Effects of fenvalerate and permethrin on soil arthropods and on residues in and decomposition of barley straw

ERJA HUUSELA-VEISTOLA, SIRPA KURPPA and JUHA-MATTI PIHLAVA

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The effects of two pyrethroids, fenvalerate and permethrin, were studied in field experiments on two soil types: organic soil and sandy loam. The objectives were to determine 1) the persistence of fenvalerate and permethrin in straw, 2) the effects of the pyrethroids on epigeal Arachnida and Collembola, and other soil animals and 3) the effects of the pyrethroids on the decomposition rate of straw.

The residues of fenvalerate and permethrin in straw approximately 2 months after application varied between 0.1 to above 5 mg/kg straw in 1986, 1988 and 1989, but was less than 0.5 mg/kg straw at harvest in 1991. No pesticide residues were found in straw samples taken in the following summer in the 1991 experiment.

The decomposition rate of straw did not differ between permethrin and fenvalerate-treated plots and control plots. The rate of decomposition was slightly higher in sandy soil than in organic soil, but the same on tilled and non-tilled plots.

Fenvalerate and permethrin affected the numbers of epigeal Arachnida and Collembola in the field. Araneae were more numerous in pitfall samples taken from control plots than in insecticide-treated plots immediately after treatment. In organic soil the difference was marginally significant after harvest. The abundance of Acarina in pitfalls was significantly lower in insecticide-treated plots than in control plots. In the sandy soil experiment, less Collembola occurred in pitfalls of fenvalerate plots than in permethrin or control plots. There were no differences in any of the groups of soil animals in soil cores extracted with dry funnels between the treatments.

Key words: insecticide, Arachnida, Collembola, litterbag, pitfall

Introduction

Pesticide residues in straw and soil may be directly toxic to soil animals or affect their activity. Changes in soil fauna may in turn affect an agricultural ecosystem, especially by altering nutrient cycling (HUHTA and SETÄLÄ 1984). A change in the decomposition rate of organic matter may result. In Finland, where the climate is cool and the growing period short, the activity of microbes tends to be low and as a consequence biodegradation rates are low, the effects of pesticide residues may be substantial and long term (HEINONEN-TANSKI 1989).

The half-lives of both pyrethroids vary greatly, from 10 days in plants (permethrin) to 3 months in the soil (fenvalerate)(WHO 1990a, 1990b), and permethrin has been observed to persist in soil for over 1 year (Torstensson 1993 pers. commun.). Fenvalerate and permethrin, like many other pyrethroids, are toxic to the biota. The LD^{50} of fenvalerate for *Coccinella undecimpunctata* is 0.38 mg/kg (WORKMAN 1977). With a slide dip method, the LD^{50} of fenvalerate ranged 2.0–8.0 $mg.l^{-1}$ (a.i.) (WONG and CHAPMAN 1979) and that of permethrin 0.7–14.8 $mg.l^{-1}$ (a.i.) (ROUSH and HOY 1978). Permethrin has been shown to suppress bacterial and actinomycete populations in Canadian organic soil (MATHUR et al. 1980). The pyrethroids fenvalerate and permethrin investigated in the present study are among the ten most toxic compounds to natural enemies (CROFT 1990). Both fenvalerate and permethrin are highly toxic to bees (WHO 1990a, 1990b) and have a strong repellent effect (PIKE et al. 1982).

To test the anticipated non-target effects of fenvalerate and permethrin, an experiment was made on two soil types: organic soil and sandy loam. The objectives of the experiment were to determine 1) the persistence of fenvalerate and permethrin in straw, 2) the effects of pyrethroids on epigeal arthropods and other soil fauna and 3) the effects of pyrethroids on the decomposition rate of straw.

Material and methods

Preliminary residue studies were carried out in 1986, 1988 and 1989, and the experiments were performed during 1991–1992 at the Agricultural Research Centre of Finland (ARC), Jokioinen (60°80'N 23°50'E).

