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Influence of some insecticides on the development of caterpillar populations on cabbage

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Abstract

Five insecticides were evaluated against caterpillars on cabbage. Before and after treatment the population size of the various species was recorded. Criteria and methods for the assessment of damage due to caterpillars and of cabbage aphid infestation are described.

Introduction

In the Netherlands cabbage is an important vegetable crop, which is attacked by various insect pests including a number of lepidopterous species. For control of the caterpillars of these Lepidoptera, several insecticides are recommended but no advice is given about conditions for their use. In practice farmers often spray when high population densities have developed. In other situations spraying is started at an earlier developmental stage of the population and then the spray frequency can often be reduced considerably. It was not clear, however, which of the available insecticides should be applied under the various conditions. Special qualities of these compounds such as persistence and knock-down effect are neither mentioned in an advisory leaflet on the culture of Brussels sprouts nor in the Guide for pest control (Anonymous, 1973, 1977a). According to technical information on diflubenzuron (Anonymous, 1977b), this new insecticide behaves differently from the conventional ones. It belongs to the group of 2,6-dihalogenated benzoyl-aryl ureas, which inhibit chitin biosynthesis (Van Daalen et al., 1972). A prolonged series of observations seems necessary to show whether diflubenzuron is effective against the caterpillars involved. Elings and Dieperink (1974) reported a maximum mortality of *Pieris brassicae* larvae on Brussels sprouts six days after treatment; three days after treatment mortality was only 75%. In general they found variable results, also against *Mamestra brassicae*. It seems that a minimum dosage of 180 g per ha should be used.

To compare the long term influence of diflubenzuron with that of the other compounds mentioned in Table 1, observarions during a longer period were needed.

Materials and methods

Experimental field. The experimental field was situated at the Schuilenburg in the area between the rivers Rhine and Waal. Brussels sprouts were planted on July 4. The plants were treated with pirimicarb against the aphid *Brevicoryne brassicae* on August 8. On September 12 the lepidopterous insects on all experimental plots were counted. Per eight plants a mean of 217 caterpillars was found ($S_{\bar{x}} = 28$). A slow decrease in insect pest populations was observed from September 13 until October 10 in the untreated plots (Table 2).

On the field four rows of 72 plants divided in plots of 4 × 6 plants were available; only 4 × 4 plants per plot were used for counting and sampling. The others served as a barrier. In two replicates the treatments were located in the same sequence, as at random sampling was not necessary in this situation.

Owing to cold weather in August oviposition of *Mamestra brassicae* started only in September. The progress of the pest population was carefully observed to enable us to start the trial at the most opportune moment: when caterpillars of the different species and in various developmental stages were present.

The following important lepidopterous species were found: *Mamestra brassicae* in relatively large numbers, *Pieris brassicae* rarely, *Pieris rapae* in low numbers, *Plutella xylostella* in low and gradually decreasing numbers, *Evergestis forficalis* in relatively large and still increasing numbers and *Plusia gamma* occasionally. Only the numbers of *M. brassicae* and *E. forficalis* were so large, that a separate analysis of the results was justified.

Insecticides. The insecticides were obtained from the Plant Protection Service in Wageningen. They were applied by a mist blower in a volume of 600 ml of water per plot of 10 m^2 (Table 1). On September 12, the day of application the weather was cool and cloudy, in the observation period almost dry until the beginning of October.

Table 1. List of treatments.

Common name of insecticide	Trade mark	Applied dose (g per 10 m^2)	
		formulated	A.I.
Acephate	Orthene	0.625	0.5
Carbaryl	Carbaryl	1.25	0.625
Bromophos-ethyl	Nexagan	3.25	1.3
Diflubenzuron	Dimilin	0.9	0.225
Azinphos-methyl/dimethoate	Azinphos-D	5.0	0.75

Tabel 1. Behandelingen.

