

Express Pest Risk Analysis:

.....

(Meloidogyne ethiopica and Meloidogyne luci)

Prepared by:

Dr. Saša Širca and dr. Polona Strajnar, Kmetijski inštitut Slovenije (Agricultural Institute of Slovenia), Hacquetova ulica 17, 1000 Ljubljana, Slovenia. E-mail: sasa.sirca@kis.si; polona.strajnar@kis.si;

Adopted: 9 March 2018

The PRA was reviewed and comments provided by the Expert working group for PRA (dr.Gregor Urek, dr.Irena Mavrič Pleško (Agricultural Institute of Slovenia), dr. Sebastjan Radišek (Slovenian Institute of Hop Research and Brewing) and Administration for Food Safety, Veterinary Sector and Plant health (Anita Benko Beloglavec, dr. Alenka Zupančič).

Summary¹ of the Express Pest Risk Analysis for “*Meloidogyne ethiopica* and *Meloidogyne luci*”

Root knot nematodes *M. ethiopica* and *M. luci* are serious pests of several agricultural crops belonging to monocotyledons, dicotyledons, including herbaceous and woody plants. All previously reported populations of *M. ethiopica* in Europe and Turkey were reclassified as *M. luci*. In Brazil and Chile, *M. ethiopica* is considered to be a damaging species on kiwi and grapevine, as infestations lead to a reduction of plant growth, fruit size and quality. It is widely distributed in vineyards in Chile. In Brazil, *M. ethiopica* has also been reported to cause multiple galls on potato root systems, as well as protuberances on tubers. Similarly, *M. luci* has been reported on several vegetable crops and has also been shown as a potential threat to the potato production in Portugal.

M. ethiopica and *M. luci* can be introduced by several pathways but the highest risk for entry and spread in the PRA area is considered the pathway of host plants for planting with or without soil attached. In addition, plant parts like tubers may present also high risk of spreading in case of pest establishment outdoors. Human assisted spread of the pests is the most important one. The probability of establishment in the protected area is high. *M. luci* has already been detected in the open field production in Europe (Mediterranean climate), in corn and kiwi production in Greece, and potato production in Portugal. There is a high risk of *M. luci* establishment outdoors in the PRA area, as this species was proved to overwinter outdoors at the open field in continental and Mediterranean climate. Once the RKNs have been introduced, it is in general difficult to control or eradicate them, especially outdoors at the open field. On the other hand the ability of *M. ethiopica* to overwinter at the open field in continental and Mediterranean climate has not been tested yet. The endangered area in the PRA area for *M. luci* is therefore: protected production area, vegetable production area, potato production area, corn and other cereals production area, vineyards, kiwi and peach production area.

PRA area: whole territory of Slovenia

Describe the endangered area: protected production area, vegetable production area, potato production area, corn and other cereals production area, vineyards, kiwi and peach production area

Main conclusions

Root knot nematodes *M. ethiopica* and *M. luci* can be introduced by several pathways:

- High risk for entry in the PRA area: host plants for planting with roots, with or without soil attached (planting material of vegetables, ornamental plants, fruit trees and grapevine), non-host plants for planting with soil attached and in addition, plant parts like tubers may present also high risk of spreading in case of pest establishment outdoors.
- Moderate risk: soil and growing medium
- Low risk: non-hosts plant parts contaminated with soil (such as roots, tubers, bulbs), for consumption or processing, soil attached to equipment and machinery, travellers

Human assisted spread of the pests is the most important.

M. ethiopica and *M. luci* have very wide host range including majority of vegetable crops which are cultivated in the protected area. The probability of establishment in the protected area is high. *M. luci* has already been detected outdoors in Europe (Mediterranean area), in corn and kiwi production in Greece, and potato production in Portugal. There is a high risk of *M. luci* establishment outdoors in the PRA area, as this species was proved to overwinter outdoors in European temperate regions and countries of Mediterranean area. Once the RKNs have been introduced, it is in general difficult to control or eradicate them, especially outdoors. On the other hand the ability of *M. ethiopica* overwintering in the open field in temperate and Mediterranean areas has not been tested yet.

The potential impact of both pest species in the PRA area is high especially in the light of climate change scenarios. The models of climate changes predict an increase of average temperatures and

more frequent periods of drought, floods and heat waves. Higher temperatures would allow development of more generations of RKNs in a growing season and consequently higher yield losses. In addition, the findings of virulent populations of *M. luci* in Turkey that can reproduce on tomato plants bearing *Mi-1* resistance gene adds to the concern about the damage potential of this pest.

Phytosanitary measures to prevent the spread of these pests within the PRA area in case of an outbreak are necessary. The measures should include prohibition of movement of plants for planting originating from infested area, ban of movement of soil from infested area, cleaning and disinfection of facilities, tools and machinery, destruction of nematode infested plant waste, survey, sampling scheme and laboratory testing (within infested area and the surroundings).

