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Short Notes

Potato (*Solanum tuberosum*) - a new host for the root-knot nematode *Meloidogyne inornata*

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Summary. The tropical root-knot nematode (RKN) *Meloidogyne inornata* infects soybean, tobacco, yacon, common bean and *Anthurium andreanum*. This species was reported as the cause of damage in commercial yacon production in Brazil, and has potential to cause losses to common bean crops. Potato (*Solanum tuberosum* L.) cv. Désirée infected with *M. inornata* exhibited typical RKN galls on roots and tuber surfaces, similar to those caused by the two quarantine pathogens *M. chitwoodi* and *M. fallax,* and the non-quarantine *M. luci*. This study has indicated that *M. inornata* has considerable potential to cause severe damage to potato tubers. The potential spread of this pathogen into new areas should be assessed, as it can damage potato tubers and could be a problem for economically important crops. Ensuring pest-free seed potatoes is important to prevent dissemination and establishment of *M. inornata* in uninfested areas. Phytosanitary measures and monitoring programmes developed to prevent spread of this pest in Europe may be warranted.

Keywords. Pathogenicity, plant-parasitic nematodes.

INTRODUCTION

Species of tropical root-knot nematodes (RKN), clade I of genus *Meloidogyne*, cause significant economic losses in several agricultural crops, including vegetables, and field and fruit crops. *Meloidogyne inornata* Lordello, 1956 was first described from soybean in Brazil (Lordello, 1956; Carneiro *et al*., 2008), and was later detected on tobacco *Nicotiana tabacum* L., yacon *Smallanthus sonchifolius* (Poepp.) H. Rob., common bean *Phaseolus vulgaris* L. and *Anthurium andreanum* Linden ex André (Whitehead, 1968; Carneiro *et al*., 2008; Machado *et al*., 2013; Camara *et al*., 2020). This nematode, reported by Camara *et al.* (2020) as the cause of damage in commercial yacon production in Brazil, also has potential to cause losses in common bean crops (Dadazio *et al*., 2016).

Meloidogyne inornata is closely related and very similar to *M. ethiopica* and *M. luci*, and the three species are collectively referred to as the *M. ethiopica* group (Gerič Stare *et al*., 2019). While the broad host range of *M. ethiopica* and *M. luci* overlaps (Gerič Stare *et al*., 2017), few hosts have been reported for *M. inornata*. Given the close relationship and similarities between the three species, it is plausible that hosts of *M. ethiopica* and *M. luci*, including potato, could also be parasitized by *M. inornata*.

Meloidogyne luci has already been found in potato fields in Portugal, and reproduced in 16 commercial cultivars with high reproduction factor values (Maleita *et al.*, 2018; Rusinque *et al.*, 2021; Şen and Aydınlı, 2021). Severe damage caused by RKN species of the tropical group had been recorded in Europe (Bačič *et al.*, 2016), and due to climate change and increased temperatures, these pests may become increasing problems in potato production in temperate regions (Širca *et al.*, 2021). Potato is an important crop in Europe and was cultivated on 1.7 million hectares (ha) in the EU-27 in 2020 (Eurostat, 2021), which corresponds to an estimated 1.7% of all arable land in the EU. The harvested production of potato in the EU was 55.3 million tonnes in 2020. The value at basic prices of raw potatoes and seed potatoes produced in the EU in 2020 was an estimated EUR 12.3 billion, which was 3.1% of the value of total EU agricultural output, but which varied among Member States (Eurostat, 2021).

The potato–*M. inornata* relationship was evaluated, due to the importance of potato production in Europe, and as a first step in assessing whether *M. inornata* is a threat in Europe. Three plants of potato Désirée were infected with 42,000 *M. inornata* eggs/plant, and uninfected plants were used as experimental controls. Plants were grown in individual 5 L pots filled with autoclaved 2:2:1 substrate containing fine-grain (MP1/G) and coarse-grain (MP4) quartz sand (Termit), and peat substrate Potgrond P (Klasmann-Deilmann). The substrate was supplemented with 5 g L^{-1} slow release fertilizer Osmocote® Exact Standard [ICL Specialty Fertilizers; N-P-K(+Mg) = 15-9-12(+2)]. The experiment was conducted from May to September 2021 in a greenhouse in Ljubljana, Slovenia (natural daylight, 19.7±2.4°C, 67.0±11.9% relative humidity). The *M. inornata* isolate used in this study was first isolated from tomato, *Solanum lycopersicum* L., in Chile and was provided by Dr. Gerrit Karssen, National Plant Protection Organization, The Netherlands.

