https://doi.org/10.17221/156/2018-PPS

Meloidogyne hapla development on growing legume plants – Short Communication

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Citation: Dobosz R., Krawczyk R. (2019): *Meloidogyne hapla* development on growing legume plants – Short Communication. Plant Protect. Sci., 55: 274–277.

Abstract: The legume genus lupine, pea, faba bean and common vetch were cultivated under natural conditions in pots filled with soil naturally infected with *Meloidogyne hapla* Chitwood, 1949. The nematode population density increased relevantly in the soil planted with the faba bean (cultivars (cvs.) Bobas, Amulet, Albus) and the pea cv. Lasso, in which numerous root galls and egg masses appeared. The narrow-leaved lupine (cvs. Karo, Zeus), yellow lupine (cvs. Parys, Lord) and white lupine (cv. Boros) cultivation decreased the nematode population density and these were not statistically significant when compared with the nematode density in a fallow soil.

Keywords: dry pulses; root-knot nematode; population density; root galls; egg masses

Root knot nematodes (RKN), *Meloidogyne* spp., are the most significant plant-parasitic nematodes occurring on crops in temperate, subtropical and tropical regions (Luc *et al*. 2005; Perry *et al*. 2009; Singh *et al*. 2013; Nijs *et al*. 2016). *M. arenaria* (Neal, 1889), *M. incognita* (Kofoid & White, 1919), *M. javanica* (Treub, 1885) and *M. graminicola (*Golden & Birchfield, 1965) cause great damage to growing crops in subtropical and tropical climates (Ravichandra 2013; Talwana *et al*. 2016; Wang *et al*. 2017). *M. chitwoodi* (Golden *et al*., 1980) and *M. hapla* (Chitwood, 1949) are harmful RKN species in temperate climate regions (Chitwood 1949; Golden *et al*. 1980; Wesemael *et al*. 2011). *M. hapla* is a common pest of many plant species such as the lettuce, potato, carrots, strawberries, roses, and fruit trees (Olthof & Potter 1972; Brzeski 1974; Viaene & Abawi 1996; Sahu *et al*. 2015; Bernard *et al*. 2017). *M. hapla* is the most important parasitic species of the *Meloidogyne* genus in Poland (Brzeski 1998).

According to the current data, many pulse crop species are hosts of *M. hapla* (Santo & Ponti 1985; Griffin *et al*. 1986; Wofford *et al*. 1989; Griffin & Rumbaugh 1996; Dobosz & Krawczyk 2017). The root-knot nematode life cycle is held in the plant's roots where egg-filled deposits (egg masses) develop. These larvae hatch from the eggs and become second-stage juveniles (J2s) which can move in the soil and infect other roots. Crop damage is associated with the population density in the soil (Olthof & Potter 1972). Therefore, the change of nematode population density before and after the growing season indicates the nematode development in the crops. The crops with low nematode reproduction can be used for crop rotation to reduce the nematode damage in the field.

The aim of the study was to determine the impact of commonly cultivated legumes in Poland including lupins (*Lupinus* Linnaeus), peas (*Pisum sativum* Linnaeus), faba beans (*Vicia faba* Linnaeus) and common vetches (*Vicia sativa* Linnaeus) on the development of the *M. hapla* population.

MATERIAL AND METHODS

The study was carried out at the Institute of Plant Protection – National Research Institute (IOR – PIB)

Supported by the IOR – PIB, Project No. ENTOAGRO-02, and by the Polish Ministry of Agriculture and Rural Development, Project No. RM-111-146-18.

https://doi.org/10.17221/156/2018-PPS

in Poznań, in 2016–2017. The assessment of the changes in the *M. hapla* population density and the observations on the number of outgrowths and egg masses in the roots were conducted in pot experiments (15 dcm^3), filled with soil naturally infected with *M. hapla* (50 J2/200 cm^3 – initial density P_i), in four replicates. Seeds of the narrow-leaved lupine (cultivars (cvs.): Karo, Oskar, Zeus), the yellow lupine (cvs.: Lord, Parys), the white lupine (cv. Boros), the faba bean (cvs.: Albus, Amulet, Bobas, Granit), the pea (cvs.: Huball, Lasso), the common vetch (cvs: Ina, Jaga) were sown in the soil-filled pots. Plants with mature pods were harvested for the nematode counts. Fallow was defined as the control treatments wherein no plants were grown in the pots. Plants with mature pods were removed from the pots and the roots were rinsed. To determine the number of outgrowths and the number of egg masses, the roots were stained with acid fuchsin in lactoglycerol (Hooper 1986). The egg masses dissected from root tissues were crushed and the mean number of eggs per egg mass was assessed. The final population density of J2 (P_f) was estimated for a soil sample of 200 cm^3 (Brzeski *et al*. 1976) and the P_f/P_i factor was calculated.

