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Effect of Agrochemicals on Nematode Community Structure in a Soybean Field

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Nematodes play significant roles in the decomposition of soil organic matter, mineralization of plant nutrients and nutrient cycling (Griffiths 1994). Since nematodes are ubiquitous and occupy important positions in the detritus food web, they can be used as sensitive indicators of ecosystem change (Bongers 1990; Freckman and Ettema 1993). Analysis of the nematode community trophic structure in agroecosystems helps provide important insights into ecosystem-level processes (Parmelee 1995) and increases our understanding of responses of nematode communities to agricultural management, such as agrochemicals (Bohlen and Edward 1994; Yardim and Edwards 1998; Liang *et al.* 2002).

As important agrochemicals, acetochlor and seed coating are extensively used in soybean fields in Northeast China. The application of acetochlor and seed coating had effects on the composition of soil microbiota. Chen *et al.* (1999) reported that the acetochlor reduced the numbers of fungi and bacteria. But little is known about the impacts of acetochlor and seed coating on the nematode community structure until now in Northeast China. The objectives of this study were to: 1) monitor the effect of acetochlor and seed coating on nematode community structure in a soybean field and 2) to evaluate several ecological indices of nematode community in the Lower Reaches of Liaohe Plain, Northeast China.

MATERIALS AND METHODS

The field work in this study was conducted at the Chinese Ecosystem Research Network (CERN) site established in 1987 at the Shenyang Experimental Station of Ecology (41°32'N, 123°23'E), Chinese Academy of Sciences, Sujiatun District, Liaoning Province. The Station is located at Shilihe village, with a mean annual temperature of 7.0-8.0 °C. Its annual precipitation is about 700 mm, and the frost-free period is 147-164 d. The soil at the study site is classified as meadow burozem, which suitable for growing corn and soybean. The experiment was based on a randomized block design with nine plots, 100 m^2 each, involving three treatments with three replicates. The field was planted with soybean (*Glycine max* L.) in May 2001. The selected soybean variety is Liaodou10 and the proceeding crop was corn. The three treatments were: 1) treatment with acetochlor (herbicide); 2) treatment with seed coating; 3) treatment with no agrochemicals (control).

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During a soybean growing season, the samplings were taken on 18 May 2001 (Sowing stage), 10 June (seeding stage), 23 July (Flowering stage), 29 August (Podding stage) and 24 September (Ripening stage), respectively. Each soil sample from the depth of 0-10cm comprised 5 cores. Nematodes were extracted from 100 g (fresh wt) soil from each sample using a sieving and centrifugation procedure (Liang *et al.* 2002). All extracted nematodes in each sample were counted and expressed per 100g dry wt soil according to the soil moisture (Liang *et al.* 1999). Nematodes in each sample were identified to family level using light microscope. The classification of trophic groups was assigned to bacterivores, fungivores, plant-parasites and omnivore-predators based on known feeding habitats or stoma and esophageal morphology (Yardim and Edwards 1998).

Several ecological indices of nematode community structure were calculated from data on density of the nematode family. The four ecological indices of nematode communities, as used by Yeates and Bongers (1999), were calculated as:

$$\text{Diversity } H' = -\sum p_i \ln p_i$$
$$\text{Evenness } J' = H'/H'_{max} = H'/\ln S$$
$$\text{Richness SR} = (S-1)/\ln N$$
$$\text{Dominance } \lambda = \sum p_i^2$$

Where p_i is the proportion of individuals in the ith taxon, S is the number of taxa, N is the number of individuals identified.

Table 1. Mean relative abundance (MRA)(%) of soil nematodes under three treatments during the study period

Family	Trophic group*	MRA			Dominance		
		A**	S**	CK**	A	S	CK
Cephalobidae	BF	7.1	8.0	7.4	++***	++	++
Rhabditidae	BF	2.1	2.0	2.3	++	++	++
Aphelenchidae	FF	1.1	0.4	0.6	++	+	+
Aphelenchoidae	FF	1.2	0.6	0.7	++	+	+
Anguinidae	PP	0.8	0.0	0.5	+	+	+
Criconematidae	PP	0.8	0.2	0.0	+	+	+
Hoplolaimidae	PP	47.7	46.6	58.8	+++	+++	+++
Longidoridae	PP	0.0	0.1	0.1	+	+	+
Paratylenchidae	PP	4.9	13.6	13.1	++	+++	+++
Pratylenchidae	PP	27.9	24.3	12.4	+++	+++	+++
Tylenchidae	PP	4.7	2.8	3.2	++	++	++
Dorylaimidae	OP	1.6	1.3	0.9	++	++	+
Leptonchidae	OP	0.1	0.1	0.0	+	+	+

*Trophic group: BF, bacterivores; FF, fungivores; PP, plant-parasites; OP, omnivore-predators. **A is the treatment with acetochlor; S is the treatment with seed coating; CK is the treatment with no agroechemicals. ***+ (MRA≤1), rare family; ++ (1<MRA≤10), ordinary family; +++ (MRA >10), dominant family.