Quantitative damage assessment. Observations were made on September 12, 13, 15, 19, 22, 26, 30 and on October 6 and 18. Spraying took place in the afternoon of September 12, after the first sampling. Numbers of caterpillars, aphid infestation and damage were assessed on eight plants evently distributed over the plots: so 16 plants per treatment per date provided the information on the effects of the various treatments. Two persons observed each four plants in every replicate. We determined on each plant the damage and degree of infestation by *Brevicoryne brassicae* and counted the various developmental stages of the following insects:

M. brassicae: number of egg batches, eggs per batch (estimate), small (< 2 cm) and large (> 2 cm) caterpillars;

P. brassicae and *P. rapae:* number of eggs, small (< 1 cm) and large (> 1 cm) caterpillars and pupae;

P. xylostella: caterpillars and pupae;

E. forficalis: caterpillars.

Table 2. Numbers of caterpillars on Brussels sprouts in various treatments (numbers per 100 plants).

Date	Treatments					
	orthene	carbaryl	azinphos-D	nexagan	dimilin	water
12/9	1512	2225	2644	2231	4144	3550
13/9	2394	2644	2750	1625	4250	4762
15/9	1200	2162	1400	769	4244	4575
19/9	212	2000	1100	81	1875	2975
22/9	106	1456	762	50	937	2931
26/9	87	1094	369	100	431	2375
30/9	156	937	369	62	337	1912
6/10	87	581	400	106	119	1144
18/10	50	250	87	44	156	281

Tabel 2. Verloop van rupsenpopulatie op spruitkool in de verschillende objecten (aantal rupsen per 100 planten).

For a repeated evaluation of the damage due to caterpillar feeding it was necessary to index the damage relating to the percentages of eaten leaf surface, which was done as follows: 0:0%, 5:0–5%, 10:6–10%, 25:10% or more eaten. The leaves around the middle were observed only. They represent that part of the plant which is newly formed after the previous observation. To each plant an index number was allocated, the sum of the index numbers represents the damage. In the same way aphid infestation was classified. The index numbers relating to the estimates of aphids per plant were: 0:0, 10:0–10, 50:11–50, and 100: more than 50.

Results

Table 2 shows the total number of caterpillars in the various treatments. In both replicates eight plants were counted and the average per 100 plants was calculated as a standard: dividing by 6.25 results in the number actually counted. The species involved were: *M. brassicae*, *P. rapae*, *E. forficalis* and *P. xylostella*.

Figure 1 shows the changes in their populations. Fig. 1, 2, 3 and 4 were obtained by expressing the numbers counted, as percentages of those in the treatment on September 12 and by dividing this value by the corresponding value from the untreated plots. In Fig. 5 the numbers of aphids per date were related to those on the untreated plants on that date. Possible side-effects of the various compounds on natural mortality factors could not be eliminated but the final results of these insecticide applications can be evaluated as described above. The sharp decrease in caterpillar populations treated with bromophos-ethyl and acephate is obvious, carbaryl shows a limited action against the target insects. Azinphos-methyl/dimethoate and diflubenzuron maintain an intermediate position. The difference in effectiveness between the former and acephate on September 19 and 22 was significant ($P = 0.05$), that between diflubenzuron and acephate was almost significant on September 22 (Fig. 1).

The decline of the total caterpillar population on the plants treated with diflubenzuron was not so sharp initially, due to the slow mode of action but the result after 24 days is as good as that of bromophos-ethyl and acephate. Fig. 1 shows the

Fig. 1. Caterpillar population development. The total numbers of caterpillars in the various treatments are expressed on the ordinate as an index of 'untreated' (= 100).

