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INFLUENCE OF DIFFERENT COMPOSITAE ON POPULATION DENSITY OF *PRATYLENCHUS PENETRANS* AND SOME OTHER ROOT-INFESTING NEMATODES[1]

De invloed van verschillende Composieten op de populatiedichtheid van Pratylenchus penetrans *en enkele andere wortelaaltjes*

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Field and pot experiments with over 35 different Compositae, mainly perennial and annual flower crops, show that *Helenium* hybrids, *Gaillardia* hybrid 'Burgunder' and *Eriophyllum caespitosum*, in addition to *Tagetes patula* 'Harmony', suppress populations of *Pratylenchus penetrans* very effectively. In other genera of Compositae species also occur which are poor hosts of *P. penetrans*, although their suppressive action is generally significantly less marked than that of the species mentioned. Within the same plant genus considerable differences in host suitability were found. These results may prove to be useful in providing indications as to the most suitable sequence of crops for the control of *P. penetrans* in nurseries of perennial crops, parks and gardens. Some data collected on host suitability of Compositae to *Rotylenchus robustus* and *Tylenchorhynchus dubius* show differences, though less marked than those relating to *P. penetrans*.

INTRODUCTION

It has been known for more than ten years that marigolds *(Tagetes* spp.*)* effectively control some species of root-infesting nematodes (SLOOTWEG, 1956; OOSTENBRINK, KUIPER & 'S JACOB, 1957; DAULTON & CURTIS, 1963). The effect of one crop of *Tagetes* may approximate that of treatment with a nematicide (OOSTENBRINK, KUIPER & 'S JACOB, 1957). This property is found in various species of the genus *Tagetes*, although differences exist in the effectiveness of the species (DAULTON & CURTIS, 1963). UHLENBROEK & BIJLOO (1958) found that this crop contains chemical substances which are strongly nematicidal.

In 1962 a grower of perennial flower crops at Huis ter Heide reported *Helenium* hybrid 'Moerheim Beauty' to be a very good preceding crop for many perennials in his nursery, which was infested with *Pratylenchus penetrans* (Cobb). He used this crop to "clean" beds in which damage by *P. penetrans* was observed. Like *Tagetes*, *Helenium* belongs to the tribe Helenieae of the Compositae. Consequently, several experiments were conducted to investigate the suitability of various Compositae as host plants of *Pratylenchus penetrans*.

EXPERIMENTS

The following experiments were conducted:

A. In 1962 a crop rotation trial with a fixed rotational scheme (design C according to OOSTENBRINK, 1959) was set up in a perennial flower crop nursery at Huis ter Heide, to investigate the above-mentioned observations of the grower. In addition to several crops (see Table 2) important on this nursery,

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Tagetes patula 'Harmony' and *Helenium* hybrid 'Moerheim Beauty' were included. The soil was of a light sandy type with a relatively light infestation level of *P. penetrans*, viz. 20–70 per 100 ml soil in spring 1962. Larvae of *Meloidogyne hapla* (Chitwood) were found in small numbers. Early in May all the crops were planted as young plants or rooted cuttings, with 25 cm between the plants on plots of 4 m².

B. In 1964 three experiments were conducted:

1. A pot experiment at Wageningen with 34 Composites to compare their suitability as hosts of *P. penetrans*. This experiment was set up with three replications, using 4 1 plastic pots. For this trial sandy peat soil from the vicinity of Winschoten was collected. This soil harboured 300 *P. penetrans*, 300 *Tylenchorhynchus dubius* (Bütschli) and 200 *Rotylenchus robustus* (de Man) per 100 ml. The various Composites were raised from seed or from cuttings. At the beginning of May, three plants were planted in each pot. In October the nematode population per 10 g of fresh roots was determined and in November the population per 100 ml of soil.

2. A field experiment was again set up in the nursery at Huis ter Heide with 18 Composites, a number of them being the same as those used in B 1. This was a block experiment with three replications and plots of $1\frac{1}{2}$ m² with 20 plants per plot. At the beginning of the experiment the average population density of *P. penetrans* was 60 per 100 ml soil; there were also 600 *R. robustus* per 100 ml soil. The nematode population in the roots was assessed at the end of August, and at the beginning of December the population in the soil was assessed again.

3. A field experiment was also conducted on a sandy peat soil at Nieuwe Pekela, with among other crops *Helenium* hybrid 'Moerheim Beauty', *Tagetes* sp., red clover and fallow. The experiment was conducted in block design with three replications and plots of 4 m². At the commencement of the trial *P. penetrans* was found at densities of 300 per 100 ml soil. The nematode population in the soil was assessed again in autumn 1964.