Preliminary residue studies

During experiments concerning the biological evaluation and agricultural performance of fenvalerate and permethrin at ARC, plant and straw samples were taken approximately 50 days after application. The residue analyses were carried out by the State Institute of Agricultural Chemistry. Pyrethroids were determined by gas chromatography and the detection limit was 0.05 mg/kg.

Field experiments

The experiments were carried out on organic soil and sandy loam.

A factorial split-plot design was used:

In the main plots the factor was cultivation technique and the levels were
- A1 minimum till (no tilling after harvest)
- A2 normal till (ploughing after harvest)

In the subplots the factor was insecticide application and the levels were
- B1 fenvalerate
- B2 permethrin
- B3 control

The subplots were 10 * 10 m in size with four replicates. The crop was spring barley, cultivar Arra, and the seed rate was 215 kg/ha (sowing density 450 seeds/m^2). The plots were sown on 10 May 1991 on sandy loam and on 13 May 1991 on organic soil. Fertilizer was applied simultaneously: N–P–K 105–41–21 kg/ha on sandy loam and N–P–K 52–68–28 kg/ha on organic soil. Weeds were controlled chemically with Actril-S (MCPA + dichlorprop + ioxynil + bromoxynil 285/184/38/24 g/l) 3 l/ha on 17 June 1991.

The plots were treated with fenvalerate and permethrin using a tractor sprayer, those on sandy loam on 23 June 1991 and those on organic soil on 24 June 1991. Application rates were 0.1 kg/ha fenvalerate (Sumicidin; 100 g a.i./l) and 0.1 kg/ha permethrin (Ambush; 250 g a.i./l); the control was left untreated.

The plots were harvested on 24 August 1991. The A1 plots were left untilled and the other plots were ploughed on 10–14 September 1991.

Crop and soil samples

The crop or its residues were sampled two weeks and 2, 3, 4, 10 and 12 months after insecticide treatment. Each sample (0.5 kg) was a composite of subsamples representing the whole plot. After tilling, straw was sampled only from non-tilled (A1) plots. Insecticide residues were analysed in pooled samples of all replicates or in two replicates by the multiresidue method of LUKE et al.

(1981). One soil sample (diameter 9.5 cm and depth 10 cm) from each treatment of both experiments was taken on 27 September 1991 and analysed for insecticide residues according to the method of Steinwandter (1985). Both methods used consisted of extraction with acetone, partition with dichloromethane and petroleum ether, and concentration of the sample. Fenvalerate and permethrin were identified and measured either by gas chromatography with a mass selective detector or by gas chromatograph – mass spectrometry using selected ion monitoring (SIM) technique. The detection limit was 0.04 mg/kg for fenvalerate and 0.02 mg/kg for permethrin.

Arthropod samples

Arthropods on the soil surface were sampled with pitfall traps (diameter 9.5 cm and depth 10 cm). Four pitfalls per plot were placed 2 m apart in the middle of the plot. The trapping liquid was concentrated NaCl solution (300 g/l). Pitfalls were covered with a plastic roof. The trapping periods were two weeks after spraying (27 June – 16 July 1991) and two weeks after harvest (26 August – 5 September 1991). For storage, specimens were removed from salt solution to 70% alcohol. The numbers of Collembola, Acarina, Staphylinidae and Araneae were counted.

Four soil cores (diameter 9.5 cm and depth 10 cm) were taken per plot. Sampling was done twice: 3 days after insecticide treatment (27 June 1991) and after harvest (26 August 1991). Soil animals were extracted from soil with dry and wet funnels, two soil cores for each system. In dry funnels the size of samples was 240 ml, in wet funnels 200 ml. Incubation time in both systems was 44 hours. Only one sample of each treatment was extracted with dry funnel from soil cores taken in the autumn. Numbers of Acarina, Collembola, Staphylinidae, Nematoda and Enchytraeidae were counted.