<p>Phytosanitary risk for the <i>endangered area</i> <i>(Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document)</i></p>	<p>High <input checked="" type="checkbox"/></p>	<p>Moderate <input type="checkbox"/></p>	<p>Low <input type="checkbox"/></p>
<p>Level of uncertainty of assessment <i>(see Q 17 for the justification of the rating. Individual ratings of uncertainty of entry, establishment, spread and impact are provided in the document)</i></p>	<p>High <input type="checkbox"/></p>	<p>Moderate <input checked="" type="checkbox"/></p>	<p>Low <input type="checkbox"/></p>

Other recommendations:

- Inform EPPO or EU
- Surveys are recommended to confirm the pests status
- Additional research is needed to support phytosanitary decisions (needed research on the damage potential of both species to major crops (early, late potato cultivars, corn etc.); the ability of *M. ethiopica* to overwinter at the open field in continental and Mediterranean climate; assessment of the efficiency of biological and low risk control/management options)

Stage 1. Initiation

Reason for performing the PRA:

M. luci is a root knot nematode (RKN) which has recently been discovered in several European countries. Pest specimens, previously found in Europe and Turkey have been identified as *M. ethiopica* but recent studies justified reclassification to *M. luci* (Janssen et al. 2016; Gerič Stare et al. 2017a). RKN *M. luci* was detected for the second time in Slovenia, near Ljubljana in 2015 (Gerič Stare et al. 2017b), while the first found was in 2003. Sister species *M. ethiopica* and *M. luci* were found to be closely related and no differential host has been discovered so far. The pest risk assessment therefore comprises both species, *M. ethiopica* and *M. luci*.

PRA area: whole territory of Slovenia

Stage 2. Pest risk assessment

1. Taxonomy:

Meloidogyne ethiopica Whitehead, 1968

Domain: Eukaryota

Kingdom: Metazoa

Phylum: Nematoda

Family: Meloidogynidae

Genus: *Meloidogyne*

Species: *Meloidogyne ethiopica*

And

Meloidogyne luci Carneiro et al., 2014

Domain: Eukaryota

Kingdom: Metazoa

Phylum: Nematoda

Family: Meloidogynidae

Genus: *Meloidogyne*

Species: *Meloidogyne luci*

Common name (of the genus): root knot nematodes (RKN)

2. Pests overview

M. ethiopica was described by Whitehead in 1968 from the Mlalo region of Tanzania. It has been reported from Africa - Kenya, Ethiopia, Mozambique, Zimbabwe, Tanzania, South Africa (Whitehead 1968, 1969), South America - Chile, Brazil, Peru (Carneiro et al. 2003, 2004), Europe - Slovenia (Širca et al. 2004), Greece (Conceição et al. 2012), and Italy (Maleita et al. 2012) and Asia - Turkey (Aydinli et al. 2013). *M. ethiopica* can parasitize several crops including monocotyledons, dicotyledons, and herbaceous and woody plants (Carneiro et al. 2003, 2004; Lima et al. 2009; O'Bannon 1975; Strajnar et al. 2009, 2010; Whitehead 1968). It is widely distributed in vineyards in Chile (Aballay et al. 2009). In Brazil, *M. ethiopica* affects the root growth, yield and quality of grapevines and kiwi, causing serious crop damage and economic losses (Carneiro et al. 2003). In Chile, *M. ethiopica* was found to be the major root knot nematode parasite of grapevines (*Vitis vinifera*) and other crops (Carneiro et al., 2007). Furthermore, Medina et al. (2014) reported *M. ethiopica* on potato plants from Parana state, Brazil, showing root systems with multiple galls and tubers with protuberances.

5. Regulatory status of the pest

Meloidogyne ethiopica: EPPO Alert List pest since 2011, no other status

Meloidogyne luci: EPPO Alert List pest since 2017, no other status

6. Distribution

Meloidogyne ethiopica distribution

Continent	Distribution (list countries, or provide a general indication , e.g. present in West Africa)	Provide comments on the pest status in the different countries where it occurs (e.g. widespread, native, introduced...)	Reference
Africa	Ethiopia, Kenya ,Mozambique, South Africa, Tanzania, Zimbabwe	Native, Present, no details	Whitehead, 1969; Mandefro & Dagne, 2000 Carneiro et al., 2004;
America	Brazil, Chile, Peru	Brazil (present in 5 provinces); Chile (widespread: area of 1000 km distance, causing economic damage)	Carneiro et al., 2003; Gomes et al., 2005; Carneiro et al., 2007; Somavilla et al., 2011; Murga-Gutierrez et al., 2012;
Asia	Absent	Reclassified in <i>M. luci</i>	Gerič Stare et al. 2017a;
Europe	Absent	Reclassified in <i>M. luci</i>	Gerič Stare et al. 2017a;
Oceania	Absent	No records	

Meloidogyne luci distribution

Continent	Distribution (list countries, or provide a general indication , e.g. present in West Africa)	Provide comments on the pest status in the different countries where it occurs (e.g. widespread, native, introduced...)	Reference
Africa	Absent	No records	
America	Brazil, Chile	Brazil (Present, few occurrences) Chile (Present, one occurrence)	Carneiro et al., 2014; Belle et al., 2016a;
Asia	Iran, Turkey	Iran (Present, no details) Turkey (widespread in Samsun province)	Aydinli et al., 2013; Gerič Stare et al. 2017a;
Europe	Greece, Italy, Portugal, Slovenia	Greece (Present, few occurrences) Italy (Present, one occurrence) Portugal (Present, one occurrence)	Sirca et al., 2004; Strajnar et al., 2009; Conceição et al., 2012; Maleita et al. 2012; Maleita

Continent	Distribution (list countries, or provide a general indication , e.g. present in West Africa)	Provide comments on the pest status in the different countries where it occurs (e.g. widespread, native, introduced....)	Reference
		Slovenia (Present, two occurrences; first occurrence eradicated; second occurrence under eradication)	et al. 2016; Gerič Stare et al. 2017b;
Oceania	Absent	No records	

7. Host plants /habitats* and their distribution in the PRA area

There is no dependable differential host plant between *M. ethiopica* and *M. luci* known so far. It seems that these two species are so closely related that there is no biological difference between them in terms of parasitizing different plant species. Host species lists for *M. ethiopica* and *M. luci* were prepared based on recorded infestation in the field and tests of host status for each species in literature.