The above ground plant parts did not show specific symptoms, but typical RKN galls were detected on the roots (Figure 1). The majority (>90%) of the tubers had characteristic symptoms of RKN infections, i.e. surface galls which were small, pimple-like quality-reducing

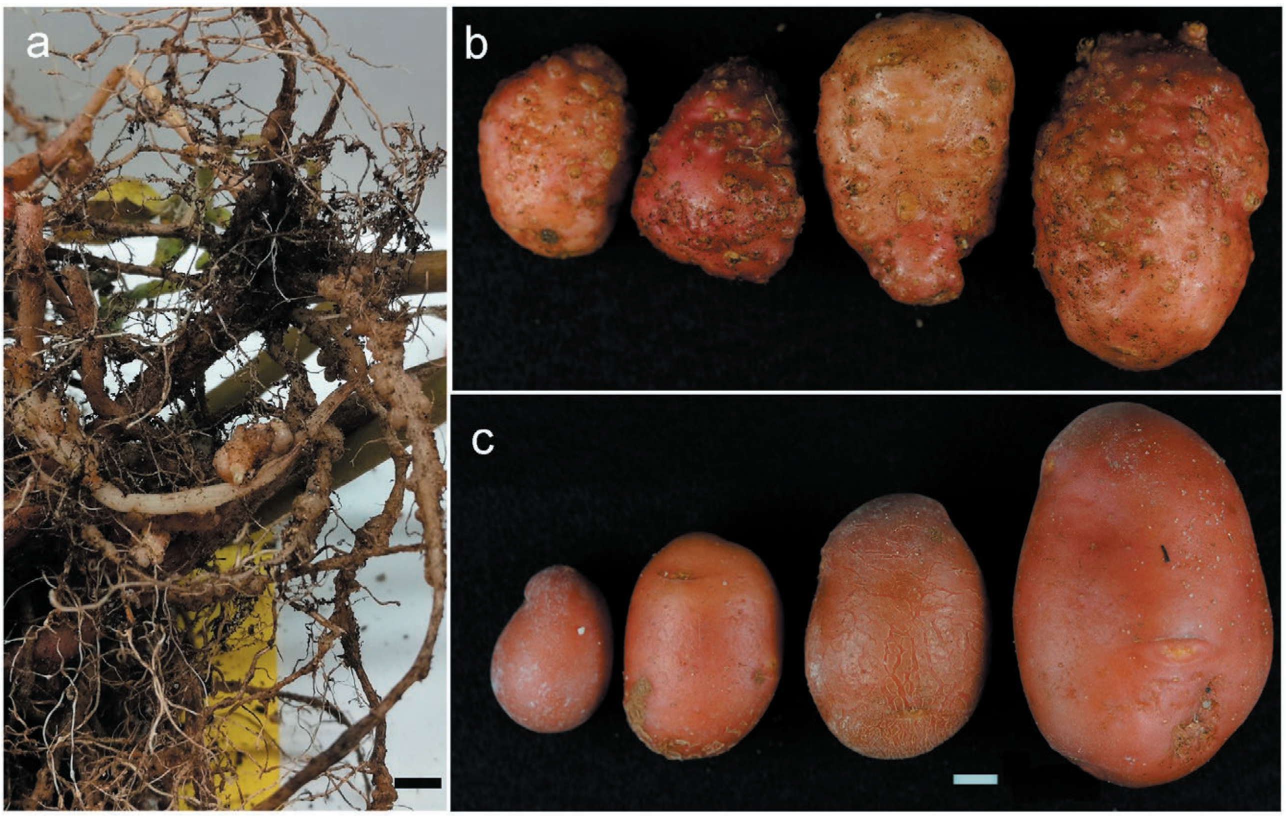

Figure 1. Symptoms of infection by the root-knot nematode *Meloidogyne inornata* on *Solanum tuberosum* 'Désirée'. a) Roots with galls. b) Tubers with surface galls. **c)** Uninfected potato tubers. Scale bars = 1 cm.

swellings on the tuber surfaces (Figure 1). A few tubers had no visible symptoms on the surfaces, although female nematodes were detected under the skins of the potato tubers. These were defined as latent infections. The infection symptoms by *M. inornata* were identical to those caused by *M. luci* (Žibrat *et al*., 2021), and by the two quarantine species *M. chitwoodi* and *M. fallax* (EPPO, 2016).

