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HERBICIDES CAN INFLUENCE THE LEVEL OF PEA INFESTATION BY *HETERODERA GOETTINGIANA*

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Abstract: The invasion, development and number of generations of *Heterodera goettingiana* in pea plants were examined in a glasshouse experiment after plants were treated with herbicides, recommended for pea cultivation (terbutryn + terbuthylazine, methabenz thiazuron, prometryne, bentazone, cyanazine, pendimethalin, benthiocarb and fluazifop-butyl). There was a non-target effect of herbicides. Prometryne, cyanazine and benthiocarb reduced female number in the roots. This effect may be due to the inhibition of hatching or/and retardation of female development.

Key words: *Heterodera goettingiana*, herbicides, pea cyst nematode, *Pisum sativum*

INTRODUCTION

It is known that some plant growth inhibitors interfere with development of plant diseases (Katan and Eshel 1973) and may affect plant-parasitic nematodes. Some herbicides may reduce nematode population not only by controlling weed hosts. They can influence nematodes directly or indirectly by altering the host-plant metabolism., They can modify in this way the egg hatch activity, disturb migration of invaded larvae to host plant or even inhibit development of nematodes in the host plant (Beane and Perry 1990; Browde et al. 1994; Das 1998; Egunjobi and Adegoke 1990; Kornobis 2000; Kraus and Sikora 1981; Levene et al. 1998a; 1998b; Perry and Beane 1989; Wong et al. 1994; Yardin and Edwards 1998). Weischer and Müller (1985) tested 29 herbicides and found that some of them were toxic to nematode, but another ones promoted nematode multiplication.

Our paper reports results of a glasshouse experiment on the effect of herbicides, recommended in pea cultivation, on the invasion, development and number of first generations of *Heterodera goettingiana* in pea plants.

MATERIALS AND METHODS

Experiment: Pea plants (*Pisum sativum* c.v. Hamil), susceptible to *H. goettingiana*, were grown from germinated seeds in 16-cm diameter pots, filled up with soil infested with 120–160 eggs of pea nematode per 1g of soil. Four replicate pots with 10 plants in each were used for each tested herbicide. Plants were kept in a glasshouse under controlled condition (25/19°C day/night, 16-h period) and watered when needed.

Tested herbicides were applied in spray solution using a hand sprayer. Pre-emergence products were applied one day after sowing, while post-emergence ones were used three weeks later, i.e. at first tendril development (BBCH 11) stage. The list of herbicides and their application rates are presented in table 1. Doses per one pot used, in the experiment, were calculated to those recommended for field condition.

The development of nematodes: Roots from 6-week old plants were washed carefully, weighed and stained with acid fuchsin in lactophenol (Goodey 1963). We understood that the numbers of all nematode stages as well as numbers of the J_2, J_3-J_4 of males would not be veritable because the estimates were made after 6-weeks, when many males might have already left the roots. On the other hand, so long term was advisable for the cyst formation.

All nematodes from 10 plants growing in each pot were counted and their number per 1g of roots was calculated. In parallel the developmental of the nematodes was recorded. So, we obtained data from four replications for particular herbicide. To statistical analysis it used Dunnet's test, and significant differences from the check at $\alpha=0.05$ was determined. The data from experiment with terbutryn + terbuthylazine were not included to statistical analysis due to their high variability.

RESULTS AND DISCUSION

Herbicides recommended as standard treatment in pea cultivation were applied in this experiment. A non-target action of these herbicides on *H. goettingiana* should be examined in the contest of the biology and population dynamics of nematodes, as such additional effects could influence the appropriate selection of herbicides used in pea crops.

Some herbicides tested in our experiment, as methabenz thiazuron, prometryne, pendimethalin and cyanazine, diminished considerably invasion of *H. goettingiana*.

Table 1. The herbicides and doses applied in the experiment

Herbicide	Dose per hectare	Dose per 100 cm^2 of pot	Application
TOPOGARD 50 WP (35% terbutryn + 15% terbuthylazine)	2 kg	2 mg	pre-emergence
TRIBUNIL 70 WP (70% methabenz thiazuron)	3 kg	3 mg	pre-emergence
GESAGARD 50 WP (50% prometryne)	3 kg	3 mg	pre-emergence
BLADEX 50 WP (50% cyanazine)	4 kg	4 mg	pre-emergence
STOMP 330 EC (33% pendimethalin)	3 l	3 μl	pre-emergence
SATURN 50 EC (50% benthiocarb)	8 l	8 μl	pre-emergence
BASAGRAN 480 SL (50% bentazone)	3 l	3 μl	post-emergence
FUSILADE W (25% fluazifop-butyl)	2 l	2 μl	post-emergence

However, terbutryn + terbuthylazine and fluazifop-buthyl stimulated the invasion (Tab. 2). It is important to realize that the total number of nematodes in roots does not include the number of males leaving root tissue to fertilize females.

