

## SHORT COMMUNICATION

# ***Lavandula angustifolia* and *Oxalis pes-caprae*, hosts of *Meloidogyne hapla* and *Meloidogyne javanica* - A note for *Meloidogyne luci* in Greece**

A.R. Gonçalves<sup>1</sup>, I.L. Conceição<sup>1</sup>, M. Kormpi<sup>2</sup> and E.A. Tzortzakakis<sup>3\*</sup>

**Summary** Root-knot nematodes (RKN), *Meloidogyne* spp., have a wide host range and are common in the Mediterranean area. Cultivated lavender (*Lavandula angustifolia*) was found naturally infested by *M. hapla* in Kozani area, the first documented infestation of this crop by RKN in Greece. *Oxalis pes-caprae*, a common winter weed in Crete, was found to be a host of *M. javanica* under artificial inoculation. This weed acts as a potential winter host of the nematode in fields cultivated with vegetable crops. Two populations of *M. ethiopica* were found in kiwi and maize in Greece in the past. Recently, populations of *M. ethiopica* from Europe were re-classified as *M. luci*, based only on the population isolated from kiwi for Greece. In the current work, the RKN populations originating from kiwi and maize and maintained on tomato, were identified as *M. luci*. Nematode species identification was determined by electrophoretic analysis of protein extracts obtained from females.

*Additional keywords*: Esterase phenotypes, identification, root-knot nematodes, weed

Root-knot nematodes (RKN), *Meloidogyne* spp., are amongst the most economically important nematodes in agriculture, having a wide host range and being common in the Mediterranean area (Lamberti, 1981; Moens *et al.*, 2009). Species identification using morphological characteristics is complex, difficult and time consuming. In Greece, RKN have been found in several areas and their identification was based on morphological and morphometric characters and/or differential host tests until the middle of 1990's (Tzortzakakis *et al.*, 2011). In the last 20 years, the four major RKN species (*Meloidogyne arenaria* (Neal) Chitwood, 1949, *Meloidogyne hapla* Chitwood, 1949, *Meloidogyne incognita* (Kofoid & White) Chitwood, 1949 and *Meloidogyne javanica* (Treub) Chitwood, 1949), *Meloidogyne luci* (Carneiro, Correa, Almeida, Gomes, Mohammad Deymi, Castagnone – Sereno & Karssen, 2014) (initially identified as *Meloidogyne ethiopica* Whitehead, 1968) and *Meloidogyne hispanica* (Hirschmann, 1986) have been identified in Greece using molecular and/or biochemical markers (Conceição *et al.*, 2012; Tzortzakakis *et al.*, 2011, 2014, 2016, 2019; Gerič Stare *et al.*, 2017).

Herein *Meloidogyne* spp. from populations isolated from cultivated plants in Greece, were identified by electrophoretic analysis of protein extracts obtained from RKN females, using the Mini-Protean III system (Bio-Rad) according to Esbenshade and Triantaphyllou (1985a,b) and Pais *et al.* (1986), with some modifications. The analysis revealed new host plant species for *M. hapla* and *M. javanica* and also confirmed the identity of *M. luci* in two populations maintained on tomato.

In autumn of 2018, some plants of cul-

<sup>1</sup> CFE - Centre for Functional Ecology- Science for People & the Planet, Department of Life Sciences, University of Coimbra, Portugal.