Litterbags

Decomposition of barley straw was measured by the litterbag technique. After harvest, straw from each subplot was collected from the field experiments. Straw was cut into 8–10 cm lengths and dried the room temperature. Two straw samples (1 g) were taken and their dry weight was measured. Straw (1 g) was placed into each 10 cm * 10 cm polyester mesh bag. Two mesh sizes, 5 and 0.05 mm, were used; mesh size 5 mm accessed soil mesofauna and microbes, while mesh size 0.05 mm accessed only microbes and nematodes. The bags were numbered so that they could be identified upon retrieval from the field.

The litterbags were taken back to subplots on 17 September 1991. Eight litterbags of each mesh size were placed on each subplot. In non-tilled (A1) plots the mesh bags were placed on the soil surface but in tilled (A2) plots they were buried in the soil in a horizontal position at a depth of 10 cm. Total number of litterbags used was 768.

Half of the litterbags were removed from the field on 12 May 1992 and the rest on 24 July 1992. Litterbags were dried at room temperature and, after that, the straw was removed from the bags. Straw was dried at 105°C for 20 hours, after which the dry weight was measured. The initial weights were changed into dry weights. The relative decomposition (decrease of dry weight) was used as the measure of straw decomposition:

relative decomposition =
(mass loss/initial weight) * 100%

The effects of the insecticide treatments were tested by bags with different mesh sizes separately.

Results

Fenvalerate and permethrin residues

In preliminary field tests fenvalerate and permethrin were found to be relatively persistent in cereal straw samples. Residues of 0.5 to 3.0 mg/kg straw at harvest were common in many of the years, but were higher (up to 4.1 mg/kg for fenvalerate and 5.6 mg/kg for permethrin) after the very dry seasons of 1986 and 1989 (Table 1).

Table 1. Fenvalerate and permethrin residues in straw. (Residual analysis of the official testing of pesticides according to Siltanen et al. 1988, 1990, 1991)

Year	Material	Product	Application (kg/ha)	Residue mg/kg
FENVALERATE				
1986	barley straw	Sumicidin	2 × 0.1	4.1
1988	wheat (whole plant)	Sumicidin α	0.05	0.8
PERMETHRIN				
1986	barley straw	Ambush	2 × 0.1	0.5
1988	barley (whole plant)	Ambush	0.1	0.1
1988	wheat (whole plant)	Ambush	0.1	2.5
1988	oat (whole plant)	Ambush	0.1	–
1989	barley straw	Ambush	0.1	5.6
1989	wheat straw	Ambush	0.1	5.03
1989	wheat straw	Ambush	0.1	2.98

Table 2. Fenvalerate and permethrin residues in shoot and straw samples in the field experiments (mean of two analyses).

	TIME AFTER TREATMENT				
	2 weeks	2 months	4 months mg / kg dry weight	10 months	12 months
Organic soil					
Fenvalerate	1.8	0.5	0.9	<0.04	<0.04
Permethrin	1.7	0.4	0.3	0.03	<0.02
Sandy loam					
Fenvalerate	0.7	0.2	0.2	0.06	<0.04
Permethrin	2.6	0.2	0.2	0.03	<0.02

Table 2 shows the pesticide residues of shoot and straw samples in the 1991–1992 experiment. Fenvalerate residues in straw at harvest varied from 0.2 mg/kg on sandy loam to 0.5 mg/kg on organic soil; permethrin residues varied between 0.2 and 0.4 mg/kg, respectively. In the last sample taken 12 months after insecticide treatment, residues were already below the quantitative detection limit. Figures 1 and 2 show fenvalerate and permethrin residues related to day-degrees (>0°C) after insecticide treatment.

No fenvalerate and permethrin residues were detected in soil samples taken after harvest.

Effects on epigeal arthropod fauna

Pitfall trap catches per plot were statistically tested by arthropod group (Tables 3 and 4). In pitfall catches taken immediately after insecticide treatment, Araneae were significantly less abundant in fenvalerate and permethrin plots than in control plots on both sandy loam and organic soil. The difference reflects a difference in the number of Linyphiidae, as the other common spider family, Lycosidae, was evidently not affected by either treatment (Table 3).