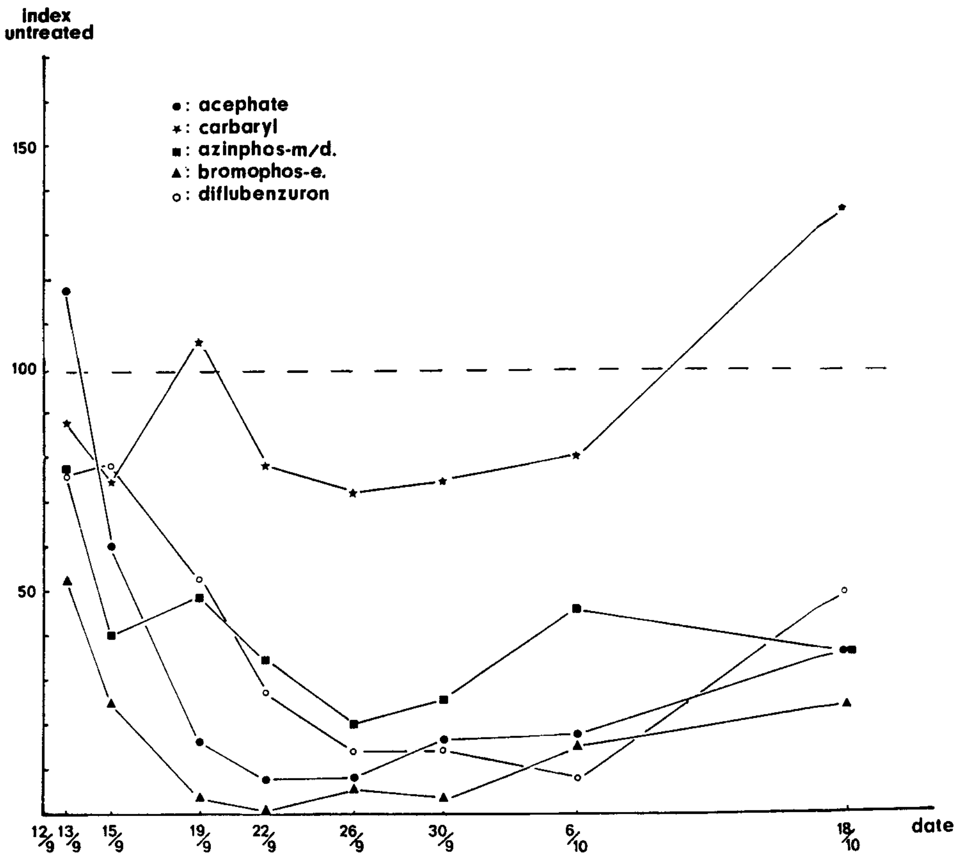

Fig. 1. Verloop van de totale rupsenpopulatie in de verschillende objecten, uitgedrukt in een indexnummer ten opzichte van de controle (= 100).

effective period of the insecticides on the crop. Decreasing effectiveness of acephate and bromophos-ethyl becomes apparent 10–14 days after treatment, for carbaryl and azinphos-methyl/dimethoate this period was 14–18 days and for diflubenzuron 24 days.

Damage levels presented in a similar way, are given in Fig. 2, which shows a great similarity to Fig. 1. This indicates a reasonable correlation between the population development and the damage assessment in the different treatments. The coëfficients of correlation on September 19 and October 6 were 0.72 and 0.72. This was significantly > 0 at significance level $= 95\%$.

Particularly the failure of carbaryl as an effective insecticide and the initially low impact of diflubenzuron on the damage development became apparent, contrary to the effect of azinphos-methyl/dimethoate.

Considering possible differences in susceptibility of the species of caterpillars present in this trial, separate calculations were made for the populations of the two

Fig. 2. Level of caterpillar damage, expressed on the ordinate as an index of 'untreated' (= 100).