In assessing whether the host is a major or minor crop two factors has been taken into account, the importance of crop in agricultural production and host suitability of plant to the root knot nematode *M. ethiopica* or *M. luci* (e.g. soybean is considered to be a major crop, since the agricultural area with soybean is increasing each year and the crop plants are a very good host for *M. luci* and *M. ethiopica*).

Host species list for *Meloidogyne ethiopica*

Host Scientific name (common name) / habitats*	Presence in PRA area (Yes/No)	Comments (e.g. total area, major/minor crop in the PRA area, major/minor habitats*)	Reference
<i>Acacia mearnsii</i> (Black wattle)	No	-	Whitehead 1968,1969
<i>Actinidia deliciosa</i> (Kiwi)	Yes	Minor crop for PRA area / Major crop for some PRA area regions	Carneiro et al. 2003, 2004
<i>Agave sisalana</i> (Sisal)	No	-	O'Bannon 1975.
<i>Ageratum conyzoides</i> (Billygoat-weed)	No	-	O'Bannon 1975.
<i>Arachis hypogaea</i> (Peanut)	No	-	Lima et al. 2009
<i>Asparagus officinalis</i> (Asparagus)	Yes	Minor crop	Murga-Gutierrez et al. 2012
<i>Avena sativa</i> (White oat)	Yes	Minor crop	Lima et al. 2009
<i>Avena strigosa</i> (Black oat)	No	-	Lima et al. 2009
<i>Brassica napus</i> (Rapeseed)	Yes	Minor crop	Lima et al. 2009
<i>Brassica oleracea</i> (Cabbage)	Yes	Major crop	O'Bannon 1975; Whitehead, 1968, 1969 Carneiro et al., 2014
<i>Cajanus cajan</i> (Dwarf pigeon pea)	Yes	Minor crop	Lima et al. 2009
<i>Capsicum annum</i> (Pepper)	Yes	Major crop	Carneiro et al., 2004
<i>Capsicum frutescens</i> (Chili Pepper)	Yes	Minor crop	Whitehead 1968, 1969
<i>Canavalia ensiformis</i> (Jack-bean)	No	-	Lima et al. 2009
<i>Carthamus tinctorius</i> (Safflower)	Yes	Minor crop	Lima et al. 2009

Host Scientific name (common name) / <i>habitats</i>*	Presence in PRA area (Yes/No)	Comments (e.g. total area, major/minor crop in the PRA area, <i>major/minor habitats</i>*)	Reference
<i>Citrullus lantanus</i> (Watermelon)	Yes	Minor crop	Carneiro <i>et al.</i> , 2003; Carneiro <i>et al.</i> , 2004
<i>Clitoria ternatea</i> (Butterfly pea)	Yes	Ornamental Minor crop	Lima <i>et al.</i> 2009
<i>Crotalaria anaguroydes</i> (Rattlepod)	No	-	Lima <i>et al.</i> 2009
<i>Crotalaria apioclice</i> (Rattlepod)	No	-	Lima <i>et al.</i> 2009
<i>Crotalaria grantiana</i> (Rattlepod)	No	-	Lima <i>et al.</i> 2009
<i>Crotalaria juncea</i> (Rattlepod)	No	-	Lima <i>et al.</i> 2009
<i>Crotalaria lanceolata</i> (Rattlepod)	No	-	Lima <i>et al.</i> 2009
<i>Crotalaria okoelvka</i> (Rattlepod)	No	-	Lima <i>et al.</i> 2009
<i>Crotalaria spectabilis</i> (Rattlepod)	No	-	Lima <i>et al.</i> 2009
<i>Cucumis melo</i> (Melon)	Yes	Major crop	Bellé <i>et al.</i> 2017b
<i>Cucumis sativus</i> (Cucumber)	Yes	Major crop	Carneiro <i>et al.</i> , 2014
<i>Cucurbita</i> sp. (Pumpkin)	Yes	Major crop	Whitehead 1969;
<i>Datura stramonium</i> (Jimson weed)	Yes	weed	O'Bannon 1975.
<i>Dahlstedtia pentaphylla</i> (Timbó)	No	-	Lima <i>et al.</i> 2009
<i>Dolichos lablab</i> (Hyacinth bean)	Yes	Ornamental Minor crop	Lima <i>et al.</i> , 2009
<i>Eleusine coracana</i> (Finger millet)	Yes	Minor crop	Lima <i>et al.</i> 2009
<i>Ensete ventricosum</i> (Ethiopian banana)	Yes	Ornamental, minor crop	Mandefro & Dagne 2000
<i>Eruca sativa</i> (Aragula)	Yes	Minor crop	Carneiro <i>et al.</i> , 2014
<i>Euchlaena mexicana</i> (synonym <i>Zea mexicana</i>)	No	-	Lima <i>et al.</i> 2009
<i>Fagopyrum esculentum</i> (Buckwheat)	Yes	Major crop	Lima <i>et al.</i> 2009
<i>Glycine max</i> (Soybean)	Yes	Major crop	O'Bannon 1975. Castro <i>et al.</i> , 2003, Carneiro <i>et al.</i> , 2003
<i>Glycine wightii</i> (Cooper)	No	-	Lima <i>et al.</i> 2009
<i>Gossypium hirsutum</i> (Cotton)	No	-	O'Bannon, 1975
<i>Helianthus annuus</i> (Sunflower)	Yes	Minor crop	Lima <i>et al.</i> 2009
<i>Jatropha curcas</i> (Barbados nut)	No	-	Lima <i>et al.</i> 2009
<i>Lactuca sativa</i> (Lettuce)	Yes	Major crop	O'Bannon 1975.
<i>Lolium multiflorum</i> (Italian ryegrass)	Yes	Minor crop	Lima <i>et al.</i> 2009

