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Diversity of *Meloidogyne hapla* Chitwood, 1949 population in Poland

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Summary. Fifty-one Polish populations of *Meloidogyne hapla* Chitwood, 1949 were compared. It was found that three second-stage juvenile groups, differing significantly from one another in body length, can be distinguished. Morphological diversity of larvae in different populations does not correspond directly to the capability to form galls on various plants. Out of ten tested plant species, celeriac was the most sensitive to *M. hapla* infection. The results of this study confirm that it is impossible to recognize clearly stabilized races of *Meloidogyne hapla*.

Key words: diversity, *Meloidogyne hapla*, races, test plants.

The northern root-knot nematode (*Meloidogyne hapla* Chitwood, 1949) occurs commonly in cultivated soils in Poland, and causes serious problems to some crops (Bogucka, 1960; Brzeski, 1970; Berbeć, 1971; Szczygieł, 1974; Brzeski & Bojda, 1974; Brzeski, 1986; Dolna, 1986; Kornobis, 1989; Głąba, 1990; Kornobis & Wolny, 1997). Due to phytosanitary regulations it has become a difficult factor to deal with in the production of seedlings, yet little is known about the variability occurring among Polish populations of this nematode species. This lack of knowledge relates not only to morphological diversity but also to differences in development capabilities of various populations on a range of plants.

Apart from a few limited reports in general papers on plant – parasitic nematode fauna, only Brzeski & Baksik (1981) provide experimental data on the biological diversity of *M. hapla* in Poland. However, there is still a lack of information on the relationship between morphological diversity and the capability of inducing galls on different plant roots.

The purpose of this study was to define the variability of second-stage larvae of Polish populations of *M. hapla*, and their respective abilities to induce galls on roots of different plants.

MATERIAL AND METHODS

Fifty-one samples of nematode populations were collected in the years 1998 and 1999 from field crops or from previously cultivated soil. The location of each sampling site is presented in table I. Populations of *M. hapla* were found on the following host plants (population number from table 1 in brackets): carrot – 19 (2, 3, 6, 7, 8, 10, 11, 18, 19, 21, 22, 24, 27, 31, 38, 40, 48, 49, 50), potato – 6 (17, 20, 23, 25, 29, 35), lettuce – 3 (16, 34, 42), sugar beet – 2 (39, 45), common parsnip – 2 (26, 51), mother chrysanthemum – 2 (15, 28), summer phlox – 1 (46), tomato – 1 (14), turnid – rooted parsley – 1 (1) and celeriac – 1 (32). Thriteen populations (4, 5, 9, 12, 13, 30, 33, 36, 37, 41, 43, 44, 47) were obtained from soil; however, it was impossible to establish the plant species on which the nematodes developed.

Identification of *Meloidogyne* species was done on the basis of the appearance of root–knots (small roots growing from knot). Additionally, ten females were isolated (Franklin & Goodey, 1949) from each population, always from untipical, small knots, without additional roots. All these females showed typical perineal patterns for *M. hapla*. Second-stage larvae were isolated by modified Baermann method, killed by hot 2% formalin and mounted on temporary slides. Measurements were performed under x1000 magnification. Tukey's test was used to determine the significant differences at a level of significance of $p=0.05$.

The capability of inducing galls on various plant species was investigated on those populations used to determine morphological diversity. Pots (12 cm

in diameter) were filled with *M. hapla* infested soil. A test plant (without *M. hapla*) was also either sown or transplanted to each pot as a control. The experiment was set up as a randomized block design with four replications. Test plants were the following species and cultivars: celeriac (*cv.* Odrzański), sugar beet (*cv.* PN Mono), onion (*cv.* Wolska), *Phacelia tanacetifolia* (*cv.* Stala), spring oat (*cv.* Komes), maize (*cv.* Duet), spring wheat (*cv.* Kadett), head lettuce (*cv.* Michalina), *Tagetes patula* (*cv.* Petit Orange) and white cabbage (*cv.* Kamienna Głowa). After two months plants were uprooted, washed and galls counted. The degree of gall development was compared on the basis of RK coefficient calculated by using the following equation:

$$RK = \frac{R_{obs}}{R_{max}} \times 10$$

Where:

R_{obs} - mean number of galls induced by *M. hapla* population on roots of the test plant

R_{max} – mean number of galls induced by *M. hapla* population on roots of the plant with the highest number of galls.