There were significantly fewer Acarina in the

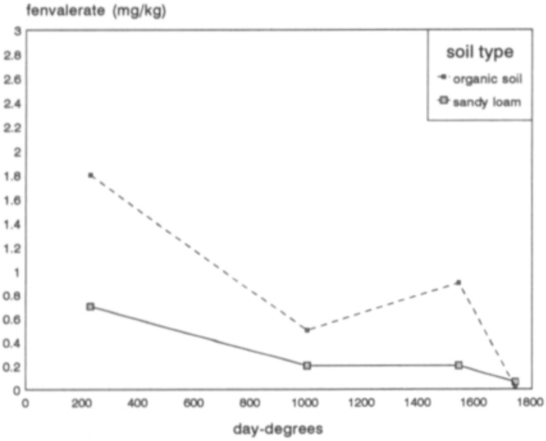

Fig. 1. Fenvalerate residues in shoot and straw samples related to day-degrees accumulated after spraying (>0 C°).

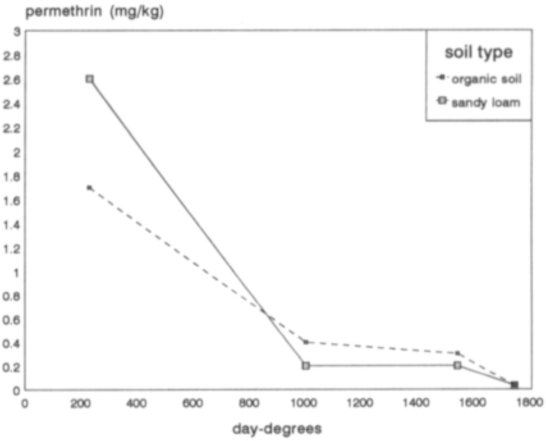

Fig. 2. Permethrin residues in shoot and straw samples related to day-degrees accumulated after spraying (>0 C°).

pitfalls in fenvalerate-treated than in control plots, and permethrin-treated plots had less Acarina than control plots only on organic soil (Table 3). On sandy loam, significantly less Collembola occurred in the pitfalls of fenvalerate-treated plots than in permethrin and control plots (Table 3).

In pitfall trap catches taken after harvest on organic soil, the abundance of Araneae differed marginally between treatments: there were more spiders in control than in insecticide-treated plots (Table 4).

Table 3. Effect of insecticide treatments on the epigeal arthropod fauna. Pitfall trapping after insecticide treatment. O = Organic soil, S = sandy loam. Values are mean catches per pitfall. One-way analysis of variance. Means with different letter differ significantly (p<0.05) in pairwise contrasts.

	Insecticide treatment				
	Fenvalerate	Permethrin	Control	F	P
Collembola					
O	16.0	20.9	15.9	1.49	0.2594
S	52.4 a	86.0 b	107.8 b	11.53	0.0011
Acarina					
O	2.6 a	1.9 a	5.0 b	5.81	0.0146
S	17.7 a	25.7 ab	33.3 b	2.98	0.0831
Araneae					
O	5.8 a	6.4 a	17.9 b	153.60	0.0001
S	3.4 a	3.2 a	7.4 b	16.23	0.0002
– Lycosidae					
O	3.3	3.3	3.8	0.99	0.3964
S	1.5	1.6	1.7	0.12	0.8870
– Linyphiidae					
O	2.4 a	2.9 a	13.9 b	130.5	0.0001
S	1.8 a	1.6 a	5.6 b	20.9	0.0001

Table 4. Effect of insecticide treatments on the epigeal arthropod fauna. Pitfall trapping after harvest. O = Organic soil, S = sandy loam. Values are mean catcheser pitfall. One-way analysis of variance.