Host Scientific name (common name) / <i>habitats</i>*	Presence in PRA area (Yes/No)	Comments (e.g. total area, major/minor crop in the PRA area, <i>major/minor habitats</i>*)	<i>Reference</i>
<i>Lupinus albus</i> (White lupin)	Yes	Minor crop	Lima et al. 2009
<i>Lupinus angustifolius</i> (Blue lupin)	Yes	Minor crop	Lima et al. 2009
<i>Lycopersicon esculentum</i> (Tomato)	Yes	Major crop	Carneiro et al., 2003 Mandefro i Dagne 2000
<i>Medicago sativa</i> (Alfalfa)	Yes	Major crop	Lima et al. 2009
<i>Mucuna aterrima</i> (Black velvet bean)	No	-	Lima et al. 2009
<i>Mucuna cinerea</i> (Grey velvet bean)	No	-	Lima et al. 2009
<i>Mucuna deeringiana</i> (Dwarf velvet bean)	No	-	Lima et al. 2009
<i>Mucuna puriens</i> (Green velvet bean)		-	Lima et al. 2009
<i>Nicotiana tabacum</i> (Tobacco)	No	-	Whitehead 1968, 1969
<i>Ornithopus compressus</i> (Yellow serradella)	No	-	Lima et al. 2009
<i>Oxalis corniculata</i> (Creeping woodsorrel)	Yes	weed	Belle et al. 2016b
<i>Oryza sativa</i> (Rice)	No	-	Lima et al. 2009
<i>Pennisetum glaucum</i> (Pearl millet)	Yes	Minor crop	Lima et al. 2009
<i>Pisum sativum</i> subsp. <i>arvense</i> (Forage pea)	Yes	Major crop	Lima et al. 2009
<i>Pisum sativum</i> (Pea)	Yes	Minor crop	Lima et al. 2009
<i>Phaseolus vulgaris</i> (Bean)	Yes	Major crop	Mandefro & Dagne 2000 Bellé et al. 2017a
<i>Polymnia sonchifolia</i> (Yacon)	No	-	Carneiro & Almeida, 2005
<i>Psidium guajava</i> (Guava)	No	-	Dias et al. 2010
<i>Prunus persica</i> (Peach)	Yes	Major crop	Carneiro et al., 2003 Somavilla et al. 2009
<i>Raphanus sativus</i> (Radish)	Yes	Minor crop	Lima et al. 2009
<i>Saccharum</i> spp. (Sugarcane)	No	-	Bellé et al. 2017c
<i>Setaria italica</i> (Foxtail millet)	Yes	Minor crop	Lima et al. 2009
<i>Secale cereale</i> (Rye)	Yes	Major crop	Lima et al. 2009
<i>Sida rhombifolia</i> (Arrowleaf sida)	No	-	Gomez et al. 2005; Lima-Medina et al. 2013
<i>Solanum melongena</i> (Eggplant)	Yes	Major crop	Carneiro et al. 2014
<i>Solanum nigrum</i> (Nightshade)	Yes	weed	O'Bannon 1975.
<i>Solanum tuberosum</i> (Potato)	Yes	Major crop	Whitehead 1968, 1969; Lima-Medina et al., 2011
<i>Spinacia oleracea</i> (Spinach)	Yes	Minor crop	Carneiro et al. 2014

Host Scientific name (common name) / habitats*	Presence in PRA area (Yes/No)	Comments (e.g. total area, major/minor crop in the PRA area, major/minor habitats*)	Reference
<i>Tephrosia candida</i> (White hoarypea)	No	-	Lima et al. 2009
<i>Triticum aestivum</i> (Triticale)	Yes	Minor crop	Lima et al. 2009
<i>Vicia faba</i> (Broad bean)	Yes	Minor crop	Whitehead 1969
<i>Vigna umbellata</i> (Ricebean)	Yes	Minor crop	Lima et al. 2009
<i>Vigna unguiculata</i> (Cowpea)	Yes	Minor crop	Whitehead, 1968 Lima et al. 2009
<i>Vigna radiata</i> (Mungbean)	Yes	Minor crop	Lima et al. 2009
<i>Vicia sativa</i> (Common vetch)	Yes	Minor crop	Lima et al. 2009
<i>Vicia villosa</i> (Hairy vetch)	Yes	Minor crop	Lima et al. 2009
<i>Vitis</i> (Grapevine)	Yes	Major crop	Carneiro et al. 2003, 2004
<i>Zea mays</i> (Corn)	Yes	Major crop	Lima et al. 2009