RK values range from 0 to 10 where a higher coefficient value relates to a higher gall number. The assignment of the degree of gall development has allowed comparison not only of the particular test plants but also amongst *M. hapla* populations. Comparing the absolute numbers of nematodes would not have been reliable, as populations differed in density.

RESULTS

Measurements of second-stage larvae revealed that Polish populations of *M. hapla* were diverse. Three second-stage larva groups differed significantly in body length from one another (Table 1). Other morphological features did not have similar significant differences. The minimum value of second-stage larva length (305 µm) has exceeded the values recorded so far in Polish populations. The same situation occurs with data for values of tail length of second-stage larvae (39 µm), minimum value of h (6 µm), maximum value of a (41) and minimum and maximum value of c (5.7 and 13.7). The data in this study extend the known range of morphological diversity of *M. hapla* in Poland.

The morphological diversity of second-stage larvae in different *M. hapla* populations does not correspond directly to gall forming capability on various plant species (Table 2). The observations have not indicated a distinct division into groups. However, the following common characteristics are clearly evident:

- all *M. hapla* populations studied either induced no galls or formed them the least frequently on monocotyledonous plants.
- a large majority of populations formed galls preferentially on celeriac. Only 4 populations (18, 26, 46 and 51) formed galls less frequently on celeriac plants (RK < 6).
- gall formation on lettuce was variable but for > 50% of the *M. hapla* populations RK < 6.
- almost all *M. hapla* populations induced galls on roots of *Tagetes patula.*

DISCUSSION

Meloidogyne hapla is generally considered a parasitic species developing on many, mainly dicotyledonous plants, including economically important food crops and ornamentals (Karssen, 1999). However, there are reports in the literature on galls induced by *M. hapla* on the following monocotyledonous species: *Allium ascalonicum* (Oostenbrink, 1960), *Hosta* sp. (Brinkman & Goossens, 1994), onion, oat and corn (Brzeski & Baksik, 1981). Data from my observations have added a new species to this list – wheat. Contrary to the observations of Brzeski & Baksik (1981), no galls were recorded on oat and corn and only a few on onion. These differences could have been caused by dissimilarities in either *M. hapla* populations or the cultivars of test plants. Unfortunately, Brzeski & Baksik (1981) did not provide information about cultivars used in their studies. Regardless of all evidence on gall formation on plant roots of monocotyledonous species, the conclusion that *M. hapla* is the species more closely associated with dicotyledonous plants seems correct.

Variability in *M. hapla* populations has previously been studied. Eisenback & Triantophyllou (1991), distinguished 2 races of *M. hapla* on the basis of analyses of different data. Race A had generally shorter second-stage larvae (357-467 µm, mean 413) and did not form galls on *T. patula.* In contrast, race B had a longer second-stage larvae (410-517 µm, mean 474) and formed galls on *T. patula.*

Polish populations of *M. hapla* do not fit this pattern as they have relatively short second-stage larvae that can form galls on *T. patula.* On the other hand the results of this study confirm the

Table 1. Measurements of second-stage larvae from 51 populations of *Meloidogyne hapla* collected in Poland. Different letters indicatestatistical differences ($\alpha < 0.05$), Tukey's test.