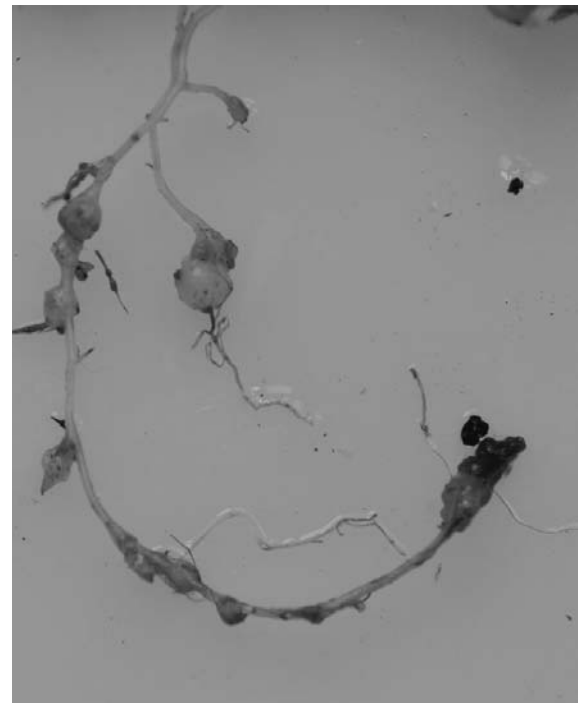
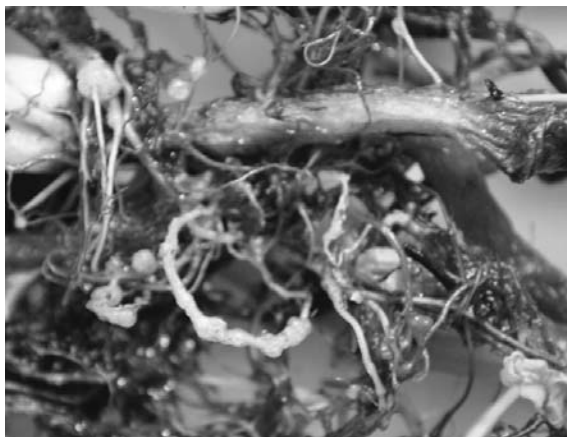
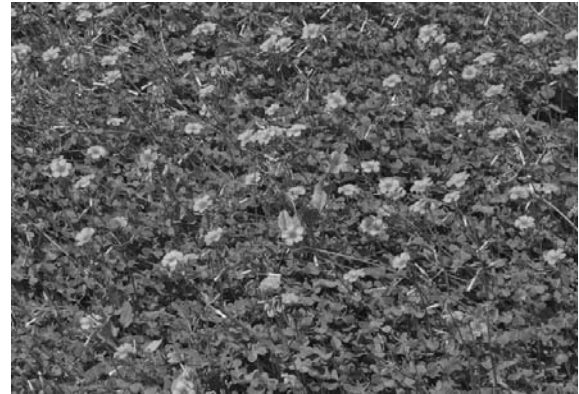
<sup>2</sup> Benaki Phytopathological Institute, St. Delta 8, GR-14561 Kifisia, Athens, Greece.

<sup>3</sup> Department of Viticulture, Vegetable Crops, Floriculture and Plant Protection, Institute of Olive Tree, Subtropical Crops and Viticulture, N.A.G.R.E.F., Hellenic Agricultural Organization-DEMETER, 32A Kastorias street, Mesa Katsabas, 71307, Heraklion, Crete, Greece.

\* Corresponding author: etzortza@gmail.com

tivated lavender (*Lavandula angustifolia*) from the area of Kozani, North Greece, indicated symptoms of stunting. Roots were examined and galls typical for RKN infestation were detected (Fig. 1). Egg masses were col-

lected and used to inoculate tomato plants (*Solanum lycopersicum*, cv. ACE) grown in pots filled with commercial compost soil and maintained in a growth room with 16h photoperiod and temperature ranging from



**Figure 1.** Top left: Root of cultivated lavender (*Lavandula angustifolia*) with galls caused by *Meloidogyne hapla*. Top right: *Oxalis pes-caprae*, a quite common winter weed in Crete, Greece. Bottom: Root of *Oxalis pes-caprae* with galls caused by *Meloidogyne javanica* after artificial inoculation.

21 to 24°C. The RKN population originating from lavender was identified as *M. hapla*. This species has been previously reported in Greece based only on morphological identification characteristics (Hirschman *et al.*, 1966; Koliopanos, 1980; Pyrowolakis, 1980; Vovlas and Antoniou, 1987; Vlachopoulos, 1994). Recently it was found in Crete infecting the mountain tea variety "Malotira" (*Sideritis syriaca* L.) and that was the first molecular identification of this species in Greece (Tzortzakakis *et al.*, 2019). The current work represents the first report of natural infestation of cultivated lavender by *M. hapla* in Greece.