Host species list for *Meloidogyne luci*

Host Scientific name (common name) / habitats*	Presence in PRA area (Yes/No)	Comments (e.g. total area, major/minor crop in the PRA area, major/minor habitats*)	Reference
<i>Abelmoschus esculentus</i> (Okra)	No	-	Carneiro et al., 2014
<i>Actinidia deliciosa</i> (Kiwi)	Yes	Minor crop for PRA area / Major crop for some PRA area regions	Carneiro et al., 2014
<i>Allium cepa</i> var. <i>cepa</i> (Onion)	Yes	Minor crop	Strajnar et al., 2009
<i>Antirrhinum majus</i> (Snapdragon)	Yes	Ornamental Minor crop	Carneiro et al., 2014
<i>Apium graveolens</i> (Celery)	Yes	Minor crop	Strajnar et al., 2009
<i>Brassica oleracea</i> var. <i>capitata</i> (Cabbage)	Yes	Major crop	Strajnar et al., 2009
<i>Brassica oleracea</i> var. <i>botrytis</i> (Cauliflower)	Yes	Minor crop	Strajnar et al., 2009
<i>Brassica oleracea</i> var. <i>gongylodes</i> (Kohlrabi)	Yes	Minor crop	Strajnar et al., 2009
<i>Brassica oleracea</i> var. <i>italica</i> (Broccoli)	Yes	Minor crop	Strajnar et al., 2009 Carneiro et al., 2014
<i>Brassica oleracea</i> var. <i>subauda</i> (Kale)	Yes	Minor crop	Strajnar et al., 2009
<i>Beta vulgaris</i> var. <i>ciela</i> (Chard)	Yes	Minor crop	Strajnar et al., 2011
<i>Beta vulgaris</i> var. <i>conditiva</i> (Beet)	Yes	Minor crop	Strajnar et al., 2009
<i>Capsicum annuum</i> (Pepper)	Yes	Major crop	Carneiro et al., 2014
<i>Cichorium endivia</i> (Endive)	Yes	Major crop	Strajnar et al., 2009

Host Scientific name (common name) / habitats*	Presence in PRA area (Yes/No)	Comments (e.g. total area, major/minor crop in the PRA area, major/minor habitats*)	Reference
<i>Cichorium intybus</i> var. <i>foliosum</i> (Chicory)	Yes	Major crop	Strajnar et al., 2009
<i>Cucumis melo</i> (Melon)	Yes	Major crop	Strajnar et al., 2009
<i>Citrullus lantanus</i> (Watermelon)	Yes	Minor crop	Geric Stare et al., 2017a
<i>Cucumis sativus</i> (Cucumber)	Yes	Major crop	Strajnar et al., 2009 Carneiro et al., 2014
<i>Daucus carota</i> (Carrot)	Yes	Minor crop	Strajnar et al., 2009
<i>Foeniculum vulgare</i> var. <i>azoricum</i> (Florence fennel)	Yes	Minor crop	Strajnar et al., 2009
<i>Glycine max</i> L. (Soybean)	Yes	Major crop	Bellé et al., 2016a
<i>Helianthus annuus</i> L. (Sunflower)	Yes	Minor crop	Strajnar et al., 2009
<i>Hordeum vulgare</i> L. (Barley)	Yes	Major crop	Strajnar et al., 2009
<i>Hylotelephium spectabile</i> L. (Sedum)	Yes	Ornamental minor crop	Carneiro et al., 2014
<i>Lactuca sativa</i> (Lettuce)	Yes	Major crop	Strajnar et al., 2009 Carneiro et al., 2014
<i>Lavandula spica</i> L (Lavender)	Yes	Ornamental minor crop	Carneiro et al., 2014
<i>Lycopersicon esculentum</i> (Tomato)	Yes	Major crop	Strajnar et al., 2009
<i>Nicotiana tabacum</i> L. (tobacco)	No	-	Carneiro et al., 2014
<i>Phaseolus vulgaris</i> (Common Bean)	Yes	Major crop	Strajnar et al., 2009 Carneiro et al., 2014
<i>Pisum sativum</i> (Pea)	Yes	Major crop	Strajnar et al., 2009
<i>Polymnia sonchifolia</i> Poepp. Endl (Yakon)	No	-	Carneiro et al., 2014
<i>Raphanus sativus</i> var. <i>radicula</i> (Radish)	Yes	Minor crop	Strajnar et al., 2009
<i>Rosa</i> sp. (Rose)	Yes	Ornamental minor crop	Carneiro et al., 2014
<i>Rumex patientia</i> L (Curled dock)	Yes	Weed	Strajnar et al., 2009
<i>Solanum melongena</i> (Eggplant)	Yes	Major crop	Strajnar et al., 2009
<i>Solanum tuberosum</i> (Potato)	Yes	Major crop	Maleita et al., 2016
<i>Spinacia oleracea</i> (Spinach)	Yes	Minor crop	Strajnar et al., 2009
<i>Vitis vinifera</i> (Grapevine)	Yes	Major crop	Carneiro et al., 2014
<i>Zea mays</i> (Corn)	Yes	Major crop	Strajnar et al., 2011
<i>Zea mays</i> var. <i>saccharata</i> (Sweet corn)	Yes	Minor crop	Strajnar et al., 2009