C. As a consequence of the results of the experiments in previous years, two experiments were carried out in 1965:

1. A pot experiment was carried out in Wageningen, mainly to test different varieties of four Composites which in foregoing experiments had emerged as poor hosts of *P. penetrans*. In this trial, sandy peat soil from the neighbourhood of Winschoten was again used, having an average population density of 330 *P. penetrans* and 300 *T. dubius* per 100 ml soil. The experiment was conducted in 4 l plastic pots with three replications. Early in May three plants were planted in each pot. The eelworm population in the roots was determined in October, and the population in the soil in November.

2. At Huis ter Heide another field experiment was conducted, principally with the same crops as in pot experiment C 1. This experiment was laid out in block design with three replications, the plots being 1.44 m² in size with 16 plants per plot. At the commencement of the trial the eelworm population averaged 25 *P. penetrans*, 50 *T. dubius* and 40 *R. robustus* per 100 ml soil. The crops were planted early in May. Assessments of eelworm populations in the soil were made in October 1965 and again in January 1966.

In all the experiments, the degree of infestation in the soil was determined per 100 ml soil by means of the flotation apparatus developed by OOSTENBRINK (1954, 1960). In 1962 the number of endoparasitic root-eelworms was assessed per 10 g fresh roots using a modification of the spray method of SEINHORST (1950), developed at the Plantenziektenkundige Dienst at Wageningen. For the succeeding experiments a blender-method as developed by STEMERDING (1964) was adopted, in which roots were macerated for five seconds at 10,000 r.p.m. the nematodes being then extracted by incubating the material for two days on a cotton wool filter.

RESULTS

Pratylenchus penetrans

In the 1963 rotation trial (A) great differences in growth, showing a distinct

TABLE 1. Experiment A. Influence of pre-crops *Tagetes patula* 'Harmony', *Helenium* hybrid 'Moerheim Beauty' and some other flower crops on the population density of *Pratylenchus penetrans* and *Meloidogyne hapla* in the roots of *Geum* hybrid 'Prinses Juliana' and *Helenium* hybrid 'Moerheim Beauty' and on plant weight of these test crops at harvest time.

Proef A. De invloed van de voorgewassen Tagetes patula *'Harmony'*, Helenium *hybride 'Moerheim Beauty' en enige andere bloemgewassen op de populatiedichtheid van* Pratylenchus penetrans *en* Meloidogyne hapla *in de wortels van* Geum *hybride 'Prinses Juliana' en* Helenium *hybride 'Moerheim Beauty' en op het gewicht van de planten bij de oogst van deze toetsgewassen.*

Pre-crops in 1962	Crops in 1963	Nematodes per 10 g of fresh roots 22/7/63		Average plant weight in g, 7/11/63
		Pratylenchus	*Meloidogyne* larvae	
Nepeta faaseni 'Six Hills Giant'	*Geum*	5720	260	174
Tagetes patula 'Harmony'	*Geum*	450	45	455
Phlox paniculata 'Mies Copijn'	*Geum*	3280	380	166
Helenium hybrid 'Moerheim beauty'	*Geum*	880	–	545
Tagetes patula 'Harmony'	*Helenium*	5	–	130
Phlox paniculata 'Mies Copijn'	*Helenium*	1845	10	103
Geum hybrid 'Prinses Juliana'	*Helenium*	1620	5	102
Helenium hybrid 'Moerheim Beauty'	*Helenium*	20	–	119

Voorgewassen in 1962	*Gewassen in 1963*	Pratylenchus / Meloidogyne-*larven* *Aaltjes per 10 g verse wortels 22/7/63*	*Gemiddeld gewicht van de plant in g, 7/11/63*

correlation with the population of *P. penetrans*, were observed. Some results of this experiment are shown in Table 1. *Geum* hybrid 'Prinses Juliana', a sensitive test plant, harboured low numbers of *P. penetrans* and *Meloidogyne* larvae after the pre-crops *Tagetes patula* 'Harmony' and *Helenium* hybrid 'Moerheim Beauty' and mean plant weights were three times those of plants succeeding *Phlox paniculata* 'Mies Copijn' and *Nepeta faaseni* 'Six Hills Giant' (Fig. 1). *Helenium* as test crop succeeding *Tagetes* and *Helenium* harboured very low numbers of *P. penetrans* in the roots, whereas when the pre-crops were *Phlox paniculata* 'Mies Copijn' and *Geum* hybrid 'Prinses Juliana' the numbers of *P. penetrans* were substantially greater. *Helenium* hybrid 'Moerheim Beauty' is fairly insensitive to damage by *P. penetrans*, as differences in plant weights remained relatively slight. It can also be seen that *T. patula* 'Harmony' and *Helenium* hybrid 'Moerheim Beauty' leave low population densities of *P. penetrans* in the soil as compared with other ornamental crops. Both are capable of cleaning infested plots to such an extent that cultivation of sensitive crops can be attempted without appreciable risk.