Population	Locality (UTM grid)	Measurements (n=10) (min-max)						
		Body length (μm)	Tail length (μm)	h (μm)	a	b'	c	Stylet length(μm)
1	Jowiszowice (CA54)	448 ± 18 (420-480) x	50 ± 8 (30-63) x	16 ± 3 (10-20) x	34 ± 4 (23-38) x	2.5 ± 0.2 (2.3-2.7) x	8.4 ± 0.8 (7.3-13.7) x	10.5 ± 0.5 (10-11) x
2	Piotrywki (XU08)	446 ± 19 (425-480) x	52 ± 4 (46-57) x	13 ± 3 (9-17) x	33 ± 2 (31-36) x	2.8 ± 0.2 (2.6-3.2) x	8.6 ± 0.4 (7.8-9.3) x	10.7 ± 0.6 (10-12) x
3	Kłobuck (CB54)	442 ± 20 (401-466) x	51 ± 5 (44-60) x	12 ± 2 (9-17) x	33 ± 2 (30-35) x	2.8 ± 0.2 (2.5-3.1) x	8.6 ± 0.6 (7.8-9.7) x	10.3 ± 0.3 (10-11) x
4	Środa (XT59)	434 ± 19 (382-456) x	51 ± 3 (45-56) x	12 ±2 (9-15) x	33 ± 2 (29-36) x	2.8 ± 0.2 (2.4-3.1) x	8.5 ± 0.4 (8.0-8.9) x	10.6 ± 0.4 (10-11) x
5	Nowa Wieś (XT79)	430 ± 19 (401-453) x	50 ± 3 (45-54) x	14 ± 2 (11-16) x	32 ± 2 (30-34) x	2.5 ± 0.1 (2.3-2.7) x	8.7 ± 0.4 (8.3-9.5) x	10.3 ± 0.4 (10-11) x
6	Zwoleń (EB49)	429 ± 17 (400-458) x	49 ± 2 (48-52) x	15 ± 3 (10-19) x	30 ± 2 (27-33) x	2.8 ± 0.2 (2.6-3.1) x	8.7 ± 0.3 (8.3-9.2) x	11.2 ± 0.5 (11-12) x
7	Puławy (EB79)	428 ± 16 (407-450) x	49 ± 4 (44-54) x	13 ± 3 (11-16) x	34 ± 2 (31-38) x	2.7 ± 0.4 (1.9-3.4) x	8.8 ± 0.4 (8.3-9.6) x	10.5 ± 0.5 (10-11) x
8	Jeżewo (FD49)	426 ± 29 (390-486)	50 ± 4 (45-56) x	12 ± 2 (9-17) x	32 ± 4 (27-41) x	2.8 ± 0.3 (2.6-3.1) x	8.6 ± 0.6 (8.1-9.3) x	11.4 ± 0.6 (11-12) x
9	Komorze (WU94)	425 ± 11 (408-433) x	49 ± 2 (45-52) x	12 ± 2 (9-17) x	31 ± 1 (29-33) x	2.6 ± 0.1 (2.5-2.7) x	8.7 ± 0.5 (8.2-9.6) x	10.5 ± 0.4 (10-11) x
10	Smarchowice (XS87)	415 ± 15 (396-439) x y	47 ± 3 (45-52) x	13 ± 2 (11-16) x	36 ± 2 (33-38) x	2.8 ± 0.2 (2.5-3.1) x	8.8 ± 0.3 (8.1-9.3) x	10.6 ± 0.3 (10-11) x
11	Ciechanyw (DD76)	415 ± 15 (391-437) x y	47 ± 3 (42-50) x	14 ± 3 (12-19) x	29 ± 1 (28-31) x	2.8 ± 0.2 (2.5-3.0) x	8.8 ± 0.4 (8.4-9.7) x	11.1 ± 0.7 (10-12) x
12	Śrem (XT35)	414 ± 13 (390-430) x	48 ± 3 (40-51) x	13 ± 2 (12-18) x	28 ± 2 (27-30) x	2.7 ± 0.2 (2.5-2.8) x	8.7 ± 0.3 (8.4-9.1) x	10.3 ± 0.4 (10-11) x
13	Dasze (FD50)	412 ± 20 (385-430) x y	47 ± 3 (39-50) x	12 ± 2 (11-16) x	29 ± 2 (26-30) x	2.8 ± 0.4 (2.5-3.0) x	8.9 ± 0.3 (8.5-9.1) x	10.3 ± 0.4 (10-11) x
14	Owińska (XU32)	410 ± 19 (380-431) x y	46 ± 2 (42-49) x	11 ± 1 (8-13) x	31 ± 2 (29-33) x	2.6 ± 0.1 (2.4-2.7) x	9.0 ± 0.4 (8.7-9.5) x	10.3 ± 0.4 (10-11) x
15	Poznań I (XU20)	402 ± 12 (390-435) x y	49 ± 6 (40-60) x	13 ± 2 (11-15) x	31 ± 3 (26-34) x	2.5 ± 0.2 (2.3-2.8) x	8.2 ± 0.6 (6.8-10.8) x	10.7 ± 0.5 (10-11) x
16	Puszczykowo (XT29)	398 ± 13 (387-430) x y	49 ± 3 (41-56) x	12 ± 2 (12-17) x	30 ± 3 (28-37) x	2.4 ± 0.1 (2.2-2.5) x	8.0 ± 0.4 (7.0-9.5) x	10.3 ± 0.4 (10-11) x
17	Szydłowiec (DB98)	390 ± 10 (375-420) x y	50 ± 4 (40-60) x	12 ± 2 (10-15) x	30 ± 2 (27-36) x	2.5 ± 0.1 (2.3-2.6) x	8.1 ± 0.2 (7.5-9.0) x	10.5 ± 0.2 (10-11) x