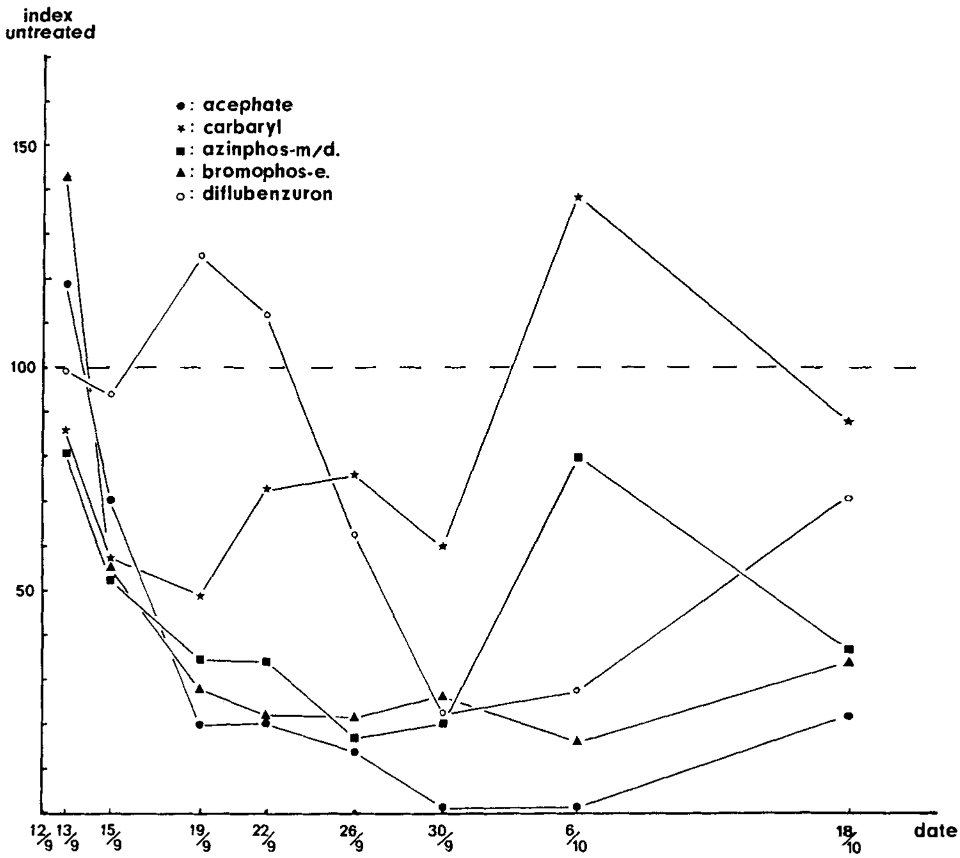

Fig. 2. Verloop van schade door rupsenvraat in de verschillende objecten, uitgedrukt in een indexnummer ten opzichte van de controle (= 100).

most numerous species *M. brassicae* and *E. forficalis*. These are presented in Fig. 3 and 4 according to the system already described.

Until October 6 the shape of the curves in Fig. 3 shows much similarity to those in Fig. 1. This is caused by the initially predominant position of *M. brassicae* in the total population of caterpillars, which amounted to 432 specimens counted per 16 plants on September 12. Of these only 30 were *E. forficalis*. The population of this species increased during the trial but a large variation in its numbers should be taken into consideration. The treatment with diflubenzuron was, particularly over a longer period, very affective against *Mamestra*, whereas for *Evergestis* numbers were recorded that, a considerable variation taken into account, did not differ from 'untreated' (P = 0.05).

For *Mamestra* the analysis of variance on logarithms of the records resulted in non-significant differences (P = 0.05) between the treatments with azinphos-methyl/dimethoate and carbaryl. For *Evergestis* this difference was significant when records

Fig. 3. Population development of *Mamestra brassicae* caterpillars. The numbers of caterpillars in the various treatments are expressed on the ordinate as an index of 'untreated' (= 100).