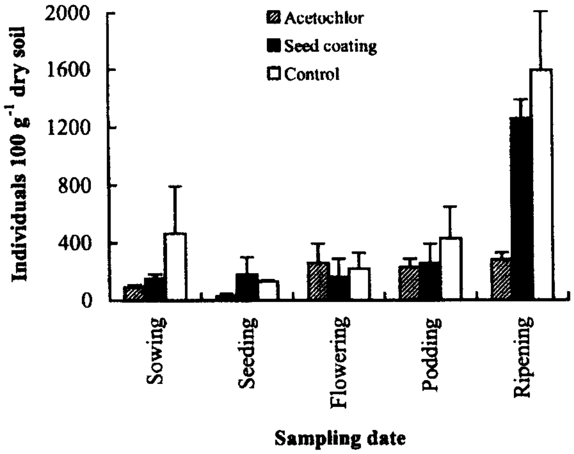

Figure 1. Changes in the numbers of total nematodes under the three treatments during the study period

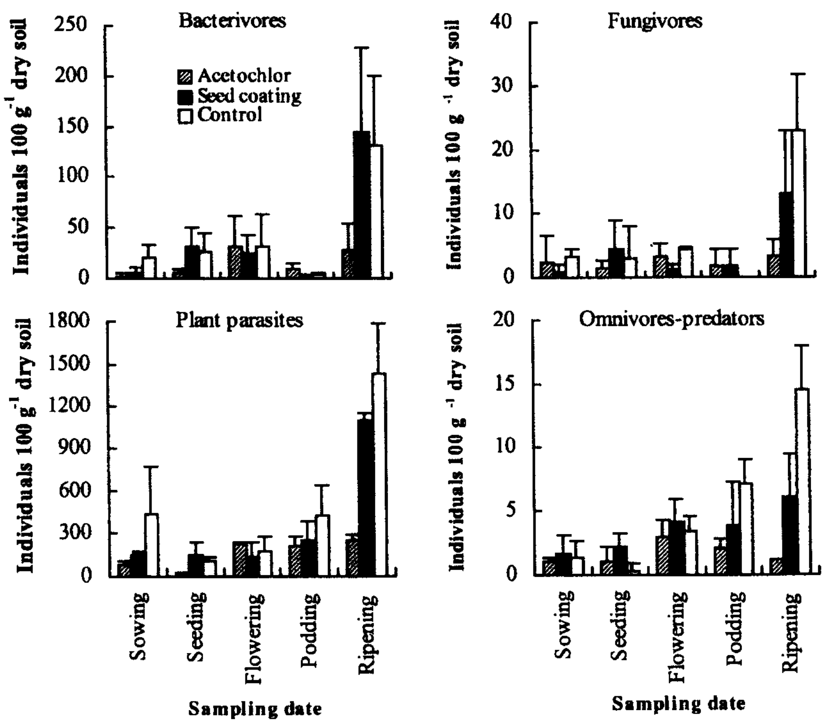

Figure 2. Distribution of nematode trophic groups under three treatments during the study period

RESULTS AND DISCUSSION

Thirteen families were observed in the nematode suspensions. Hoplolaimidae, Paratylenchidae, and Pratylenchidae were found to be the dominant families. While Anguinidae, Criconematidae, Longidoridae and Leptonchidae were observed to be rare families. The common families included Aphelenchidae, Aphelenchoidae, Cephalobidae, Dorylaimidae, Rhabditidae, Tylenchidae (Table 1).

During the soybean growing period, the numbers of total nematodes were lower in the acetochlor plots than in the seed coating and control plots except flowering stage (Fig.1). Acetochlor treatment could significantly inhibit the numbers of total nematodes as compared to seed coating treatment during the soybean growing season. The numbers of total nematodes were lower in the seed coating plots than in the control plots during the soybean growing season except seeding stage. The plant-parasites were found to be the dominant trophic group, and omnivore-predators were observed to be the least one. The both trophic groups averaged 87.5% and 1.3% of the nematode community, respectively. Except the podding stage, the numbers of bacterivores were lower in the acetochlor plots than in the control plots (Fig.2). The numbers of fungivores were lower in the acetochlor plots than in the control plots during the soybean growing season except the podding stage. The numbers of plant parasites exhibited similar trend to those of total nematodes (Fig.2). Significant differences were observed between the sampling dates, between the treatments in the numbers of total nematodes, plant parasites and omnivores-predators during the soybean growing period ($P<0.01$). Significant differences were found between the acetochlor treatment and the control in the numbers of bacterivores and fungivores during the soybean growing season ($P<0.05$). No significant differences were observed between the seed coating treatment and the control in the numbers of bacterivores and fungivores during the study period.