Species identification of the nematodes in the infected tubers was based on morphology of females, males and second-stage juveniles from galls and infected roots, and was confirmed by isozyme analysis of malate dehydrogenase (MDH) and esterase (EST) of individual females (Gerič Stare *et al*., 2017). The morphometric analyses found characters typical for *M. inornata*. In females, the stylets were robust, slightly curved dorsally with well-developed knobs. Perineal patterns of the females were variable (oval to squarish), with dorsal arches moderately high to high and rounded to squarish. Lateral fields were without distinct incisures, phasmids were small and located posterior to the anuses. The morphometric characters of females, males and second-stage juveniles were in agreement with previously published data for the *M. inornata* Chile isolate (Gerič Stare *et al*., 2019).

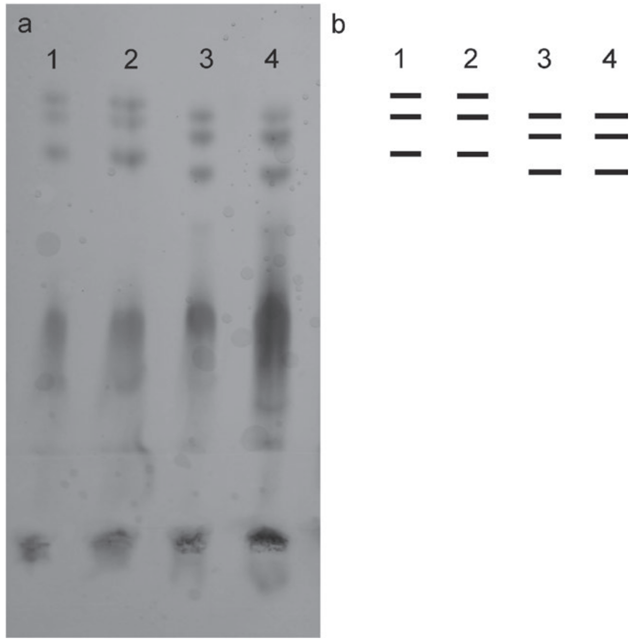

Figure 2. a) Esterase and malate dehydrogenase phenotypes, and b) schematic representation of *Meloidogyne inornata* (lanes 3 & 4). Lanes 1 & 2: *M. javanica* (reference isolate).

Determination of morphological characters alone and comparison with previous reports by Carneiro *et al.* (2008) and Gerič Stare *et al.* (2019) did not provide unambiguous identification, as several morphological characteristics were overlapping between sister species of the *M. ethiopica* group (Gerič Stare *et al.,* 2019). The *M. inornata* species-specific isozyme esterase pattern I3, and a non-specific malate dehydrogenase N1 were observed (Figure 2). A real-time PCR-based assay was performed to detect *M. inornata* directly in secondary tuber peels, using the *M. ethiopica* group primers (Žibrat *et al*., 2021). *Meloidogyne inornata* was detected in infected tubers with a low detection limit and high analytical sensitivity. One peel of a symptomatic tuber added to 99 uninfected peels gave Ct = 32.26 ± 0.24, and ten isolated females with attached egg mass added to a sample of 100 uninfected peels gave a Ct = 27.21 ± 0.06. Addition of one or three female(s) with attached egg mass to a sample of 100 uninfected peels weren't reliably detected across all biological and technical replicates tested. Melting temperature (Tm: 68.2–68.7^{o}C) indicated specific DNA amplification.

The pathogenicity assay identified potato as a new experimental host (i.e. identified by artificial inoculation) of *M. inornata*. Although *M. inornata* was not detected on potato in natural field conditions in a specific geographic location, the results indicate that this nematode has considerable potential to cause severe damage to potato crops. Further studies to determine *M. inornata* reproduction factor and susceptibility of different potato cultivars are needed. The potential spread of this pathogen into new areas should be determined, as it is able to damage potato tubers and could be a threat to economically important crops. Ensuring pest-free seed potatoes is critical to prevent the dissemination and establishment of *M. inornata* to uninfested areas of Europe and elsewhere. Phytosanitary measures and monitoring programmes to prevent the introduction and spread of this pest in Europe may be warranted. Additionally, as *M. ethiopica* and *M. luci*, which are pests on the EPPO Alert List, pose a similar threat, a real-time PCR-based test to detect the *M. ethiopica* group in potatoes could be a useful tool for phytosanitary monitoring programmes.

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LITERATURE CITED

Bačić J., Gerič Stare B., Strajnar P., Širca S., Urek G., 2016. First report of a highly damaged potato crop from Serbia caused by *Meloidogyne incognita. Plant Disease* 100: 1021. doi: 10.1094/PDIS-09-15-1072-PDN.