8. Pathways for entry

Possible pathways (in order of importance)	Short description explaining why it is considered as a pathway	Pathway prohibited in the PRA area? Yes/No	Pest already intercepted on the pathway? Yes/No
Host plants for planting (except seeds, bulbs and tubers) with or without soil attached	Infested plant roots (early or later stage) carry viable pest; in case of planting infected material;	No for all hosts/countries Yes- for some hosts from some non-EU or non-European countries. See points 9., 11., 13., 15., 18. of Annex III CD 2000/29/EC and specific requirements for all soil attached to plants originating in some non-EU countries and non-European countries. See point 34. of Annex IV CD 2000/29/EC	No
Plants for planting of non-hosts with soil	Infested soil attached (pest in egg stage and J2)	No for all hosts/countries Yes- for some hosts from some non-EU or non-European countries. See points 1,2,3, 9.1, 16, 17,19. of Annex III CD 2000/29/EC. Specific requirements for all soil attached to plants originating in some non-EU countries and non-European countries. See point 34. of Annex IV CD 2000/29/EC	No
Bulbs, tubers, corms, rhizomes as plants for planting	Infested tubers (e.g. potato) carry viable pest; in case of planting infected material;	No for all hosts/countries Yes- for some hosts from non-EU or non-European countries. See points 10.of Annex III CD 2000/29/EC	No
Host plant parts contaminated with soil (such as roots, tubers, bulbs, corms, rhizomes), for consumption or processing.	Infested consumption tubers, roots (e.g. infested consumption potato, celery, carrots etc.);	No for all hosts/countries Yes- for some hosts from non-EU or non-European countries. See points 12.of Annex III CD 2000/29/EC.	No

Non-host plant parts contaminated with soil (such as roots, tubers, bulbs, corms, rhizomes), for consumption or processing.	Infested soil attached (pest in egg stage and J2)	No	
Soil/ growing medium	There is a possibility to introduce the pest in egg stage and J2.	No for all hosts/countries Yes- from some non-EU countries and non-European countries. See point 14. of Annex III CD 2000/29/EC	No
Plant waste	There is possibility to introduce the pest in egg stage;	No	No

<i>Rating of the likelihood of entry</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input checked="" type="checkbox"/>	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input checked="" type="checkbox"/>	<i>High</i> <input type="checkbox"/>

Pathways for entry of *M. luci* from EU countries, where *M. luci* is present, are not regulated (Italy, Greece, Portugal). It is not known how RKN *M. luci* was introduced in Slovenia. However, *M. luci* was detected in Slovenia twice. The location of infestation from 2015 is situated more than 100 km away from location found in 2003 and no direct connections between these farms could be found. This indicates that infestation at the new location might be a result of a new entry into the county. Therefore rating of the likelihood of entry and uncertainty was assessed as moderate.

9. Likelihood of establishment outdoors in the PRA area

M. luci has already been detected in the open field production in Europe (Mediterranean climate) in corn and kiwi production in Greece, and potato production in Portugal. In addition, the potential of *M. luci* to survive outdoors under a continental climate even in areas where soil temperatures fall below zero during winter, as well as under a sub-Mediterranean climate (Strajnar et al. 2011) indicates that *M. luci* could establish in most parts of the PRA area .

M. luci

<i>Rating of the likelihood of establishment outdoors</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input type="checkbox"/>	<i>High</i> <input checked="" type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input checked="" type="checkbox"/>	<i>Moderate</i> <input type="checkbox"/>	<i>High</i> <input type="checkbox"/>

M. ethiopica

<i>Rating of the likelihood of establishment outdoors</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input checked="" type="checkbox"/>	<i>High</i> <input type="checkbox"/>
<i>Rating of uncertainty</i>	<i>Low</i> <input type="checkbox"/>	<i>Moderate</i> <input checked="" type="checkbox"/>	<i>High</i> <input type="checkbox"/>

10. Likelihood of establishment in protected conditions in the PRA area

Both pest species have very wide host range including majority of vegetable crops which are cultivated in the protected areas. The probability of establishment in the protected area is high.

M. ethiopica & *M. luci*

Rating of the likelihood of establishment in protected conditions	Low <input type="checkbox"/>	Moderate <input type="checkbox"/>	High <input checked="" type="checkbox"/>
Rating of uncertainty	Low <input checked="" type="checkbox"/>	Moderate <input type="checkbox"/>	High <input type="checkbox"/>

11. Spread in the PRA area

- Natural spread

Natural spreading of RKNs is very slow in the soil and can reach up to few meters from the infestation in a growing season.

- Human assisted spread

Human assisted spread is much more important. The spreading may occur by agricultural machinery (tractor wheels, tillage and cultivator equipment, any equipment that have direct soil contact). Further, nematodes can be spread by irrigation, movement of crop plants and crop products, or by infested soil and growing media. .

Plants for planting (vegetables, ornamental plants, fruit trees and grapevine) with or without soil attached are considered the main pathway for spread of *M. ethiopica* and *M. luci* within the PRA area. In addition, plant parts like tubers may present also high risk of spreading in case of pest establishment outdoors, especially in potato tuber seed production where latent infestations may also occur (tubers with no visible symptoms of infestation).

M. ethiopica & *M. luci*

Rating of the magnitude of spread	Low <input type="checkbox"/>	Moderate <input checked="" type="checkbox"/>	High <input type="checkbox"/>
Rating of uncertainty	Low <input type="checkbox"/>	Moderate <input checked="" type="checkbox"/>	High <input type="checkbox"/>

12. Impact in the current area of distribution

M. ethiopica is widely distributed in vineyards in Chile (Aballay et al. 2009) and was found to be the major root knot nematode parasite of grapevines (*Vitis vinifera*) and other crops in Chile (Carneiro et al., 2007). In Brazil, *M. ethiopica* affects the root growth, yield and quality of grapevines and kiwi, and cause serious economic losses (Carneiro et al. 2003). Furthermore, Medina et al. (2014) reported *M. ethiopica* on potato plants from Parana state, Brazil, showing root systems with multiple galls and tubers with protuberances. *M. luci* has been reported on several vegetables but there are no reports of economic damage caused by *M. luci* except from Slovenia.