These observations were confirmed by the results of field experiment B at Nieuwe Pekela. In the autumn, after one year's growth of *T. patula* 'Harmony' and *Helenium* hybrid 'Moerheim Beauty', the mean population density of *P. penetrans* was 7 and 8 per 100 ml soil respectively, whereas after red clover, a susceptible host, it was 575 per 100 ml soil. In the fallow plots an average of 185 *P. penetrans* per 100 ml soil was found. The reduction of population by the two first-mentioned crops markedly surpassed natural mortality in the fallow plots. It therefore seems evident that these plants are playing an active role in diminishing the eelworm population.

TABLE 2. Influence of the cultivation of *Tagetes patula* 'Harmony', *Helenium* hybrid 'Moerheim Beauty' and five other flower crops on population density of *Pratylenchus penetrans* in a field experiment (A) at Huis ter Heide.

Invloed van de teelt van Tagetes patula '*Harmony*', Helenium *hybride* '*Moerheim Beauty*' *en vijf andere bloemgewassen op de bevolkingsdichtheid van* Pratylenchus penetrans *op een proefveld (A) te Huis ter Heide.*

Crops	*P. penetrans* per 100 ml of soil, spring 1964	
	Population on monocultural plots (1962 and 1963)	Average population on seven plots after one year of cultivation (1963)
Tagetes patula 'Harmony'	20	13
Helenium hybrid 'Moerheim Beauty'	5	7
Nepeta faaseni 'Six Hills Giant'	170	73
Phlox paniculata 'Mies Copijn'	155	189
Geum hybrid 'Prinses Juliana'	85	62
Trollius hybrid 'Earliest of All'	165	146
Delphinium hybrid	45	59
Gewassen	*Populatie op monocultuurveldjes (1962 en 1963)*	*Gemiddelde populatie op zeven veldjes na één jaar teelt (1963)*
	P. penetrans *per 100 ml grond, voorjaar 1964*	