Camara G.R., Carvalho A.H.O., Teixeira A.G., Ferreira M.L.S.M., Oliveira F.L. de, … Alves F.R., 2020. First report of *Meloidogyne inornata* on *Smallanthus sonchifolius* in Brazil. *Plant Disease* 104: 595‑595. doi: 10.1094/PDIS-08-19-1739-PDN.

Carneiro R.M.D.G., Mendes M.L., Almeida M.R.A., Santos M.F.A., Gomes A.C.M.M., Karssen G., 2008. Additional information on *Meloidogyne inornata* Lordello, 1956 (Tylenchida: Meloidogynidae) and its characterisation as a valid species. *Nematology* 10: 123‑136.

Dadazio T.S., Silva S.A. da, Dorigo O.F., Wilcken S.R.S., Machado A.C.Z., 2016. Host-parasite relationships in root-knot disease caused by *Meloidogyne inornata* in common bean (*Phaseolus vulgaris*). *Journal of Phytopathology* 164: 735‑744.

Eurostat - Statistics Explained, July 2021. *The EU potato sector* - statistics on production, prices and trade. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=The_EU_potato_sector_-_statistics_on_production,_prices_and_trade#Potato_production_in_the_EU_is_highly_concentrated Accessed January 10, 2022.

EPPO - European and Mediterranean Plant Protection Organization, 2016. Diagnostics, PM 7/41 (3) *Meloidogyne chitwoodi* and *Meloidogyne fallax. EPPO Bulletin* 46: 171–189.

Gerič Stare B., Aydinli G., Devran Z., Mennan S., Strajnar P., … Širca S., 2019. Recognition of species belonging to *Meloidogyne ethiopica* group and development of a diagnostic method for its detection. *European Journal of Plant Pathology* 154: 621‑633. doi: 10.1007/s10658-019-01686-2.

Gerič Stare B., Strajnar P., Susič N., Urek G., Širca S., 2017. Reported populations of *Meloidogyne ethiopica* in Europe identified as *Meloidogyne luci*. *Plant Disease* 101: 1627‑1632. doi: 10.1094/PDIS-02-17-0220-RE.

Lordello, L.G.E., 1956. *Meloidogyne inornata* sp. n. a serious pest of soybean in the state of São Paulo, Brazil (Nematoda, Heteroderidae). *Revista Brasileira de Biológia* 16: 65–70.

Machado A.C.Z., Dorigo O.F., Mattei D., 2013. First report of the root knot nematode, *Meloidogyne inornata*, on common bean in Paraná State, Brazil. *Plant Disease* 97:431. https://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-09-12-0832-PDN.

Maleita C., Esteves I., Cardoso J.M.S., Cunha M.J., Carneiro R.M.D.G., Abrantes I., 2018. *Meloidogyne luci*, a new root-knot nematode parasitizing potato in Portugal. *Plant Patho*logy 67: 366–376. doi: https://doi.org/10.1111/ppa.12755.

Rusinque L., Nóbrega F., Cordeiro L., Serra C., Inácio M.L., 2021. First detection of *Meloidogyne luci* (Nematoda: Meloidogynidae) parasitizing potato in the Azores, Portugal. *Plants* 10: 99. DOI:10.3390/plants10010099.

Şen F., Aydınlı G., 2021. Host status of cultivated crops to *Meloidogyne luci*. *European Journal of Plant Pathology* 161: 607–618. DOI:org/10.1007/s10658-021-02346-0.

Širca S., Gerič Stare B., Strajnar P., Knapič M., Žibrat U., … Maleita C., 2021. *Global warming and distribution of root-knot nematode species of the tropical group (MeloTrop),* Euphresco: final report. Geneva: Zenodo, doi: 10.5281/zenodo.5171594. Available at: https://zenodo.org/record/5171594#.YRZE1tUzaUl. Accessed January 21, 2022.

Whitehead A.G., 1968. Taxonomy of *Meloidogyne* (Nematoda: Heteroderidae) with description of four new species. *Transactions of the Zoological Society of London* 31: 263–401.

Žibrat U., Gerič Stare B., Knapič M., Susič N., Lapajne J., Širca S., 2021. Detection of root-knot nematode *Meloidogyne luci* infestation of potato tubers using hyperspectral remote sensing and real-time PCR molecular methods. *Remote Sensing* 13: 1‑21. https://www.mdpi.com/2072-4292/13/10/1996.