Table 1. (continued). Measurements of second-stage larvae from 51 populations of *Meloidogyne hapla* collected in Poland. Different letters indicate statistical differences ($\alpha < 0.05$), Tukey's test.

Population	Locality (UTM grid)	Measurements (n=10) (min-max)						
		Body length (µm)	Tail length (µm)	h (µm)	a	b'	c	Stylet length(µm)
18	Żyrawie (VV60)	389 ± 20 (370-433) x y	51 ± 5 (45-61) x	12 ± 2 (9-15) x	29 ± 1 (27-30) x	2.6 ± 0.2 (2.3-2.9) x	7.7 ± 0.4 (7.1-8.3) x	10.5 ± 0.5 (10-11) x
19	Przasnysz (DD97)	388 ± 15 (360-410) y	51 ± 4 (42-55) x	11 ± 2 (8-15) x	26 ± 1 (23-27) x	2.4 ± 0.3 (2.1-2.7) x	7.9 ± 0.2 (7.5-8.2) x	10.3 ± 0.3 (10-11) x
20	Myślenice (DA22)	387 ± 24 (352-431) y	49 ± 4 (44-54) x	12 ± 3 (9-16) x	31 ± 1 (28-33) x	2.5 ± 0.3 (2.2-2.7) x	7.9 ± 0.3 (7.4-8.5) x	11.2 ± 0.6 (11-12) x
21	Golina (XT75)	387 ± 19 (367-405) y	39 ± 2 (34-47) x	12 ± 3 (8-15) x	29 ± 1 (27-32) x	2.4 ± 0.2 (2.2-2.6) x	10.1 ± 0.5 (8.1-11.9) x	10.4 ± 0.8 (10-12) x
22	Częstochowa (CB63)	386 ± 15 (360-416) y	52 ± 6 (46-66) x	11 ± 1 (8-12) x	29 ± 1 (27-30) x	2.5 ± 0.2 (2.2-2.8) x	7.5 ± 0.6 (6.3-8.2) x	10.3 ± 0.3 (10-11) x
23	Ulesie (DB02)	386 ± 18 (360-400) y	50 ± 2 (47-55) x	12 ± 2 (8-14) x	30 ± 1 (28-32) x	2.6 ± 0.2 (2.3-2.9) x	7.8 ± 0.4 (6.5-9.5) x	10.4 ± 0.4 (10-11) x
24	Nowe Miasto (DE02)	385 ± 15 (370-400) y	49 ± 2 (46-50) x	13 ± 2 (11-17) x	29 ± 1 (26-31) x	2.7 ± 0.2 (2.4-3.1) x	8.0 ± 0.3 (7.0-9.0) x	10.3 ± 0.3 (10-11) x
25	Liszkowo (WU93)	383 ± 12 (338-408) y	48 ± 7 (35-55) x	12 ± 1 (11-13) x	28 ± 2 (22-33) x	2.5 ± 0.1 (2.4-2.5) x	8.5 ± 0.6 (6.8-11.1) x	10.4 ± 0.4 (10-11) x