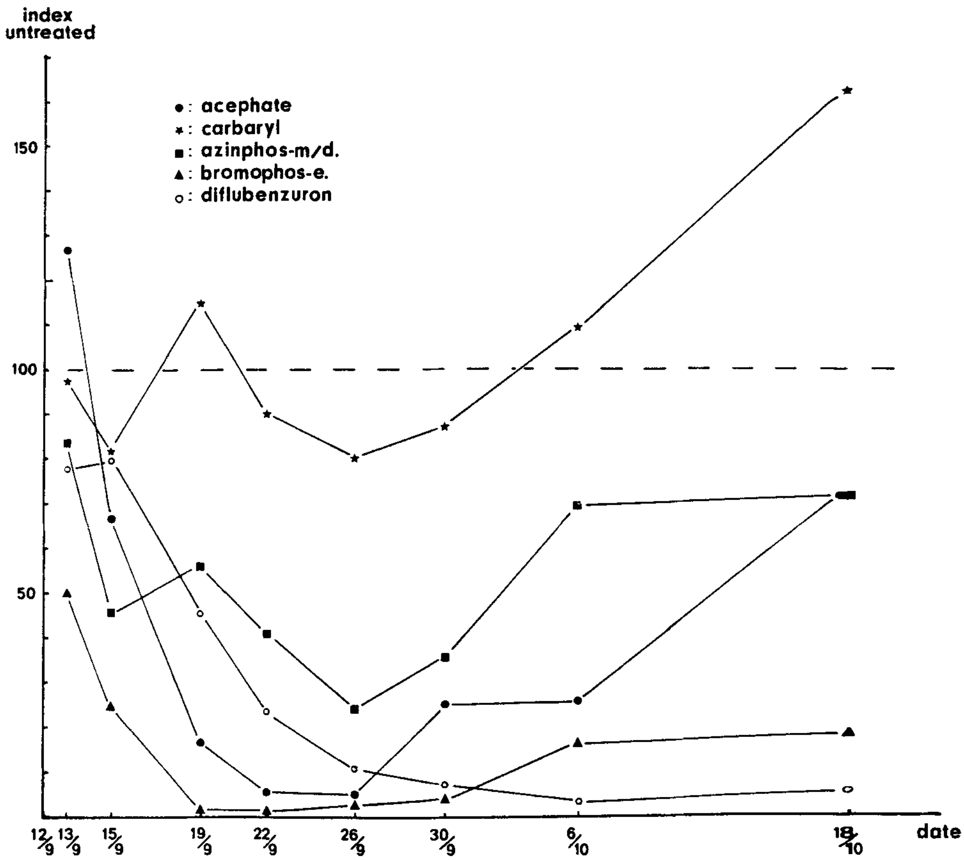

Fig. 3. Populatieverloop van M. brassicae rupsen in de verschillende objecten, uitgedrukt in een indexnummer ten opzichte van de controle (= 100).

from the dates September 15 to October 6 were averaged. So azinphos-methyl/dimethoate was better against *Evergestis* than against *Mamestra* when compared with carbaryl (Fig. 3 and 4). When compared with 'untreated', the effectiveness of azinphos-methyl/dimethoate on *Evergestis* was superior to that on *Mamestra*.

E. forficalis is an important pest of cabbage particularly late in the growing season; its caterpillars are still active after those of *M. brassicae* have disappeared. In early summer caterpillar populations are generally low and gradually the numbers increase, especially those of *P. xylostella*, which is usually abundant in midsummer. Later in summer populations of *P. rapae* and *M. brassicae* increase.

Although the present evaluation of insecticides was not aimed at aphicide action in particular, aphid infestation allowed us to gather information on the impact of these insecticides on aphids. Because infestation of the crop with *B. brassicae* before treatment differed per plot and was sometimes absent, the infestation in each treatment was expressed as a percentage only of the infestation of the control (Fig. 5). Only azinphos-methyl/dimethoate had a satisfactory effect against *B. brassicae*.

Fig. 4. Population development of *Evergestis forficalis* caterpillars. The numbers of caterpillars in the various treatments are expressed on the ordinate as an index of 'untreated' (= 100).