	Insecticide treatment				
	Fenvalerate	Permethrin	Control	F	P
Collembola					
O	12.4	11.7	11.6	0.07	0.9334
S	20.6	14.2	8.0	2.10	0.1594
Acarina					
O	0.6	1.3	0.9	3.08	0.0777
S	0.6	0.8	1.3	0.36	0.7022
Araneae					
O	2.5	2.3	3.4	2.94	0.0856
S	3.3	3.8	3.3	0.37	0.6981
– Lycosidae					
O	0.3	0.3	0.4	0.33	0.7221
S	0.6	0.8	0.5	0.90	0.4303
– Linyphiidae					
O	2.2	1.9	2.9	1.88	0.1890
S	2.6	2.9	2.8	0.15	0.8647

Table 5. Effect of insecticide treatments on the soil fauna separated with dry funnel. Soil cores sampled three days after insecticide treatment. Values are mean catches soil core (volume 240 ml). O = Organic soil, S = sandy loam. One-way analysis of variance.

	Insecticide treatment				
	Fenvalerate	Permethrin	Control	F	P
Collembola					
O	9.8	7.2	6.7	0.80	0.4708
S	3.7	2.8	4.0	0.81	0.4639
Staphylinidae					
O	0.2	0.1	0	1.20	0.3317
S	0.1	0.4	0.1	1.17	0.3399
Acarina					
O	9.6	10.5	9.7	0.09	0.9173
S	25.1	23.5	23.1	0.03	0.9749
Enchytraeidae					
O	0.2	0.3	0.1	1.11	0.3584
S	0	0	0.2	2.03	0.1679

Effects on soil fauna

There was no significant difference in the number of soil animals in soil cores extracted with the dry funnel three days after insecticide treatment (Table 5). Only part of the samples taken after harvest were analysed. Because of the small number of samples, data was not statistically tested.

The number of soil animals in soil cores extracted with the wet funnel was very small, and the samples were not further analysed.

Table 6. Relative decomposition of straw (% of dry weight) in litterbags from 17 September 1991 to 12 May 1992 on organic soil. Two-way analysis of variance.

	mesh size 5 mm			mesh size 0.05 mm		
	$\bar{x}$	F	P	$\bar{x}$	F	P
Cultivation technique		3.70	0.150		19.2	0.117
Non-tilled	19.3			19.2		
Tilled	24.0			23.3		
Insecticide treatment		1.02	0.390		1.21	0.332
Fenvalerate	20.3			19.4		
Permethrin	22.9			21.4		
Control	21.7			22.9		

Table 7. Relative decomposition of straw (% of dry weight) in litterbags on nontilled plots of the experiments on on organic soil and sandy loam. One-way anova.

	Mesh size 5 mm			Mesh size 0.05 mm		
	$\bar{x}$	F	P	$\bar{x}$	F	P
17 SEPTEMBER 1991 – 12 MAY 1992						
Sandy loam						
Insecticide treatment		0.79	0.497		1.45	0.306
Fenvalerate	30.5			33.4		
Permethrin	33.0			31.2		
Control	33.3			35.4		
17 SEPTEMBER 1991 – 24 JULY 1992						
Organic soil						
Insecticide treatment		2.38	0.173		0.26	0.776
Fenvalerate	32.7			24.5		
Permethrin	33.3			23.0		
Control	23.8			21.6		
Sandy loam						
Insecticide treatment		2.49	0.163		1.61	0.276
Fenvalerate	31.2			31.3		
Permethrin	28.6			27.1		
Control	37.5			31.5		

Decomposition of straw

The decomposition rate of straw did not differ statistically between the insecticide treatments. Relative decomposition rates at different points of time are presented in Tables 6–7.

The litterbags removed from tilled plots at both experimental sites in July and on sandy loam in May contained considerable amounts of soil. Because of the difficulties of removing the soil from the straw the bags from tilled plots were excluded from the analysis except for those removed from organic soil in May. The relative decomposition rate was slightly higher in tilled than in non-tilled plots, but not significantly (Table 6).

The mass loss of straw did not differ between litterbags removed in May and in July. Only slight decomposition was observed at the beginning of the summer perhaps because of the very dry conditions.

