EFFECT OF GROWING CROPS AND CROP RESIDUES IN ARABLE FIELDS ON NEMATODE PRODUCTION

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ABSTRACT. The effect of growing wheat and of various crop residues on the production of the major non-herbivorous soil nematode taxa was studied in pots and microcosms with arable soil and in undisturbed soil cores taken from an arable field. Production of bacterivorous Rhabditidae was in particular stimulated by easily decomposable organic matter such as fresh crop residues and dissolved glucose and proteose-peptone. Production of bacterivorous Cephalobidae was stimulated by growing wheat and by fresh and resistent crop residues. Production of bacterivorous Monhysteridae and Dorylaimidae was only stimulated by fresh crop residues deposited on the soil surface. Production of fungivorous Aphelenchidae and Aphelenchoididae was stimulated by growing wheat and by resistent crop residues, respectively. Substrates with high nitrogen contents gave the strongest stimulation of nematode production. Dry soil conditions reduced the production of bacterivorous taxa, the Cephalobidae excepted.

1. Introduction

Nematodes are the most numerous soil inhabiting metazoans. The topsoil of arable fields in The Netherlands (25 cm) contained 0.5×10^6 to 18.5×10^6 specimens m^{-2}, i.e. up to 2 kg carbon. $hectare^{-1}$ (Brussaard et al., 1990). In terrestrial habitats nematodes are sustained by growing crops, crop residues and manure. In turn, the nematodes affect plant growth and mineralization of nutrients (Freckman, 1988; Verhoef and Brussaard, 1990). Generally bacterivores constitute the numerically dominating category, followed by the herbivores, the fungivores and the omnivores/predators, respectively. On the level of taxonomic composition large differences exist between nematode faunas of different agricultural fields. These differences are assumed to be caused by differences in physico-chemical and agricultural management conditions. For example, in the arable fields in Kjettslinge, Sweden, under barley bacterivores were dominated by Cephalobidae (Boström and Sohlenius, 1986),

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whereas in comparable Dutch arable fields (Brussaard et al., 1990) Rhabditidae dominated.

Little is known about the development of populations being part of the other non-herbivorous feeding guilds. Therefore, the production of non-herbivorous nematode taxa was measured i)in undisturbed soil cores, ii)in microcosms with soil amended with crop residues and iii)in pots with growing wheat. Results are used to analyse which factors determine the relative abundancy of taxa in arable soil.

2. Materials and Methods

Incubation of undisturbed soil cores in the laboratory

After the wheat harvest in 1986, 40 cores of the upper 10 cm of soil were taken from two differently managed arable fields on the Lovinkhoeve experimental site, The Netherlands. The cores contained fresh decomposing wheat roots as the most recently added organic substrate and were incubated at 20^{0}C. After 7, 14, 28, 42 and 57 days, nematodes were isolated.

Also after wheat harvest, 12 cores were taken of the upper 5 cm of soil from each of the arable fields on the Lovinkhoeve. The surface of these cores was dressed with 100 mg dried and ground lucern and cores were subjected to different soil moisture regimes, ranging from -3.1 kPa (wet) to -31 kPa (dry). After an incubation time of 4 weeks at 20^{0}C nematodes were isolated.

Pot experiment with wheat growing in sandy clay soil in the glasshouse

Thirty plastic pots (3 l) were filled with 3.8 kg sandy clay each. Ten wheat seedlings were planted in half of the pots, and all 30 pots were kept in a glasshouse at 17^{0}C and a light/dark regime of 14/10 hours. After 4, 5, 6, 7 and 8 weeks incubation, three replicates of each series were analysed for total numbers of nematodes and numbers per separate taxum.

Laboratory incubation of sieved and homogenized soil amended with organic matter in microcosms

Lovinkhoeve soil, 200 g, was amended with 170 mg carbon in the form of different types of organic matter: dissolved glucose (mN) and proteose-peptone (C:N ratio < 4), dried and ground wheat straw (C:N ratio = 70) and lucern (C:N ratio = 13). Soil was incubated in jars (0.47 l) closed with parafilm, at

10^{0}C. Nematodes were isolated after 0, 14, 28, 56, (glucose, proteose-peptone), 121 and 174 (crop residues) days of incubation. The treatments were in triplicate.

3. Results and Discussion

Fig.1. shows nematode population dynamics in the undisturbed soil cores after incubation for 57 days. Total numbers ranged from c. 1600 to 2450 per 100 g fresh soil.

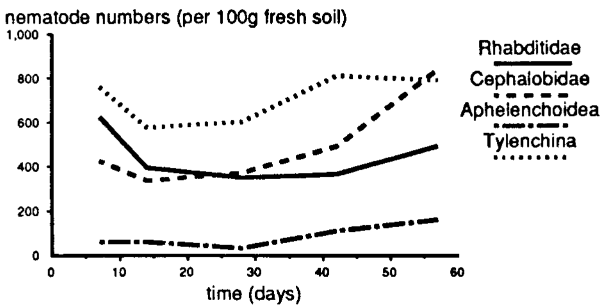

Figure 1. Numbers of nematodes of different taxa, per 100 g of fresh soil, as isolated from undisturbed soil cores (Lovinkhoeve) after laboratory incubation at 20^{0}C for 57 days.

Growing wheat led to a strong increase in some microbivorous taxa of nematodes, especially near the roots (Table 1).

TABLE 1. Effects of growing wheat on numbers of soil nematodes in a pot experiment after up to 8 weeks growth (average numbers of nematodes per 100 g fresh soil and 100 g fresh roots).