26	Nowy Tomyśl (WT79)	383 ± 10 (340-395) y	48 ± 5 (38-51) x	12 ± 3 (8-14) x	28 ± 3 (21-31) x	2.5 ± 0.2 (2.3-2.7) x	8.5 ± 0.3 (7.8-9.1) x	10.4 ± 0.5 (10-11) x
27	Poznań II (XU41)	383 ± 11 (371-402) y	50 ± 2 (46-54) x	13 ± 1 (11-15) x	29 ± 1 (28-32) x	2.7 ± 0.2 (2.5-3.5) x	7.7 ± 0.3 (7.2-8.1) x	10.5 ± 0.4 (10-11) x
28	Grudziądz (CE03)	381 ± 9 (360-390) y z	49 ± 2 (41-55) x	12 ± 1 (8-13) x	28 ± 1 (26-29) x	2.6 ± 0.2 (2.2-2.8) x	7.9 ± 0.6 (5.1-10.3) x	10.6 ± 0.2 (10-11) x
29	Dębno (FA06)	380 ± 9 (355-390) y z	48 ± 3 (40-50) x	13 ± 4 (9-14) x	27 ± 2 (25-28) x	2.5 ± 0.1 (2.3-2.7) x	7.4 ± 0.3 (6.0-8.5) x	10.3 ± 0.3 (10-11) x
30	Stare Drawsko (WU74)	379 ± 16 (345-385) y z	41 ± 4x (36-45)	13 ± 2 (11-15) x	28 ± 1 (26-30) x	2.6 ± 0.2 (2.3-2.8) x	7.8 ± 0.4 (6.7-9.1) x	10.3 ± 0.3 (10-11) x
31	Staszyw (EB51)	373 ± 14 (360-390) y z	39 ± 4 (36-45) x	14 ± 3 (13-15) x	30 ± 2 (27-32) x	2.4 ± 0.3 (2.1-2.6) x	9.7 ± 0.4 (8.5-10.1) x	10.5 ± 0.4 (10-11) x
32	Poznań III (XV30)	370 ± 18 (332-401) y z	46 ± 5 (42-52) x	9 ± 4 (6-12) x	31 ± 3 (28-34) x	2.3 ± 0.2 (2.1-2.5) x	8.2 ± 0.6 (7.3-11.6) x	10.6 ± 0.5 (10-11) x
33	Błotnica (WU39)	369 ± 17 (340-380) y z	41 ± 4 (38-45) x	10 ± 4 (6-14) x	30 ± 3 (28-34) x	2.5 ± 0.3 (2.2-2.7) x	8.5 ± 0.3 (7.8-9.0) x	10.3 ± 0.4 (10-11) x
34	Wągryw (ED70)	367 ± 13 (365-377) z	42 ± 3 (40-47) x	10 ± 1 (9-10) x	30 ± 1 (28-31) x	2.2 ± 0.1 (2.1-2.3) x	8.7 ± 0.2 (8.0-9.1) x	10.4 ± 0.4 (10-11) x

Table 1. (continued). Measurements of second-stage larvae from 51 populations of *Meloidogyne hapla* collected in Poland. Different letters indicate statistical differences ($\alpha < 0.05$), Tukey's test.