*Oxalis pes-caprae* (Fig. 1) is a common winter weed in Crete. Bulbs of *O. pes-caprae* were collected from soil samples originating from vineyards in autumn and stored. In October, they were planted in pots filled with commercial compost soil and inoculated with pieces of heavily galled roots of a tomato plant found infested with RKN in a home garden. The pots were maintained in a glasshouse without artificial light or heating from October to April, when the plants were let to dry. Air temperature fluctuated from 3°C at winter nights to as high as 35°C in spring. The roots were washed from the soil and revealed presence of galls with egg masses (Fig. 1). Several egg masses were collected and inoculated to tomato plants (cv. ACE) grown in pots in a growth room as described previously. After approximately two months, the plants were uprooted and RKN females isolated from the roots were used for species identification.

The population that infested and reproduced on *O. pes-caprae* in pots was identified as *M. javanica* which is a prevalent species of RKN in Crete (Tzortzakakis *et al.*, 2011). The related species *Oxalis corniculata* has been reported as a host of *Meloidogyne* species (Dabaj and Jenser, 1990; Belle *et al.*, 2016; Santos *et al.*, 2019). In Italy, *M. javanica* has been found parasitizing *O. pes-caprae* in citrus groves (Ciancio *et al.*, 1992). The current work indicates that this weed could act as a potential winter host of this nematode species, especially in fields cultivated with

vegetable crops in the period from spring to autumn.

*Meloidogyne luci* was recently described from populations originating from Brazil, Chile, Iran (Carneiro *et al.*, 2014) and later from Guatemala and Portugal (Janssen *et al.*, 2016; Maleita *et al.*, 2018; Santos *et al.*, 2019). Gerič Stare *et al.* (2017) stated that all reports of *M. ethiopica* from Europe (Slovenia, Italy and Greece) refer to the species *M. luci*. The first report of *M. ethiopica* in Greece was based on the identification of two populations, one isolated from kiwi and the other from maize (Conceição *et al.*, 2012). Both of these populations have been cultured in potted tomatoes at the Nematology Laboratory of the Institute of Olive Tree, Subtropical Crops and Viticulture, Heraklion, Crete, since 2009. In 2017, Gerič Stare *et al.* identified the population isolated from kiwi as *M. luci*. In the present work, the RKN populations originating from kiwi and maize were both identified as *M. luci* confirming the presence of this species in two different areas of Greece. Recently, 26 different plant species were recognized as hosts of *M. luci* and because it has been misidentified as *M. ethiopica* for several years, a broader distribution is currently documented (EPPO, 2017).

## Literature Cited

- Belle C., Kaspary T.E., Schmitt, J. and Kuhn, P.R. 2016. *Meloidogyne ethiopica* and *Meloidogyne arenaria* parasitizing *Oxalis corniculata* in Brazil. *Australasian Plant Disease Notes*, 11: 24.
- Carneiro, R.M.D.G., Correa, V.R., Almeida, M.R.A., Gomes, A.C.M.M., Mohammad Deimi, A., Castagnone – Sereno, P. and Karsen, G. 2014. *Meloidogyne luci* n.sp. (Nematoda: Meloidogynidae), a root-knot nematode parasitizing different crops in Brazil, Chile and Iran. *Nematology*, 16: 289-301.
- Ciancio, A., Lo Giudice, V., Bosignore, R. and Rocuzzo, G. 1992. [Root knot nematodes attacking weeds in Southern Italy]. *Informatore Fitopatologico*, 6: 55-57.
- Conceição, I.L., Tzortzakakis, E.A., Gomes, P., Abrantes, I. and da Cunha, M.J. 2012. Detection of the root-knot nematode *Meloidogyne ethiopica* in Greece. *European Journal of Plant Pathology*, 134: 451-457.
- Dabaj, K.H. and Jenser, G. 1990. Some weed host-