The data were subjected to the ANOVA and Tukey's test at $P \leq 0.05$. In order to classify the studied plant species in terms of host suitability for *M. hapla*, the cluster analysis was performed by using Ward's method with a squared Euclidean distance measure in multidimensional space – STATISTICA (Version 10).

RESULTS AND DISCUSSION

Comparison of the change in the population density of *M. hapla* in the growing seasons did not show differences between the years ($F_{1, 90} = 0.9973$, $P = 0.3349$). There were differences between the final densities of J2 in the first ($F_{14, 59} = 45.0747$, $P < 0.001$) and in the second growing season ($F_{14, 59} = 21.4725$, $P < 0.001$) (Table 1). The greatest increase of J2 per unit of soil was recorded in pots with the faba bean cultivars (Bobas, Amulet, Albus). By equating the obtained P_f/P_i values to the scale developed by Ferris *et al*. (1993), these plants were good host plants for *M. hapla* ($10 > P_f/P_i > 1$). The final population density of the J2s in the soil after the Bobas cultivation exceeded the number of the individuals at which the yields of the marketable lettuce heads and potato tubers' weight were reduced (Olthof & Potter 1972).

The population density of the nematode decreased in the pots with the growing of the narrow-leaved lupine, Karo and Zeus, the white lupine Boros and both yellow lupine cultivars. These cultivars composed the group of poor hosts for *M. hapla* ($P_f/P_i < 1$). Some of the white lupine cultivars tested in a greenhouse experiment turned out to be a poor host for *M. chitwoodi* as well (Ferris *et al*. 1993). The horse bean cv. Granit, the narrow-leaved lupine cv. Oskar and both pea and vetch cultivars form a group of supporting plants with values of P_f/P_i close to 1. The results for the pea and vetch cultivars differed from those obtained under the controlled temperature conditions in a greenhouse by Santo and Ponti (1985) and Mosjidis *et al*. (1994), respectively. All the tested pea cultivars proved to be very good hosts of both *M. hapla* and *M. chitwoodi* ($P_f/P_i > 10$) (Griffin & Rumbaugh 1996) while the vetch was a poor host plant for *M. arenaria*, in the cultivation of which P_f/P_i reached the value of 0.18 (Mosjidis *et al*. 1994).

The assessment of the nematode population development in the root tissues of the host plants at the end of the experiment revealed no differences between the years in the number of galls ($F_{1, 90} = 0.8202$, $P = 0.6455$), egg masses ($F_{1, 90} = 0.9958$, $P = 0.4645$) and eggs per egg mass ($F_{1, 90} = 0.25$, $P = 0.621$). The galls and egg masses appeared most often on the roots of the faba bean cvs.: Bobas, Amulet and Albus, the pea cv. Lasso and the vetch cv. Ina. No statistically differences among the mean values of the number of eggs per egg mass on the roots of the tested crops was observed, however, the eggs were most numerous in the egg mass vetch cv. Ina.

As a result of the cluster analysis (the Ward method) based on the average values of the *M. hapla* population density changes in the soil, the number of galls, the number of egg masses deposited on the root system and the number of eggs per egg mass, it was shown that all plants are divided into two clusters (Figure 1). The parameters characterising the nematode population development in the cultivation of the lupines, the pea cv. Hubal, the faba bean cv. Granit and the vetch cv. Jaga were the closest to those observed in the fallow. The lowest P_f/P_i index values were noticed on the fallow field, which indicates the greatest decrease in the nematode number in this experimental facility. Among the tested crops, only the lupins, with the exception of the Oskar lupine, the P_f/P_i index value was less than 1. This indicates that after the end of the tested plants' vegetation, the nematode population density in the soil was lower than it was before seeding them.

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Table 1. Changes in the population development of the northern root-knot nematode – *Meloidogyne hapla* Chitwood, 1949 on the growing legume plants