Population	Locality (UTM grid)	Measurements (n=10) (min-max)						
		Body length (μm)	Tail length (μm)	h (μm)	a	b'	c	Stylet length(μm)
35	Wymysływ	366 ± 20	45 ± 5	11 ± 4	30 ± 3	2.3 ± 0.2	8.0 ± 0.4	10.2 ± 0.2
	(DC66)	(335-390) z	(37-50) x	(6-13) x	(27-33) x	(2.1-2.5) x	(7.2-10.4) x	(10-11) x
36	Wenecja	366 ± 19	43 ± 3	10 ± 3	29 ± 2	2.4 ± 0.2	7.9 ± 0.4	10.3 ± 0.3
	(XV89)	(340-395) z	(36-46) x	(6-13) x	(26-30) x	(2.2-2.7) x	(7.2-10.0) x	(10-11) x
37	Chomiąża	366 ± 14	42 ± 3	11 ± 3	30 ± 3	2.5 ± 0.3	7.8 ± 0.3	10.4 ± 0.4
	(XV94)	(338-380) z	(37-45) x	(6-12) x	(27-34) x	(2.3-2.8) x	(7.1-8.2) x	(10-11) x
38	Lubsko	366 ± 13	48 ± 4	12 ± 3	30 ± 3	2.6 ± 0.3	7.9 ± 0.3	10.3 ± 0.3
	(WT93)	(340-371) z	(41-52) x	(8-14) x	(28-36) x	(2.2-2.8) x	(7.3-8.1) x	(10-11) x
39	Pokrywka	366 ± 10	44 ± 3	13 ± 2	29 ± 2	2.5 ± 0.3 x	8.0 ± 0.3 x	10.4 ± 0.2
	(FB76)	(350-375) z	(40-46) x	(11-15) x	(26-33) x	(2.2-2.8)	(7.5-9.0)	(10-11) x
40	Chełm	365 ± 10	47 ± 3	12 ± 3	29 ± 3	2.4 ± 0.3	7.9 ± 0.4	10.3 ± 0.4
	(FB76)	(348-375) z	(44-51) x	(10 -16) x	(22-33) x	(2.0-2.7) x	(7.5-8.1) x	(10-11) x
41	Skierniewice	365 ± 9	48 ± 3	13 ± 3	28 ± 3	2.4 ± 0.2	8.0 ± 0.4	10.2 ± 0.5
	(DC45)	(340-370) z	(41-51) x	(11-16) x	(22-34) x	(2.1-2.6) x	(7.5-8.7) x	(10-11) x
42	Rzeszyw	365 ± 11	48 ± 3	12 ± 2	27 ± 2	2.3 ± 0.2	8.1 ± 0.3	10.2 ± 0.6
	(EA74)	(345-380) z	(40-50) x	(10-13) x	(22-30) x	(2.2-2.6) x	(7.8-8.5) x	(10-11) x
43	Frankopol	364 ± 17	49 ± 6	13 ± 2	28 ± 1	2.1 ± 0.2	8.0 ± 0.6	11.1 ± 0.6
	(FD00)	(341-388) z	(44-62) x	(9-15) x	(27-30) x	(1.9-2.4) x	(6.2-8.5) x	(11-12) x
44	Czaplinek	363 ± 20	46 ± 5	12 ± 3	28 ± 1	2.1 ± 0.1	8.0 ± 0.48 x	11.2 ± 0.7
	(WV83)	(343-379) z	(40-53) x	(8-16) x	(26-29) x	(2.0-2.3) x	(7.1-9.1)	(11-12) x
45	Mielec	363 ± 14	47 ± 5	11 ± 2	29 ± 2	2.2 ± 0.1	7.8 ± 0.68 x	11.1 ± 0.4
	(EA37)	(351-386) z	(42-60) x	(9-15) x	(26-30) x	(2.0-2.4) x	(6.5-9.1)	(11-12) x
46	Smolno	363 ± 10	50 ± 3	13 ± 3	29 ± 1	2.2 ± 0.2	7.2 ± 0.2	10.2 ± 0.4
	(WT35)	(326-382) z	(45-55) x	(8-20) x	(27-30) x	(2.1-2.5) x	(6.8-7.7) x	(10-11) x
47	Grodzisk	361 ± 18	48 ± 3	13 ± 2	28 ± 1	2.2 ± 0.2	7.5 ± 0.3	10.4 ± 0.2
	(FD85)	(319-387) z	(41-52) x	(11-16) x	(27-30) x	(1.9-2.5) x	(7.2-7.9) x	(10-11) x
48	Leszno	360 ± 13	45 ± 3	11 ± 2	29 ± 1	2.2 ± 0.2	7.2 ± 0.2	10.3 ± 0.3
	(XT04)	(320-375) z	(40-50) x	(10-14) x	(22-33) x	(2.0-2.6) x	(7.0-7.7) x	(10-11) x
49	Żnin	359 ± 15	49 ± 5	10 ± 8	29 ± 1	2.2 ± 0.2	7.4 ± 0.2	10.4 ± 0.3
	(XU86)	(330-390) z	(40-60) x	(0-18) x	(27-33) x	(1.8-2.7) x	(6.5-8.6) x	(10-11) x
50	Ryki	357 ± 17	45 ± 3	10 ± 3	30 ± 1 x	2.2 ± 0.2	7.9 ± 0.4	10.0 ± 0.0 x
	(EC62)	(305-373) z	(38-50) x	(8-13) x	(28-31)	(2.0-2.5) x	(6.8-9.3) x	
51	Poznań IV	356 ±15	51 ± 5	13 ± 3	30 ± 3 x	2.2 ± 0.2	7.2 ± 0.6	10.4 ± 0.5
	(XU30)	(335-390) z	(35-60) x	(10-15) x	(26-33)	(2.1-2.7) x	(5.7-9.8) x	(10-11) x