Discussion

Pesticide residues in straw observed in the 1991 experiment were smaller than recorded earlier. Rain has been shown to have an essential role in removing residues from plants. McDowell (1987) found that fenvalerate residue wash-off from plants was more related to total rainfall than to intensity of rain. Thus wide variations in the pesticide residue contents of straw may be measured even where pesticide doses would be similar. In our experiment, insecticide residues were not found in soil samples taken in autumn. However, Braunschweiler (1992) found the fenvalerate content in top soil to be 0.07 mg/kg and 0.04 mg/kg in clay and sandy soil, respectively, in soil samples taken two months after application (experiment carried out under closely resembling conditions). In his experiment, fenvalerate concentration in top soil increased towards autumn, presumably due to leaching of pesticide from plants.

Both fenvalerate and permethrin decreased the number of Linyphiidae in pitfall trap catches. Andersen (1990) found fenvalerate to decrease the activity of spiders for about six weeks, here the effect seems to last ten weeks in organic soil. Similarly, Nilsson (1980), Ekbom (1985) and Heimbach (1991) showed that fenvalerate decreased the abundance of spiders.

In spite of the small plot size (10 x 10 m), there were differences in the abundance of carabids among the insecticide treatments. In sandy soil we found the number of *Bembidion guttula* (Fabricius) in pitfalls to be smaller in fenvalerate-treated than in control plots. In a laboratory experiment DE Clerq et al. (1991) found fenvalerate to increase the mortality of ground beetles. Hagley et al. (1980) noticed the susceptibility of carabids to permethrin to be inversely related to their size. In the pitfall catches of our experiment, the effect of permethrin was noticed on two small carabid species, *Trechus quadristriatus* (Schrank) and *Bembidion guttula*, compared to control.

Environmental factors (weather), various treatments (pesticides, fertilizers, tilling), species, cultivars, chemical properties of straw and the activity of microbes and animals may affect the decomposition rate of straw (Summerell and Burgess 1989). Although the decomposition of straw is primarily based on the activity of microbes, soil animals may also be important (Singh and Gupta 1977). Thus, insecticides may indirectly decrease the decomposition rate. However, in our experiment fenvalerate and permethrin treatments did not affect the decomposition rate of straw. We do not know of any published study on the effects of insecticides on straw decomposition. In a study on the effect of herbicides on soil fauna and straw decomposition, House et al. (1987) found that straw decomposition was more rapid in non-treated than in glyphosate-treated plots. Abiotic factors such as temperature and moisture of soil were more significant than herbicides in regulating soil microarthropod numbers and their activity. Torstensson (1988) did not find any of 17 fungicides to affect the decomposition rate of wheat straw.

In our experiment, about 30% of straw was decomposed by the next summer. Table 8 shows straw decomposition rates presented in literature. In an experiment on a subarctic soil, Cochran (1991) did not notice any significant mass loss of stems or leaves during winter when the soil was frozen and microbial activity was reduced.

Decomposition of straw is usually studied with litterbags. The total weight loss of straw from bags results from three loss components: leaching, microbial decomposition and loss of straw particles through the mesh openings (Christensen 1985). In many experiments straw decomposition has been more rapid when the straw was buried in soil than when it was on the soil surface (Cochran 1991, Summerell and Burgess

Table 8. Decomposition rates of straw.

Crop	Site	Decomposition (=mass loss)	Reference
Wheat	Pullman (Washington) Bushland (Texas) West Lafayette (Indiana)	30 weeks after harvest 35–42%	Stott et al. 1986
Barley	Alaska	leaves: on soil surface 6.3%/month, in soil 7.0%/month stems: on soil surface 3.5%/month, in soil 4.3%/month	Cochran 1991
Wheat, Barley	Askov (Denmark)	during first month mass loss 30% during 6 months 50% approximately 0.10–0.17%/day	Christensen 1985
Barley	Askov (Denmark)	during 230 days 25% (15.9.–5.5.) 17% during first month	Christensen 1984
Wheat	Pullman (Washington)	during 33 days 12% during 377 days 33% approximately 0.05%/day	Collins et al. 1990
Wheat, Barley, Rye wheat (23 cultivars)	Kimberly (Idaho)	during 384 days 54–75% (over half of the cultivars 64–66%)	Smith and Peckenpaugh 1986
Barley	Örbyhus Estate (Sweden)	during first winter 4% (0.022 %/d) early summer 20% (0.255 %/d) late summer 35% (0.250 %/d) during second winter no mass loss	Wessen and Berg 1986