Table 2. Variation of ecological indices of soil nematodes under the three treatments during the study period

	SOW			SEE			FLO			POD			RIP		
	A	S	CK	A	S	CK	A	S	CK	A	S	CK	A	S	CK
H	0.95	1.1	0.76	1.79	1.5	1.59	1.22	1.3	1.48	1.08	0.7	0.60	0.95	1.0	1.46
J′	0.53	0.6	0.36	0.82	0.7	0.86	0.64	0.6	0.75	0.59	0.4	0.37	0.49	0.5	0.71
S	1.11	1.0	1.19	2.07	1.5	1.10	1.18	1.5	1.38	0.99	0.8	0.73	1.02	0.8	1.06
λ	1.11	0.4	0.64	0.23	0.2	0.25	0.40	0.3	0.32	0.45	0.6	0.73	0.56	0.5	0.31

*SOW, sowing stage; SEE, seeding stage; FLO, flowering stage; POD, podding stage; RIP, ripening stage.

Diversity calculated across families, H′ tended to be greater in the acetochlor plots than in the control plots at sowing, seeding, podding stages. The values of evenness (J′) were higher in the acetochlor and seed coating plots than in the control plots during the sowing and podding stages, while they exhibited an inverse trend during the flowering and ripening stages. The values of richness (SR) were lower in the acetochlor plots than in the control plots during sowing, flowering and ripening stages. Those of SR were higher in the seed coating plots than in the control plots across seeding, flowering and podding stages. The values of dominance (λ) were higher in the acetochlor plots than in the control plots across sowing, podding and ripening stages (Table 2).

The application of the agrochemicals could influence the soil nematode community structure. Our study indicated that the acetochlor and seed coating reduced the numbers of total nematodes. In most stages, the numbers of nematode trophic groups were significantly lower in the acetochlor plots than in the control plots. Yardim and Edwards (1998) found that fungicides and herbicides could reduce the bacterivores and fungivores, other researchers observed that bacteria and fungi around the rhizosphere supported the local abundance of fungivores and bacterivores (Curl and Truelove 1986). Yeates *et al.* (1999) reported that bacterivores were consistently low in herbicide-treated plots. These results were consistent with our study. The acetochlor could influence the roots of soybean and decrease the amounts of fungi and bacteria (Chen *et al.* 1999) which could inhibit the numbers of the bacterivores and fungivores.

The numbers of plant-parasitic nematodes and omnivores-predators were lower in the seed coating and acetochlor plots than in the control plots during the study period. Various reports have indicated that agrochemicals can cause increases in plant-parasitic nematode populations (Bohlen and Edwards 1994; Parmelle et al. 1993; Yardim and Edwards 1998). Our experiment did not support these results. In our study, acetochlor and seed coating could reduce the numbers of plant-parasite nematodes, because these agrochemicals may reduce the numbers of soil nematodes directly by inhibiting the incubation or constraining the larva moving towards the host and by influencing the development of the roots in the short period (Levene *et al.* 1998). They can also reduce the amount of weeds and influence the crop growth to inhibit the plant-parasites indirectly (Mahn and Kastner 1985).

The results of our study together with those of other researchers have shown that the soil nematode community structure can be greatly influenced by agrochemical applications. Total nematodes and the four trophic groups were very sensitive to the application of acetochlor, while plant parasites and omnivores-predators were significantly reduced in seed coating treatment as compared to control treatment in our experiment. We suggest that pesticide applications to agroecosystems should be considered carefully and understood clearly, because soil nematodes play important roles in the detritus food webs of agroecosystems, not only causing damage to crops but also contributing to organic matter decomposition and mineralization and nutrient cycling (Yardim and Edwards 1998). Among the ecological indices tested, richness (SR) was effective in distinguishing the differences ($P<0.05$) between the acetochlor plots and the control plots during the soybean growing season in our study.

In order to achieve a sustainable agroecosystem, the eco-friendly technologies for crop productions should be developed. The use of allelochemicals as herbicides for weed control has a great potential in the near future.

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