In Slovenia, *M. luci* was found at two locations. In the greenhouse in Primorska from 2003 the pest was eradicated due to omission of the agricultural production. Second location was detected in 2015 in a greenhouse in the village near Ljubljana. Infested tomato plants showed symptoms of decline, leaf chlorosis and large galls were present on the roots. Nematode infestation was relatively high as more than 80 % of plants were severely damaged. Phytosanitary measures were imposed in the infested greenhouse including the use of dazomet, a soil fumigant. All infested plant material from the affected greenhouse was destroyed. However, the eradication program implemented in the past two years has not been successful. Therefore only resistant tomato cultivars carrying *Mi* gene and poor- to non-host crops in combination with registered chemical nematicide were allowed to be grown in the infested greenhouse. The success of this management program for nematode control will be assessed in the future. The infested area measures approximately 1100 m².

M. ethiopica & *M. luci*

Rating of the magnitude of impact in the current area of distribution	Low <input type="checkbox"/>	Moderate <input type="checkbox"/>	High <input checked="" type="checkbox"/>
Rating of uncertainty	Low <input type="checkbox"/>	Moderate <input checked="" type="checkbox"/>	High <input type="checkbox"/>

Rating of the magnitude of impact in the current area of distribution was assessed as high because of high impact of *M. luci* at current area of distribution in PRA area.

Moderate rating of uncertainty was assessed due to lack of available data on economic damage caused by both species at current area of distribution.

13. Potential impact in the PRA area

M. ethiopica and *M. luci* could survive under protected cultivation (glasshouses) across the PRA area. Climatic conditions for establishment of *M. luci* in the PRA area outdoors are suitable since this species was proved to overwinter in continental and Mediterranean climate. Besides it was already detected outdoors in Europe (Mediterranean climate), in corn and kiwi production in Greece, and potato production in Portugal. Once the RKNs is introduced into the PRA area, it is in general difficult to control or eradicate them, especially outdoors at the open field. The ability of *M. ethiopica* to overwinter at the open field in continental and Mediterranean climate has not been tested yet.

The models of climate changes predict an increase of average temperatures and more frequent periods of drought, floods and heat waves. Higher temperatures will allow development of more generations of RKNs in a growing season and consequently higher yield losses. The potential impact of both pest species in the PRA area is high.

Will impacts be largely the same as in the current area of distribution? No

The potential impact of pests on outdoor crops in the PRA area is difficult to estimate. Epidemiological studies such as the assessment of the damage potential of both pest species for major crops such as potatoes, corn, soybean, grapevine, fruit trees etc. in the PRA area climate are not available. We can expect losses in the protected cultivation (with soil as natural growing medium) and the same impact as in the current area of distribution.

If No

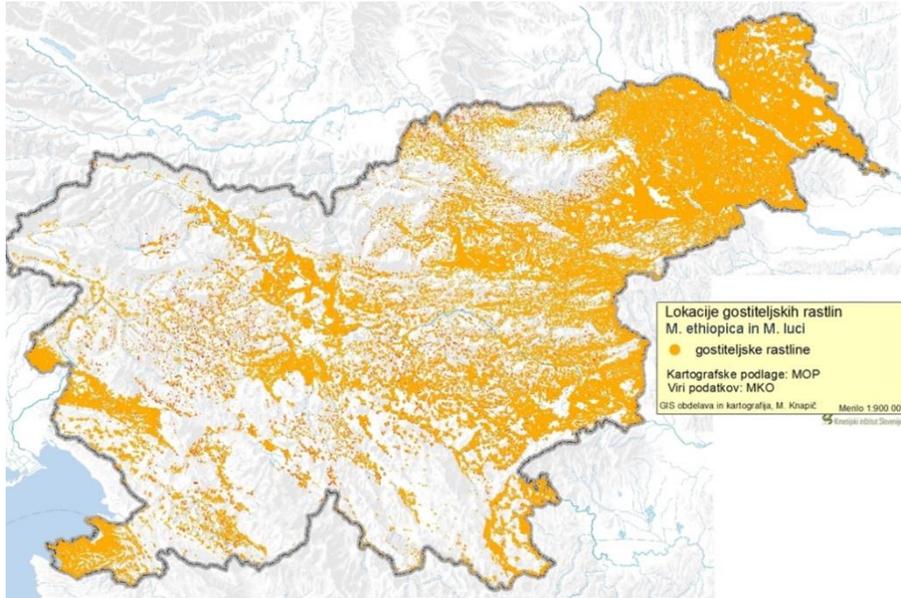
Rating of the magnitude of impact in the area of potential establishment	Low <input type="checkbox"/>	Moderate <input type="checkbox"/>	High <input checked="" type="checkbox"/>
Rating of uncertainty	Low <input type="checkbox"/>	Moderate <input checked="" type="checkbox"/>	High <input type="checkbox"/>

14. Identification of the endangered area

Endangered area in PRA area is:

- Protected area production
- Vegetable production area
- Potato production area
- Corn and other cereals production area
- Vineyards
- Kiwi and peach production area

Figure: Distribution of the most important major crops in Slovenia (covers almost all national agricultural production land).