1989). A similar trend was noticed in our experiment, although the difference was not statistically significant. Straw decomposition may decrease if the straw is not evenly distributed in soil, and the soil-straw contact is small (Brown and Dickey 1970). The decomposition of litter in mesh bags and at different layers of soil may differ because the natural environment, especially moisture, is changed (StJohn 1980, Dickinson 1983). In spite of its, limitations the litterbag technique is widely used. However, the litterbag technique are only gives relative values and should not be confounded with absolute estimates of litter decomposition (Wessen 1983).

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SELOSTUS

Fenvaleraatin ja permetriinin vaikutus maan niveljalkaisiin ja ohran oljen hajoamiseen

Erja Huusela-Veistola, Sirpa Kurppa ja Juha-Matti Pihlava

Maatalouden tutkimuskeskus

Maatalouden tutkimuskeskuksessa tutkittiin vuosina 1991–1992 kahden hyönteistorjunta-aineen, fenvaleraatin ja permetriinin, vaikutuksia peltoekosysteemiin kenttäkokeissa kahdella maalajilla. Tutkimuksessa haluttiin selvittää torjunta-aineiden säilymistä oljissa, niiden vaikutuksia oljen hajoamisnopeuteen ja maanpinnalla elävien niveljalkaisten ja maaperäeläinten esiintymiseen.

Vuosina 1986, 1988 ja 1989 tehtyjen torjunta-aineiden biologisen tehokkuuden tutkimusten yhteydessä havaittiin viljan oljissa melko korkeita fenvaleraatti- ja permetriinipitoisuuksia (jopa 4–5 mg/kg). Tässä kokeessa sadonkorjuun yhteydessä otetuissa näytteissä pitoisuudet olivat alle 0.5 mg/kg kuiva-ainetta, eikä oljessa havaittu torjunta-ainejäämiä enää seuraavana kesänä. Todennäköisesti kasvu- ja sääolosuhteet vaikuttavat hyvin paljon siihen, miten suuria torjunta-ainepitoisuuksia oljessa sadonkorjuun yhteydessä tavataan. Syksyllä otetuissa pintamaanäytteissä ei havaittu pyretroidijäämiä.

Syksyllä karikepusseihin laitetusta oljesta noin 30 % oli hajonnut seuraavaan kesään mennessä. Oljen hajoamisnopeudessa fenvaleraatilla tai permetriinillä käsitellyissä ruuduissa ei havaittu eroa kontrolliruutuihin verrattuna. Kynnettyjen ja muokkaamatta jätettyjen ruutujen välillä ei myöskään havaittu eroa oljen hajoamisnopeudessa.

Maan pinnalla liikkuvista niveljalkaisista hämähäkkejä oli vähemmän pyretroideilla käsitellyissä kuin kontrolliruuduissa heti käsittelyn jälkeen otetuissa kuoppapyydysnäytteissä. Orgaanisella maalla em. ero havaittiin vielä sadonkorjuun jälkeen otetuissa näytteissä. Orgaanisella maalla kuoppapyydysnäytteissä punkkeja oli vähemmän käsitellyissä ruuduissa kuin kontrolliruuduissa. Hietamaalla oli fenvaleraattiruuduissa merkitsevästi vähemmän hyppyhäntäisiä kuin permetriini- ja kontrolliruuduissa. Tässä tutkimuksessa havaitut erot niveljalkaismäärissä eri käsittelyjen välillä kuvastavat melko nopeasti ilmeneviä ja lyhytaikaisia vaikutuksia. Kuitenkin torjunta-aineiden subletaalit vaikutukset voivat aiheuttaa merkittäviä muutoksia populaation koossa ja rakenteessa, vaikka kuolleisuus akuutin myrkyllisyyden vuoksi ei olisikaan suurta.