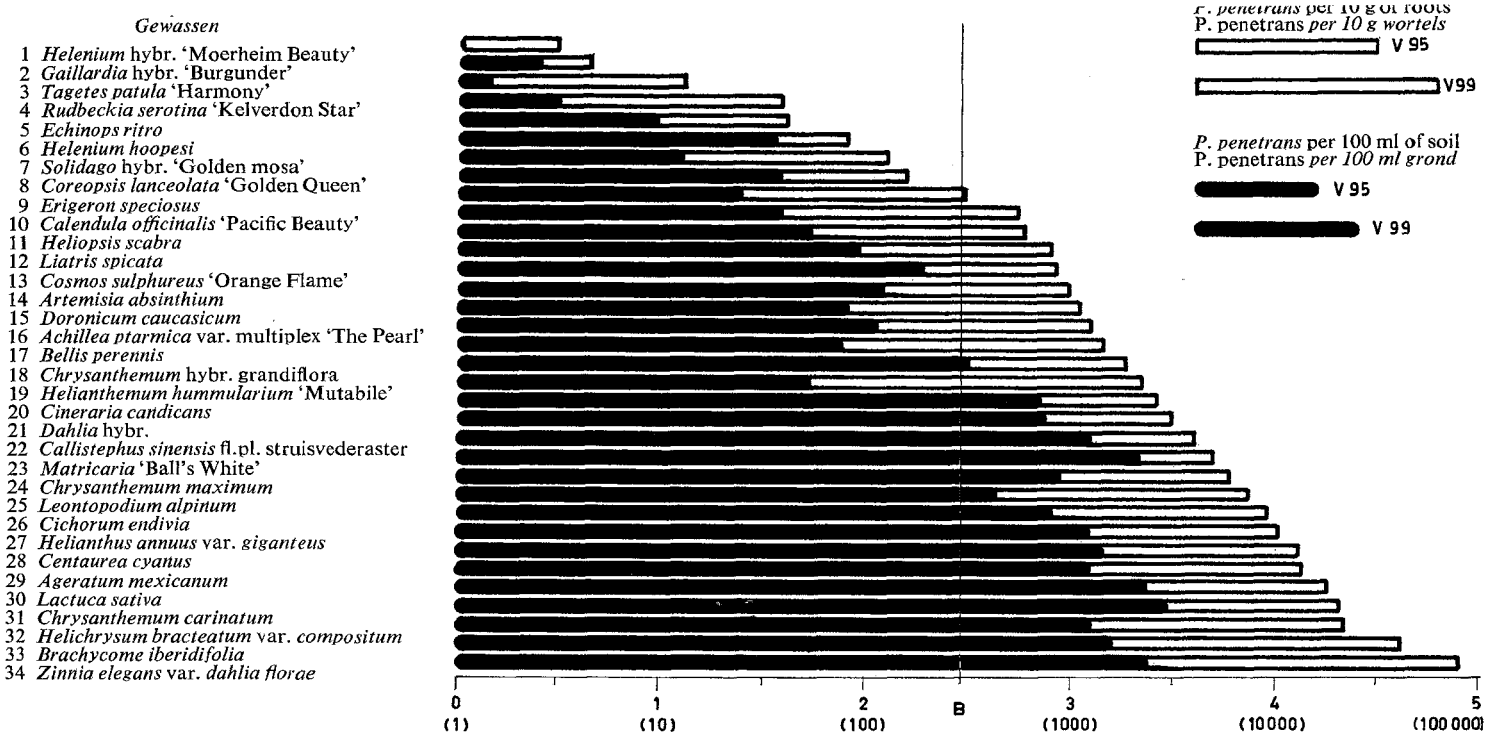


FIG. 2. Graph of the numbers of *Pratylenchus penetrans* per 10 g of fresh roots October 1964) and per 100 ml of soil (November 1964) after cultivation of 34 Compositae in a pot test (B1). The data were logarithmically transformed and subjected to analysis of variance. Differences in host efficiency of these crops are significant when differences of column lengths exceed 95% (V 95) or 99% (V 99) level. B indicates the initial population level op *P. penetrans*.

Grafiek van de aantallen Pratylenchus penetrans *per 10 g vers wortelmateriaal (oktober 1964) en per 100 ml grond (november 1964) na de teelt van 34 Compositae in een potproef (B1). De gegevens werden, logarithmisch getransformeerd, onderworpen aan een variantie-analyse. Verschillen in geschiktheid van deze gewassen als waardplant zijn significant wanneer verschillen in kolomlengten de 95 (V 95) of 99 (V 99) %-grens overschrijden. B is de beginpopulatie van* P. penetrans.

The results of pot experiment B1 are summarized in Fig. 2. The values found were logarithmically transformed and subjected to analysis of variance.

The data indicate that there are a number of Composites which reduce populations of *P. penetrans* as compared with their initial level. *T. patula* 'Harmony', *Helenium* hybrid 'Moerheim Beauty' and *Gaillardia* hybrid 'Burgunder' proved to be significantly less efficient hosts than all other crops with the exception of *Rudbeckia serotina* 'Kelvedon Star' and *Echinops ritro*. *Helenium hoopesi*, *Solidago* hybrid 'Golden mosa', *Coreopsis lanceolata* 'Golden Queen', *Erigeron speciosus*, *Calendula officinalis* 'Pacific Beauty' and *Heliopsis scabra* also gave populations of *P. penetrans* significantly lower than the initial level in the soil. *Zinnia elegans*, *Brachycome iberidifolia*, *Helichrysum bracteatum* var. *compositum*, *Ageratum mexicanum*, *Chrysanthemum* species and others proved to be very good hosts of this nematode. Within the same genus of plants, differences in host suitability exist. *Helenium hoopesi*, for example, is a significantly better host of *P. penetrans* than *Helenium* hybrid 'Moerheim Beauty'. There was a significant correlation between the populations of *P. penetrans* in the roots and the populations found in the soil after cultivation of the crops (Fig. 3).

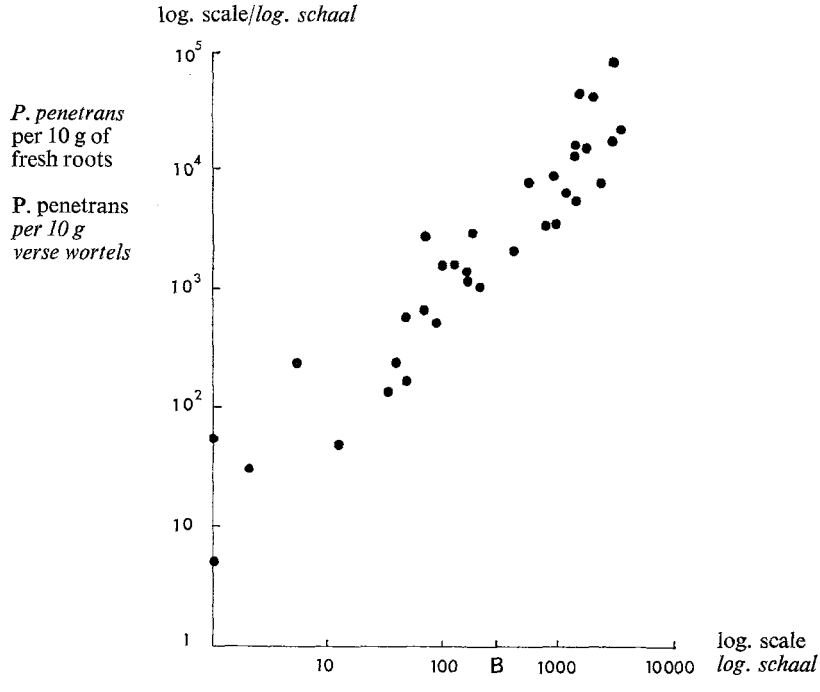
TABLE 3. Comparison of host efficiency to *Pratylenchus penetrans* of some Composites in a pot test at Wageningen (B1) and in a field experiment at Huis ter Heide (B2). The numbers of nematodes in the roots were estimated in October (B1) and August (B2); the numbers in the soil after harvest of the plants in November (B1) and December 1964 (B2). The figures given are the average of three replicates.