- plants of the northern root-knot nematode *Meloidogyne hapla* in Hungary. *Nematologia Mediterranea*, 18: 139-140.
- EPPO. 2017. EPPO Alert List: addition of *Meloidogyne luci* together with *M. ethiopica*. EPPO Reporting Service, 2017/218, accessed from: <https://gd.eppo.int/reporting/article-6186> (December 2018).
- Esbenshade, P.R. and Triantaphyllou, A.C. 1985a. Identification of major *Meloidogyne* species employing enzyme phenotypes as differentiating characters. In Barker, K.R., Carter, C.C. and Sasser, J.N. (eds). An advanced treatise on *Meloidogyne*, Vol. II: Methodology. Raleigh, NC, USA, North Carolina State University Graphics, p.113-123.
- Esbenshade, P.R. and Triantaphyllou, A.C. 1985b. Use of enzyme phenotypes for identification of *Meloidogyne* species. *Journal of Nematology*, 17: 6-20.
- Gerič Stare, B., Strajnar, P., Susič, N., Urek, G. and Širca, S. 2017. Reported populations of *Meloidogyne ethiopica* in Europe identified as *Meloidogyne luci*. *Plant Disease*, 101: 1627-1632.
- Hirschmann, H., Paschalaki-Kourtzi, N. and Triantaphyllou, A.C. 1966. A survey of plant parasitic nematodes in Greece. *Annales de l'Institut Phytopathologique Benaki*, 7: 144-156.
- Janssen, T., Karssen, G., Verhaeven, M., Coyne, D. and Bert, W. 2016. Mitochondrial coding genome analysis of tropical root-knot nematodes (*Meloidogyne*) supports haplotype based diagnostics and reveals evidence of recent reticulate evolution. *Scientific Reports*, 6: 22591, DOI: 10.1038/srep22591.
- Koliopanos, C.N. 1980. Contribution to the study of the root-knot nematode (*Meloidogyne* spp.) in Greece. *Proceedings of the 2<sup>nd</sup> Research Planning Conference on Root-knot Nematodes, Meloidogyne* spp., Athens, Greece, pp. 35-39.
- Lamberti, F. 1981. Plant nematode problems in the Mediterranean region. Helminthological Abstracts Series B, *Plant Nematology*, 50: 145-166.
- Maleita, C., Esteves, I., Cardoso, J.M.S., Cuhna, M.J., Carneiro, R.M.D.G. and Abrantes, I. 2018. *Meloidogyne luci*, a new root-knot nematode parasitizing potato in Portugal. *Plant Pathology*, 67 (2): 366-376, doi.org/10.1111/ppa.12755.
- Moens, M., Perry, R.N. and Starr, J.L. 2009. *Meloidogyne* species – a diverse group of novel and important plant parasites. In Perry, R.N., Moens, M. and Starr, L.J. (eds). Root-knot nematodes. CABI International, Wallingford, Oxon (CABI), p. 1-17.
- Pais, C.S., Abrantes, I.M. de O., Fernandes, M.F.M. and Santos M.S.N. de A, 1986. Técnica de electroforese aplicada ao estudo das enzimas dos nematodes-das-galhas radiculares, *Meloidogyne* spp. *Ciência Biológica Ecology and Systematics* (Portugal), 6: 19-34.
- Pyrowolakis, E. 1980. Distribution and control of root-knot nematodes in Crete. *Proceedings of the 2<sup>nd</sup> Research Planning Conference on Root-knot Nematodes, Meloidogyne* spp., Athens, Greece, pp. 30-34.
- Santos, D., Correia, A., Abrantes, I and Maleita, C. 2019. New hosts and records in Portugal for the root-knot nematode *Meloidogyne luci*. *Journal of Nematology*, 51. DOI: 10.21307/jofnem-2019-003.
- Tzortzakakis, E.A., da Conceição, I.L.P.M., dos Santos, M.C.V. and de O. Abrantes, I.M. 2011. Root-knot nematodes (*Meloidogyne* spp) in Greece. *Hellenic Plant Protection Journal*, 4: 25-30.
- Tzortzakakis, E.A., Anastasiadis, A.I., Simoglou, K.B., Cantapiedra-Navarrete, C., Palomares-Rius, J.E and Castillo, P. 2014. First report of the root-knot nematode *Meloidogyne hispanica* infecting sunflower in Greece. *Plant Disease*, 98(5): 703.
- Tzortzakakis, E.A., dos Santos, M.C.V. and Conceição, I. 2016. An update on the occurrence of resistance-breaking populations of root-knot nematodes (*Meloidogyne* spp.) on resistant tomato in Greece with six new records from Crete. *Hellenic Plant Protection Journal*, 9: 73-77.
- Tzortzakakis, E.A., Cantalapedra-Navarrete, Archidona, A-Y., Kormpi, M., Palomares-Rius, J.E. and Castillo, P. 2019. First report of cultivated Cretan mountain tea (*Sideritis syriaca*) as a host of *Meloidogyne hapla* and *M. javanica* in Crete, with some additional records on the occurrence of *Meloidogyne* species in Greece. *Journal of Nematology*, 51. DOI: 10.21307/jofnem-2019-010.
- Vlachopoulos, E.G. 1994. Plant protection problems caused by phytonematodes in Greece. *Bulletin OEPP/EPPO*, 24: 413-415.
- Vovlas, N. and Antoniou, M. 1987. Alterations induced by the root-knot nematode *Meloidogyne hapla* Chitwood in *Actinidia* roots. *Annales de l'Institut Phytopathologique Benaki*, 15:151-154.