Tested herbicides revealed different effect on females. Prometryne, cyanazine and benthiocarb decreased their number, while terbutryn + terbuthylazine and fluazifop-butyl increased one. However, this increase is not statistically significant.

In this experiment prometryne was the most effective herbicide in reducing the first nematode generation in pea roots. Moreover, it seems that prometryne can retard female maturation, perhaps due to its direct action on nematode or indirect influence through changes in plant metabolites. There were much younger than mature females in roots from 6-week pea plants treated with prometryne as compared with population from plants exposed to other herbicides and in the control. On the contrary, pendimethalin and benthiocarb probably favoured female maturation.

It is known that some herbicides influence population dynamics of plant-parasitic nematodes. Das (1998) observed reduction of *Meloidogyne incognita* population in mustard plants treated with thiobencarb. This herbicide also reduced number of this species in soybean (Mishera and Gupta 1991). Wrong et al. (1994) found that pendimethalin reduced number of *M. javanica* in soil and in cowpea roots. Levene et al. (1998b) observed that acifluorfen, lactofen and bentazone caused 50–60% reduction of soybean cyst nematode (*Heterodera glycines*) population. This effect was apparent when herbicide application was made to the plants but not to the soil. Thus, these authors suggested that in the roots of herbicide-treated soybean an increase of biosynthesis of compounds toxic to nematode, e.g. glyceolin, might occur.

In our experiment this relationship was not evident. Here, the effect of increasing or decreasing nematode numbers was caused by pre-emergence as well as post-emergence applications. Maybe, this phenomenon is possible through a modi-

Table 2. The number of *H. goettingiana* juveniles and females in 1g roots of pea (*Pisum sativum*) in herbicide treatment

Active ingredient	Total nematode number $\bar{x}$	Number of J2, J3 and J4 ♂ $\bar{x}$	Number of J3 and J4 ♀ $\bar{x}$	Number of white adult ♀ $\bar{x}$	Number of all female stages	Ratio of adult to juvenile females
Terbutryn + terbuthylazine	1314.8	654.8	155.8	504.3	660.1	3.2
Methabenz thiazuron	402.0	122.0	90.0	190.0	280.0	2.1
Prometryne	327.0	92.5	143.0	91.5*	234.5*	0.6
Bentazone	703.3	253.8	117.5	332.0	449.5	2.8
Cyanazine	516.0	270.0	115.8	130.3*	246.0*	1.1
Pendimethalin	546.8	243.3	46.0*	257.5	303.5	5.6
Benthiocarb	627.7	349.7	55.3*	222.7*	278.0*	4.0
Fluazifop-butyl	1191.5	583.3	125.3	483.0	608.2	3.9
None (check)	805.8	311.3	182.8	311.8	494.5	1.7

Dunnet's test for nematode number

* significantly different from the check at $\alpha=0.05$

fication of hatching invasive juveniles from cysts (see the total nematode number in table 2).

Inhibition of hatching *H. glycines* by acifluorfen was found previously (Browde et al. 1994; Wrong et al. 1994). Levene et al. (1998a) found a lower hatch activity of root exudate from acifluorfen and bentazone treated soybean plants than from control ones. In hatching tests chloridazon and tri-allate significantly reduced the hatch of *Globodera rostochiensis* from cyst (Beane and Perry 1990).

We had no intention to influence nematode populations by using herbicide. However, we attempted to find out how herbicides influence the level of pea root infestation by first nematode generation. From the practical point of view herbicides should influence negatively the total female number. The females of sedentary nematode species induce during feeding multinuclear syncitia in root tissues and in this way disturb root function and metabolism of host-plant. Well-chosen herbicide in pea cultivation may weaken, in some degree, an activity of nematodes parasitic to this plant. However, this hipothesis requeries confirmation by the experiments in field conditions.

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POLISH SUMMARY

HERBICYDY MOGĄ WPŁYWAĆ NA STOPIEŃ SKAŻENIA GROCHU PRZEZ *HETERODERA GOETTINGIANA*

W doświadczeniu szklarniowym badano wnikanie oraz rozwój *Heterodera goettingiana* w korzeniach grochu poddanego działaniu herbicydów. Stosowano następujące substancje aktywne: terbutryn + terbutylazynę, metabenz tiazuron, prometrynę, bentazon, cyanazynę, pendimetalin, bentiokarb i fluazifop-butyl. Prometryna, cyanazyna i bentiokarb obniżały liczbę samic w korzeniach. To uboczne działanie może być powodowane unieczynnianiem „czynnika wylęgu" lub/i opóźnianiem rozwoju samic.