Vergelijking van de waardplantgeschiktheid van enkele Composieten voor Pratylenchus penetrans *in een potproef te Wageningen (B1) en een veldproef te Huis ter Heide (B2). De aantallen aaltjes in de wortels zijn bepaald in oktober (B1) en augustus (B2), in de grond na de oogst van de planten in november (B1) en december (B2), en zijn weergegeven als het gemiddelde van drie herhalingen.*

Crops	Wageningen (B1)		Huis ter Heide (B2)	
	per 10 g of fresh roots	per 100 ml of soil (initial population 300)	per 10 g of fresh roots	per 100 ml of soil (initial population 60)
Tagetes patula 'Harmony'	55	1	16	3
Helenium hybrid 'Moerheim Beauty'	5	–	63	5
Solidago hybrid 'Golden mosa'	135	32	70	12
Calendula officinalis 'Pacific Beauty'	585	45	137	8
Heliopsis scabra	675	65	390	10
Dahlia hybrid	3,470	840	338	37
Doronicum caucasicum	1,355	153	1,485	87
Helianthus annuus var. *giganteus*	13,670	1,315	1,435	298
Ageratum mexicanum	15,670	1,325	5,120	63
Gewassen	*per 10 g verse wortel*	*per 100 ml grond (beginpopulatie 300)*	*per 10 g verse wortels*	*per 100 ml grond (beginpopulatie 60)*
	Wageningen (B1)		*Huis ter Heide (B2)*	

FIG. 3. Experiment B1. The relation between the numbers of *Pratylenchus penetrans* in the roots of 34 different Compositae (October 1964) and the numbers of *P. penetrans* in the soil after cultivation of these crops (November 1964). B indicates the initial population of *P. penetrans*.

Het verband tussen de aantallen Pratylenchus penetrans *in de wortels van 34 verschillende Composieten (oktober 1964) en de aantallen* P. penetrans *in de grond na de teelt van deze gewassen (november 1964).* B *is de beginpopulatie van* P. penetrans.



The results of field experiment B2 at Huis ter Heide are in close agreement with those of the pot experiment B1 at Wageningen, although the population levels were different. Table 3 gives a comparison of the figures for some crops occurring in both experiments. These figures show that *Helenium* hybrid 'Moerheim Beauty', *Solidago* hybrid 'Golden Mosa', *Calendula officinalis*, and *Heliopsis scabra*, along with *Tagetes patula* 'Harmony', are very poor hosts of *P. penetrans*.

The number of eelworms found in the soil after cropping, especially in the field, is also related to the degree of branching of the roots, the volume occupied by the root system, the condition of the roots at the time of harvesting and the method of harvesting. Under field conditions at Huis ter Heide, *Ageratum mexicanum* develops a small root system, whereas *Helianthus annuus* has an extensive one. This may explain the phenomenon that after cultivation of *Ageratum mexicanum* comparatively low numbers were found in the soil, notwithstanding high numbers in the roots. The reverse holds true for *Helianthus annuus*.

Rudbeckia serotina 'Kelvedon Star' proved to be a poor host of *P. penetrans* in the pot experiment (B1). *Rudbeckia fulgida* Ait. var. *speciosa* emerged as a good host in the field experiment (B2). This again leads to the supposition that within a plant genus considerable variation may occur in host suitability.

After reviewing the results of the above experiments, a number of species and varieties of *Helenium*, *Gaillardia*, *Rudbeckia* and *Coreopsis* were collected and these, along with some other Composites, were tested for their host suitability to *P. penetrans* in experiments C1 and C2.

The results of pot experiment C1 are depicted in Fig. 4. *Eriophyllum caespitosum*, along with *Tagetes patula* 'Harmony', *Gaillardia* hybrid 'Burgunder' and *Helenium* hybrids emerged as very poor hosts of *P. penetrans*, leaving significantly lower numbers in the soil than all other crops tested, excepted *Rudbeckia laciniata*. It is noticeable again that a considerable number of the species tested reduced *P. penetrans* populations significantly more than did the fallow. This indicates a distinct depressive effect of the crops on the nematode.

Again, marked differences were found within the same plant genus. Thus, *Helenium* hybrids were significantly poorer hosts for *P. penetrans* than *Helenium hoopesi*, and likewise *Gaillardia* hybrid 'Burgunder' was a significantly poorer host than *Gaillardia pulchella*. The annual *Rudbeckia* species (*R. serotina* 'Zomerzon' and *R. bicolor* 'Gouden Vlam') were significantly poorer hosts than the perennial species *R. speciosa* and *R. purpurea*. These results agree with some of those in the previous experiments (B1 and B2). *Zinnia elegans* and *Ageratum mexicanum* again proved to be very good hosts to *P. penetrans*.