Received: 20 August 2019; Accepted: 1 March 2020

## ΣΥΝΤΟΜΗ ΑΝΑΚΟΙΝΩΣΗ

### ***Lavandula angustifolia* και *Oxalis pes-caprae*, ξενιστές των κομβονηματοδών *Meloidogyne hapla* και *Meloidogyne javanica* - Σημείωση για τον *Meloidogyne luci* στην Ελλάδα**

A.R. Gonçalves, I.L. Conceição, M. Κορμπή και E.A. Τζωρτζακάκης

**Περίληψη** Οι κομβονηματοώδεις (*Meloidogyne* spp.) έχουν ένα μεγάλο εύρος ξενιστών και είναι ευρέως διαδεδομένοι στην Μεσόγειο. Στην περιοχή της Κοζάνης βρέθηκε καλλιεργούμενη λεβάντα (*Lavandula angustifolia*) με προσβολή από τον νηματώδη *Meloidogyne hapla* με την συγκεκριμένη καταγραφή να είναι η πρώτη στην Ελλάδα. Η οξαλίδα, *Oxalis pes-caprae*, αποτελεί ένα συνηθισμένο χειμερινό ζιζάνιο στην Κρήτη και βρέθηκε να είναι ξενιστής του είδους *M. javanica* σε συνθήκες τεχνητής μόλυνσης. Επομένως μπορεί να αποτελέσει ένα χειμερινό ξενιστή του νηματώδη σε αγρούς με καλλιέργεια κηπευτικών. Δύο πληθυσμοί του νηματώδη *M. ethiopica* είχαν βρεθεί σε καλλιέργεια ακτινιδίου και αραβόσιτου στην Ελλάδα παλαιότερα. Πρόσφατα, επιβεβαιώθηκε ότι όλες οι αναφορές του *M. ethiopica* στην Ευρώπη αφορούν το είδος *M. luci*, λαμβάνοντας υπόψη μόνο τον πληθυσμό στο ακτινίδιο για την Ελλάδα. Οι πληθυσμοί που είχαν απομονωθεί από την καλλιέργεια του ακτινιδίου και του αραβόσιτου στην Ελλάδα ταυτοποιήθηκαν ως *M. luci*. Η ταυτοποίηση των ειδών των νηματωδών έγινε με ηλεκτροφόρηση πρωτεϊνών προερχόμενες από θηλυκά άτομα.

*Hellenic Plant Protection Journal* **13**: 78-82, 2020