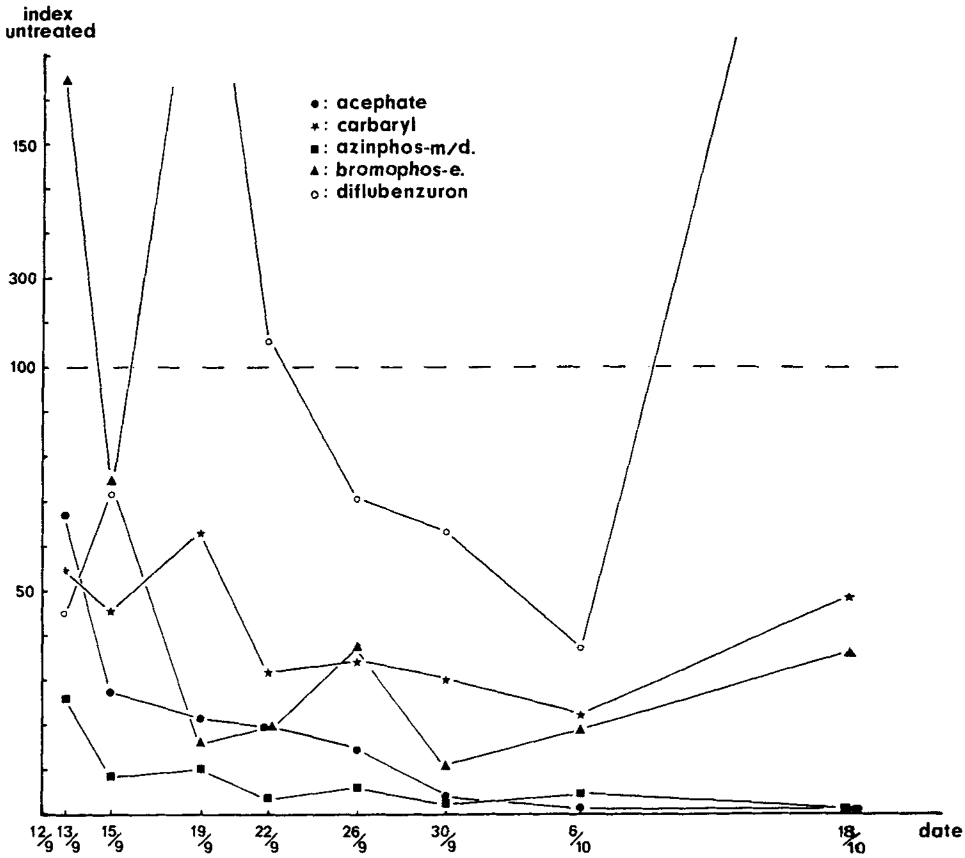

Fig. 4. Populatieverloop van E. forficalis rupsen in de verschillende objecten, uitgedrukt in een indexnummer ten opzichte van de controle (= 100).

Discussion and conclusions

It was concluded that the choice of insecticide should be determined partly on the basis of its effectiveness against the important species of the insect pest complex present at that time. So diflubenzuron was more effective against *Mamestra* than against *Evergestis*. Azinphos-methyl/dimethoate had a satisfactory effect on *Evergestis* and a moderate one on *Mamestra*. Another factor in the choice of insecticides is the quality of pest management. When an adequate monitoring of increasing insect pest populations is achieved, a timely warning can be given to the growers. Then there is no need for a 'knock-down' effect and an insecticide can be chosen with a prolonged effectiveness e.g. diflubenzuron. When the warning system fails, immediate action is required and insecticides like bromophos-ethyl or acephate have to be used.

For the determination of the effect of insecticides against lepidopterous pests in a crop it is not sufficient to make an evaluation based only on estimates of damage. It

Fig. 5. Population development of *Brevicoryne brassicae*. The level of infestation in the various treatments is expressed as a percentage of 'untreated' (= 100).