In its broad outlines, the field trial at Huis ter Heide (C2) showed the same tendencies as the pot experiment (C1). However, owing to considerable variation in levels of infestation in this field (an average of 25 *P. penetrans* per 100 ml soil with a variation from 0 to 70), the results were less significant. Nevertheless, here also *Tagetes patula* 'Harmony', *Gaillardia* hybrid 'Burgunder', *Helenium* hybrids, *Rudbeckia serotina* 'Zomerzon' and *Rudbeckia bicolor* 'Gouden Vlam' proved to be very poor hosts, harbouring very low numbers of *P. penetrans* in the roots and leaving no or hardly any *P. penetrans* per 100 ml soil. *Eriophyllum* was not represented in this test. Further, *Helenium hoopesi*, *Gaillardia pulchella*, *Rudbeckia purpurea* and *R. speciosa* proved to be more susceptible hosts than the earlier mentioned, closely related crops. *Zinnia elegans* and *Ageratum mexicanum* again emerged as very suitable hosts.

Rotylenchus robustus and *Tylenchorhynchus dubius*

In some of the above experiments data were gathered on host suitability of crops to *Rotylenchus robustus* (experiments B1, B2 and C2) and *Tylenchorhynchus dubius* (experiments B1, B2, C1 and C2). These showed that the effect of cultivated crops on populations of *R. robustus* and *T. dubius* differs from that on *P. penetrans*.

Table 4 shows some figures on host suitability for *R. robustus* in experiments B1 and B2, which are in general agreement. It is noticeable here that *Helenium* hybrid 'Moerheim Beauty', *Tagetes patula* 'Harmony', *Gaillardia* hybrid 'Burgunder' and *Zinnia elegans* are poor hosts for *R. robustus*, whereas *Solidago* hybrid 'Golden mosa' and *Calendula officinalis* are good ones. The differences in population densities of *R. robustus* were relatively greater in the pot experiments (B1) than in the field experiment (B2). In experiment C2 the lowest

