nematode was smaller demonstrates that cloethocarb and aldicarb negatively affect growth whereas carbofuran does not. Similar results were obtained by Steele (1976) with *H. schachtii* and aldicarb. Sugarbeets treated with 5 ppm aldicarb 10 days after penetration of *H. schachtii* had a lower percentage of J3 and J4 than in the control without aldicarb. On the other hand, the percentage of J2 was increased by aldicarb.

Cloethocarb and aldicarb not only delayed development but reduced juvenile growth. Comparison of the body volume of each juvenile stage demonstrated clearly that the J2/J3 and J4 in cloethocarb or aldicarb treated

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