Nematodes	Soil without barley	Soil with barley	Roots
<u>Bacterivores</u>	150	346	17 800
Rhabditidae	52	167	7 200
Cephalobidae	31	125	9 700
Others	67	54	900
<u>Fungivores</u>	51	126	7 300
Aphelenchus	9	98	7 100
Others	42	28	200

Most taxa proved to be vulnerable to dry soil conditions (Table 2).

TABLE 2. Numbers of nematodes per 100 g fresh soil, isolated from undisturbed soil cores from the Lovinkhoeve, covered with 100 mg lucern meal, subjected to different soil moisture regimes, after 4 weeks of incubation at 20°C. Figures followed by different symbols are significantly different ($p < 0.05$).

Nematodes	Soil moisture regime (kPa)		
	-3.1	-10	-31
Rhabditidae	2641^{a}	3214^{a}	748^{b}
Dorylaimidae	1023^{a}	601^{a,b}	448^{b}
Cephalobidae	509^{a}	516^{a}	714^{a}
Monhysteridae	574^{a}	1579^{b}	233^{a}

Table 2 and Fig. 2 show that the following conditions determined the development of the most common soil nematode taxa.

Rhabditidae were stimulated by all types of easily decomposable organic matter, in particular with a high N content under relatively moist soil conditions. Cephalobidae were stimulated by all types of solid substrates, including resistent soil organic matter and growing crops, and are least vulnerable to dry soil conditions. Monhysteridae and Dorylamidae were only stimulated by easily decomposable organic matter deposited on the soil surface under wet conditions (pKa ≥ -10). Aphelenchidae were only stimulated by growing crops. Aphelenchoididae were only stimulated by resistent soil organic matter, and assumed fungivorous Tylenchidae did not much numerically react on any treatment.

The results indicate that the increase of a nematode taxum depends on the type of organic substrate, the site of deposition and soil humidity: dead or alive, dissolved or solid, easily decomposable or resistent organic matter, low or high N content, deposited on the soil surface or incorporated in the soil under dry or wet moisture conditions.

4. Conclusions

The dominance of Cephalobidae in the Kjettslinge (Sweden) experimental site thus could be explained by the monoculture of barley on that site, leaving relatively resistent crop residues with a low N content in the soil and by the annual rainfall being 30% lower than on the Lovinkhoeve site (Holland). The dominance of Rhabditidae on the Lovinkhoeve (Holland) site could be explained by the crop rotation, which apart from the cereals barley and wheat included potatoes and sugar beet, both containing higher amounts of nitrogen than cereals, and by the wet soil conditions.

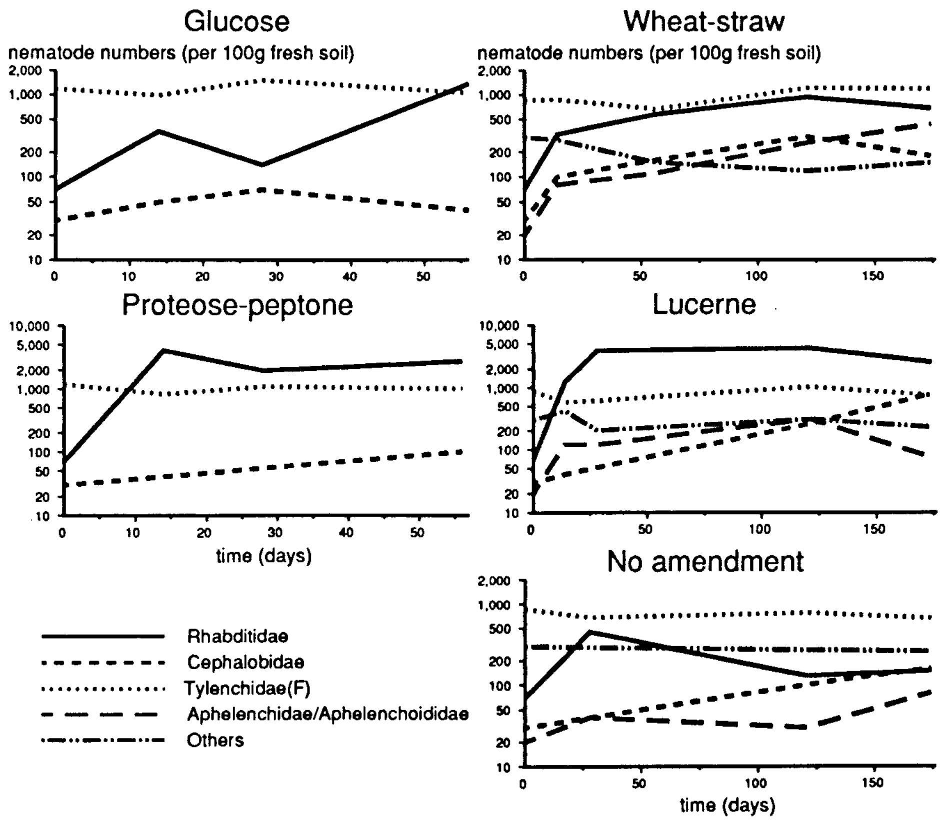

Figure 2. Numbers of nematodes of different taxa, per 100 g of fresh soil, as isolated from microcosms with Lovinkhoeve soil, amended with various types of organic matter after laboratory incubation at 10°C after different periods of incubation.

Crop rotation, organic matter management and rainfall largely determine the distribution of non-herbivorous nematodes over the various taxa. Probably Rhabditidae are indicative for short-term mineralization flushes, Cephalobidae for more stable mineralization rates.

5. References

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