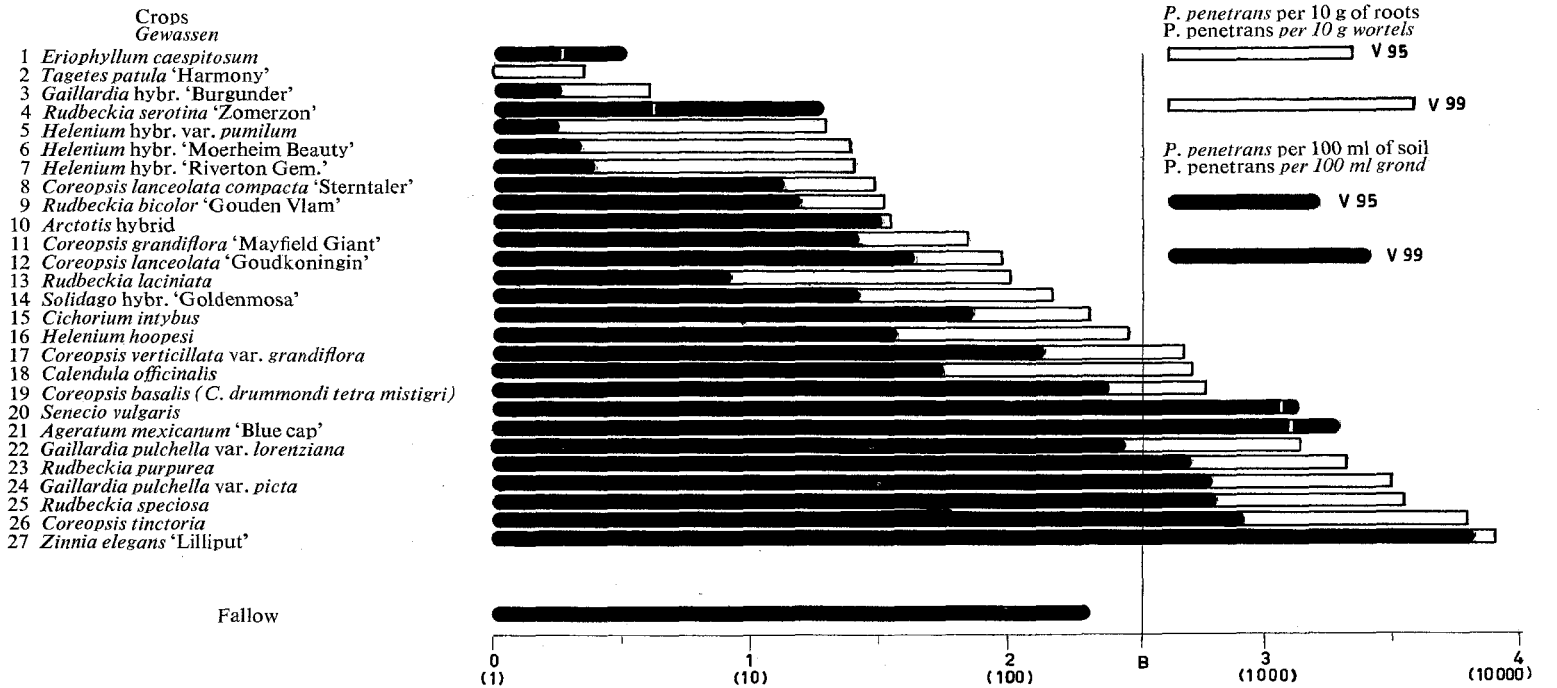


FIG. 4. Graphical presentation of the numbers of *Pratylenchus penetrans* per 10 g of fresh roots (October 1965) and per 100 ml of soil (November 1965) after cultivation in a pot test (C1) mainly with varieties of four genera of Compositae. The data were logarithmically transformed and subjected to analysis of variance. Differences in host efficiency of these crops are significant when differences of column length exceed 95% (V 95) or 99% (V 99) level. B indicates the initial population of *P. penetrans*.

Grafische voorstelling van de aantallen Pratylenchus penetrans *per 10 g vers wortelmateriaal (oktober 1965) en per 100 ml grond (november 1965) na de teelt in een potproef (C1), hoofdzakelijk met soorten van vier Composieten-geslachten. De gegevens werden, logarithmisch getransformeerd, onderworpen aan een variantie-analyse. De geschiktheid van gewassen als waardplant is significant verschillend als het verschil in kolomlengte de 95% (V 95) of 99% (V 99)-grens overschrijdt.* B *is de beginpopulatie van* P. penetrans.

TABLE 4. Suitability of different Compositae as hosts for *Rotylenchus robustus* in a pot test at Wageningen (B1) and a field experiment at Huis ter Heide (B2); the figures, which are the mean of three replicates, indicate numbers of nematodes per 100 ml of soil after the growth of the crops.

Geschiktheid van verschillende Composieten als waardplant voor Rotylenchus robustus *in een potproef te Wageningen (B1) en een veldproef te Huis ter Heide (B2); de getallen geven de aantallen aaltjes aan per 100 ml grond, als gemiddelde van drie herhalingen, na de teelt van de gewassen.*

Crops	Wageningen	Huis ter Heide
Tagetes patula 'Harmony'	55	150
Helenium hybrid 'Moerheim Beauty'	17	100
Gaillardia hybrid 'Burgunder'	8	
Solidago hybrid 'Golden mosa'	498	870
Helenium hoopesi	105	
Calendula officinalis	322	660
Heliopsis scabra	193	890
Chrysanthemum hybrid *grandiflora*	212	500
Zinnia elegans	15	
Gewassen	*Wageningen*	*Huis ter Heide*

numbers of *R. robustus* were found after cultivation of *Helenium* hybrid 'Moerheim Beauty', *Gaillardia* hybrid 'Burgunder', *Helenium* hybrid 'Riverton Gem.', *Gaillardia pulchella picta*, *Coreopsis grandiflora* 'Mayfield Giant' and *Tagetes patula* 'Harmony'. Relatively high numbers were found after *Rudbeckia laciniata*, *Ageratum mexicanum*, *Calendula officinalis* and *Solidago* hybrid 'Golden mosa'.

In experiment B1 the lowest numbers of *Tylenchorhynchus dubius* were recorded after cultivation of *Rudbeckia serotina* 'Zomerzon' (20 per 100 ml of soil), *Gaillardia* hybrid 'Burgunder' (23), *Callistephus sinensis* fl. pl. struisvederaster (70), *Helichrysum bracteatum* var. *compositum* (82) and *Helenium* hybrid 'Moerheim Beauty' (92). Very high numbers were found after *Helianthus annuus* var. *giganteus* (2600), *Brachycome iberidifolia* (1680), *Dahlia* hybrid (1280) and *Cosmos sulphureus* 'Orange Flame' (810). The remainder of the crops gave numbers from 100 to 500 per 100 ml of soil. In the field experiment C2 low population densities of *T. dubius* were estimated after *Tagetes patula* 'Harmony', *Helenium* hybrid 'Moerheim Beauty', the *Gaillardia* spp., *Rudbeckia serotina* 'Zomerzon', *Rudbeckia bicolor* 'Gouden Vlam', *Coreopsis grandiflora* 'Mayfield Giant', *Coreopsis basalis* and *Solidago* hybrid 'Golden mosa', whereas relatively high densities were found after *Ageratum mexicanum*, *Helenium hoopesi* and *Rudbeckia speciosa*. In the experiments B2 and C1 *T. dubius* showed relatively little variation after growth of the different crops. However, in B2 numbers were lowest after *Tagetes patula* 'Harmony' and *Helenium* hybrid 'Moerheim Beauty'; in C1 after *Rudbeckia serotina* 'Zomerzon', *Gaillardia pulchella* var. *picta* and *Rudbeckia bicolor* 'Gouden Vlam'.