Crop species, cultivar	Population density in soil (P_f/P_i)*			Mean of two years		
	1st year	2nd year	mean	No. of galls per root	No. of egg masses per root	No. of eggs per egg mass
Vicia faba Linnaeus, Granit	0.80^{a}	1.46^{a}	1.13^{ab}	5.1^{bcd}	5.1^{bcd}	31.4^{ab}
V. faba, Bobas	10.14^{d}	5.73^{d}	7.93^{e}	9.9^{d}	9.5^{d}	27.6^{ab}
V. faba, Amulet	5.52^{c}	4.22^{cd}	4.87^{d}	6.8^{bcd}	7.6^{cd}	24.5^{ab}
V. faba, Albus	2.85^{b}	3.31^{bc}	3.08^{c}	9.0^{cd}	8.1^{cd}	30.9^{ab}
Pisum sativum Linnaeus, Lasso	1.70^{ab}	1.57^{ab}	1.63^{b}	7.1^{bcd}	6.5^{bcd}	28.3^{ab}
P. sativum, Hubal	1.28^{ab}	1.09^{a}	1.18^{ab}	4.5^{abc}	4.5^{abc}	27.5^{ab}
Lupinus angustifolius Linnaeus, Karo	0.55^{a}	0.30^{a}	0.43^{ab}	5.0^{bc}	5.6^{bcd}	29.5^{ab}
L. angustifolius, Zeus	0.26^{a}	0.40^{a}	0.33^{a}	3.8^{ab}	4.1^{abc}	21.8^{ab}
L. angustifolius, Oskar	1.27^{ab}	0.97^{a}	1.12^{ab}	4.6^{abc}	5.0^{bcd}	25.0^{ab}
Lupinus luteus Linnaeus, Parys	0.29^{a}	0.31^{a}	0.30^{a}	2.5^{ab}	2.5^{ab}	21.0^{ab}
L. luteus, Lord	0.36^{a}	0.37^{a}	0.37^{ab}	6.0^{bcd}	6.0^{bcd}	17.5^{ab}
Lupinus albus Linnaeus, Boros	0.45^{a}	1.09^{a}	0.77^{ab}	4.4^{abc}	4.5^{abc}	33.1^{ab}
Vicia sativa Linnaeus, Ina	1.42^{ab}	0.85^{a}	1.14^{ab}	6.6^{bcd}	8.0^{cd}	42.8^{b}
V. sativa, Jaga	0.92^{ab}	1.31^{a}	1.12^{ab}	5.1^{bcd}	5.1^{bcd}	27.5^{ab}
Fallow	0.26^{a}	0.29^{a}	0.28^{a}	0^{a}	0^{a}	0^{a}

*P_f/P_i – factor of the population density change; P_f – final population density of the nematode in the soil; P_i – initial population density of the nematode in the soil; the means followed by the same letter are not statistically different, Tukey's test ($P \leq 0.05$)

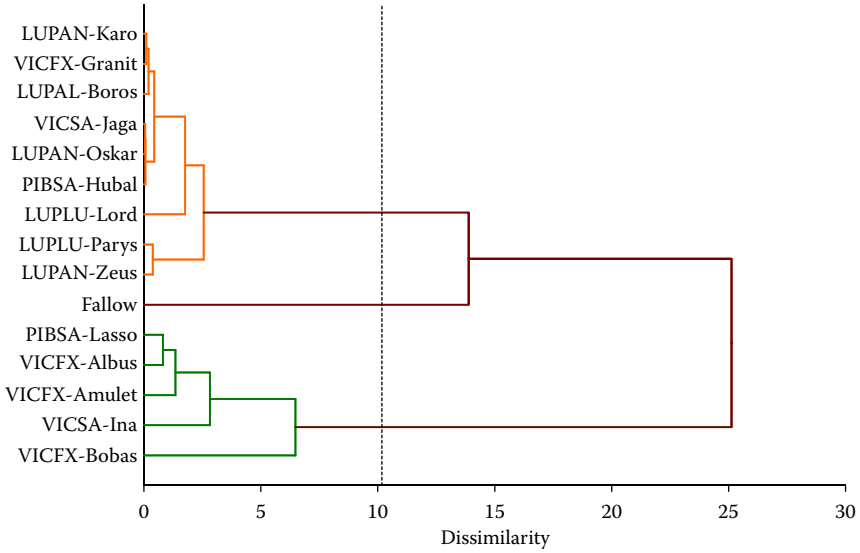

Figure 1. The dendrogram shows the approximate relationship between the *Meloidogyne hapla* Chitwood, 1949 development depending on the growing legume plants based on Ward's method with squared Euclidean distances. The branch lengths are based on the average linkage distance values of the changes in the *M. hapla* population density in the soil, the number of galls, the number of egg masses deposited on the root system and the number of eggs per egg mass

LUPAN-Karo – *Lupinus angustifolius* Linnaeus, cultivar (cv.) Karo; VICFX-Granit – *Vicia faba* Linnaeus, cv. Granit; LUPAL-Boros – *Lupinus albus* Linnaeus, cv. Boros; VICSA-Jaga – *Vicia sativa* Linnaeus, cv. Jaga; LUPAN-Oskar – *L. angustifolius*, cv. Oskar; PIBSA-Hubal – *Pisum sativum* Linnaeus, cv. Hubal; LUPLU-Lord – *Lupinus luteus* Linnaeus, cv. Lord; LUPLU-Parys – *L. luteus*, cv. Parys; LUPAN-Zeus – *L. angustifolius*, cv. Zeus; PIBSA-Lasso – *P. sativum*, cv. Lasso; VICFX-Albus – *V. faba*, cv. Albus; VICFX-Amulet – *V. faba*, cv. Amulet; VICSA-Ina – *V. sativa*, cv. Ina; VICFX-Bobas – *V. faba*, cv. Bobas

https://doi.org/10.17221/156/2018-PPS

In conclusion, among the tested Fabaceae plants, only the lupine cultivation did not influence an increase in the *M. hapla* nematodes number in the soil.

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Received: November 13, 2018
Accepted: May 28, 2019
Published online: August 16, 2019