Table 2. Comparison of gall numbers formed on different plant roots by 51 populations of *Meloidogyne hapla* collected in Poland.

Population and locality (UTM grid)		RK value									
		Celeriac	Sugar-beet	Onion	*Phacelia*	Oat	Maize	Wheat	Lettuce	*Tagetes*	Cabbage
1	Jowiszowice (CA54)	10	4	0*	4	0	0	0*	4	4	9
2	Piotrywki (XU08)	10	3	0	0	0	0	0	10	0	3
3	Kłobuck (CB54)	10	2	0	0	0	0	0	2	4	2
4	Środa (XT59)	7	10	0	3	0	0	0*	2	3	5
5	Nowa Wieś (XT79)	10	4	0	0*	0	0	0	0*	1	2
6	Zwoleń (EB49)	10	0	0	1	0	0	0	1	9	3
7	Puławy (EB79)	10	2	0	0*	0	0	0	1	1	1
8	Jeżewo (FD49)	10	1	0	1	0	0	0	1	7	1
9	Komorze (WU94)	10	1	0	0	0	0	0	3	4	2
10	Smarchowice (XS87)	10	4	0*	4	0	0	0*	4	4	9
11	Ciechanyw (DD76)	10	1	0	1	0	0	0	2	4	3
12	Śrem (XT35)	10	0	0	0	0	0	0	6	1	1
13	Dasze (FD50)	10	0	0	2	0	0	0	3	3	1
14	Owińska (XU32)	10	6	0	3	0	0	0	7	4	3
15	Poznań I (XU20)	10	10	0	7	0	0	0	1	7	3
16	Puszczykowo (XT29)	10	1	0	1	0	0	0	4	4	1
17	Szydłowiec (DB98)	10	3	0	2	0	0	0	5	5	7
18	Żyrawie (VV60)	3	2	0	1	0	0	1	10	0*	1
19	Przasnysz (DD97)	10	1	0	0	0	0	0	1	4	2
20	Myślenice (DA22)	6	1	0	0*	0	0	0	1	10	4
21	Golina (XT75)	10	1	0	1	0	0	0	3	9	1
22	Częstochowa (CB63)	10	1	0	1	0	0	0	3	6	3
23	Ulesie (DB02)	10	0	0	0	0	0	0	3	8	3
24	Nowe Miasto (DE02)	8	0	0	0*	0	0	0	8	10	9
25	Liszkowo (WU93)	10	0*	0	0*	0	0	0	2	1	5
26	Nowy Tomyśl (WT79)	3	2	0*	0*	0	0	0	10	1	2

* - Single galls were formed but their numbers were too small to give value of RK=1
Population numbers are just the same as in Table 1.