DISCUSSION

Evidently, besides *Tagetes* species, there are other plants capable of effectively suppressing *P. penetrans* and certain other root-infesting nematodes. In this connection special interest has centred on the family of Compositae. Of

this family the tribe Helenieae includes some genera, certain species of which appear to be very poor hosts of *P. penetrans*. In addition to *Tagetes* spp., these were certain species of *Helenium*, *Gaillardia* and *Eriophyllum*. Other genera of Compositae such as *Rudbeckia*, *Coreopsis*, *Arctotis*, *Solidago*, *Calendula*, *Echinops* and *Heliopsis* contain species which are also capable of suppressing *P. penetrans*, although to a significantly smaller extent than the Helenieae mentioned. Within genera, species and varieties often differ in their suitability as hosts.

The nature of the mechanism or mechanisms causing the marked reduction of *P. penetrans* is obscure. Indications exist that *Helenium* roots contain substances which, in vitro, show strong nematicidal activity. More extensive biochemical investigations will be conducted with some of the aforementioned crops.

With the data already accumulated it is possible to provide indications as to the most favourable sequence of crops in gardens and nurseries of perennial plants, especially those which are infested with *P. penetrans*. The chances of damage by *P. penetrans* to susceptible crops such as *Phlox*, *Geum*, *Nepeta*, *Ageratum* and *Chrysanthemum* are greatly reduced if they follow crops such as *Helenium* hybrids, *Gaillardia* hybrid 'Burgunder', *Tagetes patula*, *Rudbeckia serotina* and *Rudbeckia bicolor*.

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SAMENVATTING

Het is nu reeds meer dan tien jaar bekend, dat met *Tagetes* spp. (Afrikanen) enkele soorten planteparasitaire wortelaaltjes effectief kunnen worden bestreden.

Waarnemingen van een vaste-plantenkweker en resultaten van daaropvolgende veldproeven te Huis ter Heide toonden aan, dat *Helenium* hybride 'Moerheim Beauty' een vrij beweeglijk wortelaaltje *Pratylenchus penetrans* in even sterke mate kan onderdrukken als *Tagetes patula* 'Harmony' (tabel 1 en 2). De groei van *Geum* hybride 'Prinses Juliana', een gevoelig toetsgewas voor *P. penetrans*, was opmerkelijk beter na de teelt van bovengenoemde *Tagetes*- en *Helenium*-soorten, wat in verband stond met de lage aantallen aaltjes na deze voorgewassen (tabel 1, 2 en fig. 1).

Dit was aanleiding om in potproeven te Wageningen en in veldproeven te Huis ter Heide een 35-tal verschillende Composieten, hoofdzakelijk één- en meerjarige bloemgewassen, te onderzoeken op de geschiktheid als waardplant voor *P. penetrans*. Hieruit bleek, dat de onderfamilie der Helenieae enkele geslachten bevat, waarvan bepaalde soorten zeer slechte waardplanten zijn voor *P. penetrans*. Behalve *Tagetes* spp. (bijv. *T. patula* 'Harmony') zijn dit *Helenium*-hybriden, *Gaillardia* hybride 'Burgunder' en *Eriophyllum caespitosum*. Andere Composietengeslachten zoals *Rudbeckia*, *Coreopsis*, *Arctotis*, *Solidago*, *Calendula*, *Echinops* en *Heliopsis* bevatten soorten, die de bevolkingsdichtheid van

P. penetrans onderdrukken, echter vrijwel steeds in betrouwbaar minder sterke mate dan bovengenoemde Helenieae. Zeer goede waardplanten voor *P. penetrans* zijn o.a. *Zinnia elegans*, *Helichrysum bracteatum*, enige *Chrysanthemum*-soorten en *Ageratum mexicanum* (fig. 2, fig. 4 en tabel 3). Binnen de plantegeslachten bezitten de soorten en variëteiten dikwijls een verschillende geschiktheid voor *P. penetrans* (fig. 4).

Met behulp van deze resultaten kunnen voor de bestrijding van *P. penetrans* aanwijzingen gegeven worden ten aanzien van de meest geschikte opeenvolging van gewassen op vaste-plantenkwekerijen, in plantsoenen en in tuinen.

Er werden ook gegevens verzameld over de geschiktheid als waardplant ten opzichte van *Rotylenchus robustus* en *Tylenchorhynchus dubius*. De verschillen waren minder opvallend dan bij *P. penetrans*. De laagste aantallen werden meestal gevonden na de teelt van *Helenium* en *Gaillardia* spp. (tabel 4).

Door voorlopig onderzoek werd aangetoond, dat er in de wortels van *Helenium*-soorten, evenals in die van *Tagetes*, stoffen voorkomen, die in vitro een sterke nematicide werking vertonen. Een biochemisch onderzoek naar nematicide-agentia in een aantal gewassen zal worden uitgevoerd.

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