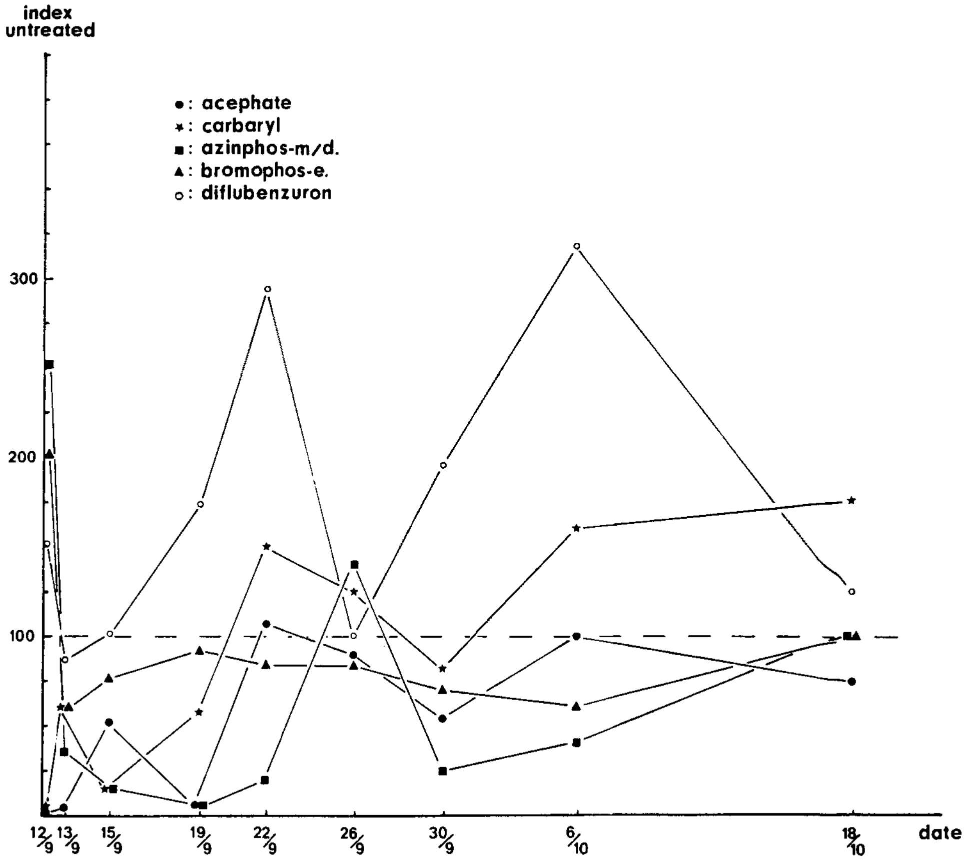

Fig. 5. Populatieverloop van koolluis, B. brassicae, in de verschillende objecten, uitgedrukt als percentage van het aantastingsniveau in de controle (= 100).

is necessary to follow the population development of important species by counting the numbers of caterpillars.

Assessment of damage and population numbers during some years may lead to the possibility of establishing a satisfactory coëfficient of correlation between damage and population density. Damage could then possibly be correlated to the observed infestation.

Samenvatting

De invloed van enige insecticiden op de ontwikkeling van rupsenpopulaties in kool

Vijf insecticiden werden op hun werkzaamheid tegen koolrupsen beproefd. Dit werd gedaan door de populatieontwikkeling van ieder object te volgen, nadat de populatiegrootte vóór de behandeling was vastgesteld (Tabel 2, Fig. 1, 3, 4). De werkzaamheid van de middelen werd bepaald zowel ten aanzien van de totale rupsenpopulatie als tegen de twee belangrijkste soorten in de proefperiode (Fig. 3, 4). Ook werden de vraatschade door de rupsen en de ontwikkeling van koolluispopulatie waargenomen en beoordeeld (Fig. 2 en 5).

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