Table 2 (continued). Comparison of gall numbers formed on different plant roots by 51 populations of *Meloidogyne hapla* collected in Poland.

Population and locality (UTM grid)		RK value									
		Celeriac	Sugar-beet	Onion	*Phacelia*	Oat	Maize	Wheat	Lettuce	*Tagetes*	Cabbage
27	Poznań II (XU41)	10	5	0	0	0	0	0	1	6	6
28	Grudziądz (CE03)	10	0*	0	0*	0	0	0	2	2	8
29	Dębno (FA06)	10	1	0	0	0	0	0	10	1	0
30	Stare Drawsko (WU74)	10	0	0	1	0	0	0	7	0	0
31	Staszyw (EB51)	10	2	0	0	0	0	0	3	4	8
32	Poznań III (XV30)	7	1	0	1	0	0	0	1	10	9
33	Błotnica (WU39)	10	0	0	0	0	0	0	4	8	8
34	Wągryw (ED70)	10	3	0	4	0	0	0	4	7	4
35	Wymysływ (DC66)	10	0	0	0	0	0	0	0*	0*	4
36	Wenecja (XV89)	10	1	0	1	0	0	0	3	2	9
37	Chomiąża (XV94)	10	0*	0	0	0	0	0	3	4	7
38	Lubsko (WT93)	10	0	0	0*	0	0	0	2	0	0
39	Pokrywka (FB76)	10	1	0	0*	0	0	0	3	2	0
40	Chełm (FB76)	10	0	0	0	0	0	0	1	0	2
41	Skierniewice (DC45)	10	0	0	0	0	0	0	3	2	2
42	Rzeszyw (EA74)	10	0*	0	0*	0	0	0	4	2	2
43	Frankopol (FD00)	10	1	0*	1	0	0	0	7	6	7
44	Czaplinek (WV83)	10	4	0	0	0	0	0	3	3	3
45	Mielec (EA37)	8	1	1	1	0	0	0	10	1	1
46	Smolno (WT35)	5	0	0	0	0	0	0	1	10	1
47	Grodzisk (FD85)	10	1	0	0	0	0	0	3	8	4
48	Leszno (XT04)	10	2	0	3	0	0	0	4	1	1
49	Żnin (XU86)	10	2	0*	1	0	0	0	7	5	1
50	Ryki (EC62)	10	1	0*	0*	0	0	0	3	1	0*
51	Poznań IV (XU30)	1	0*	0	0	0	0	0	10	1	1

* - Single galls were formed but their numbers were too small to give value of RK=1
Population numbers are just the same as in Table 1.

opinion (Potter & Olthof, 1993) that it is impossible to recognize clearly stabilized races of *M. hapla*.

Poor gall formation on lettuce by Polish populations of *M. hapla* raises the question of the usefulness of this species as a test plant for *M. hapla* detection in soil. This is especially pertinent as lettuce is used in tests performed by the Polish Advisory System of Plant Protection. The results of these investigations (Table 2) indicate that a test by celeriac plants is more sensitive. It cannot be excluded that populations of *M. hapla* in other countries of Central and Eastern Europe have similar or identical features.

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Kornobis S. Биологическое разнообразие *Meloidogyne hapla* Chitwood, 1949 в Польше.

Резюме. Проведено сравнение особей *Meloidogyne hapla* Chitwood, 1949 из 51 польской популяции. Среди этих популяций можно выделить три группы отличающиеся друг от друга по длине тела личинок второй стадии. Морфологические особенности строения личинок не связаны жестко со способностью этих нематод образовывать галлы на различных растениях. Из десяти исследованных видов растений, сельдерей оказался наиболее чувствительным к поражению *M. hapla*. Полученные результаты показывают, что невозможно выделить и различать стабильные расы у *Meloidogyne hapla*.