15. Overall assessment of risk

Root knot nematodes *M. ethiopica* and *M. luci* can be introduced by several pathways but the highest risk for entry and spread in the PRA area is considered the pathway of host plants for planting (except seeds, bulbs and tubers) with or without soil attached, like the planting material of vegetables, ornamental plants, fruit trees and grapevine. Furthermore, plant parts like tubers may present also high risk of spread in case of pest establishment outdoors, especially in potato tuber seed production where latent infestations may also occur (tubers with no visible symptoms of infestation). Human assisted spread of the pests is the most important.

M. ethiopica and *M. luci* have very wide host range including majority of vegetable crops which are cultivated in the protected areas. The probability of establishment in the protected area is high. *M. luci* has already been detected in the open field production in Europe (Mediterranean climate), in corn and kiwi production in Greece, and potato production in Portugal. There is a high risk of *M. luci* establishment outdoors in the PRA area, as this species was proved to overwinter in open field in continental and Mediterranean climate. Once the RKNs have been introduced, it is in general difficult to control or eradicate them, especially outdoors at the open field. The ability of *M. ethiopica* to overwinter at the open field in continental and Mediterranean climate has not been tested yet. The endangered area in the PRA area is therefore: protected production area, vegetable production area, potato production area, corn and other cereals production area, vineyards, kiwi and peach production area.

Phytosanitary measures to prevent the spread of these pests into non-infested area in case of an outbreak are necessary. The measures should include prohibition of movement of plants for planting production outside infested area, movement of soil outside infested area, disinfection of equipment and footwear, destruction of nematode infested plant waste, and intensive monitoring of infested area and the surroundings.

The potential impact of both pest species in the PRA area is high especially in the light of climate change scenarios. The models of climate changes predict an increase of average temperatures and more frequent periods of drought, floods and heat waves. Higher temperatures would allow development of more generations of RKNs in a growing season and consequently higher yield losses.

Stage 3. Pest risk management

16. Phytosanitary measures

16.1 Measures on individual pathways

Measures for host plants for planting, roots, bulbs, tubers, corms, rhizomes are listed in the table below as the high risk pathway, in order to prevent entry of *M. ethiopica* and *M. luci* into host production systems.

For soil (and growing media), the risk of entry relates mostly to soil from where RKNs are present, but many EPPO countries prohibit import of soil from third countries. Internal movement of soil within the EU is not regulated, but the likelihood of entry from Italy, Greece and Portugal is considered as low (due to the types of environments in which the nematode is currently present). Measures were not studied, but are likely to be similar to those for other nematodes.

Possible pathways (<i>in order of importance</i>)	Measures identified
Host plants for planting with roots (including rooted cuttings, bulbs, tubers, corms, rhizomes; except plants in tissue culture), with or without soil or growing media	Pest free area Or Pest-free production site or pest-free place of production (with all production sites pest-free) Or Growing under complete physical isolation (EPPO Standard PM5/8) (with requirements appropriate for RKN)
Host plant parts (bulbs, tubers, corms, rhizomes) with soil or growing media	Pest free area Or Pest-free production site (or pest-free place of production with all production sites pest-free) Or Growing under complete physical isolation (EPPO Standard PM5/8) (with requirements appropriate for RKN)

16.2 Eradication and containment

- Prevention of spread

At the current *M. luci* infested area several phytosanitary measures were implemented to prevent the spread of the pest into non-infested areas. The measures include prohibition of movement of plants for planting and soil from infested area, disinfection of equipment and footwear, destruction of nematode infested plant waste, and intensive survey of the infested area and surroundings.

- Eradication/control

Once RKN have been introduced, it is in general difficult to control or eradicate them mainly because of their polyphagous nature and limited management options. At the place of production RKNs can be controlled with a proper crop rotation of poor and non-host crops, resistant varieties and the usage of nematocides. Efficient crop rotation is very difficult to set up in vegetable production as there are many vegetable crops that are good hosts for both species. Several commercial tomato and pepper varieties exhibit resistance and tolerance against RKN. However, the resistance breaking populations of *M. luci* have already been reported from Turkey. No other host crop exhibit resistance.

There are two registered nematocides in Slovenia, a soil fumigant dazomet for protected areas and open field, and fluopyram for protected areas only. Dazomet was used in *M. luci* eradication program at 2015 outbreak but did not reach successful effect as the RKN population rendered again in next growing season, maybe due to unsuitable application. The efficiency of fluopyram at the same location is

currently under investigation. A product which employs a biological mode of action with *Bacillus firmus* bacteria strain that prevents nematodes from causing damage is currently in the registration process (Terefe et al., 2009)

17. Uncertainty

The main sources of uncertainty within the risk assessment:

- the likelihood of pest entry,
- the magnitude of spread in the PRA area,
- the magnitude of impact in the area of potential establishment.

It is presumed that *M. luci* was introduced in Slovenia twice, in separate entries into the county. The pathways of entry in both cases have not been identified. At the same time origin of the pest is difficult to suspect because of very limited known pest distribution in European and at the world scale.

The uncertainty for the magnitude of spread and potential impact in the PRA was also assessed as “moderate” mainly because of uncertain entry pathways and the lack of epidemiological data for the PRA area climate conditions. Both pest species might colonise entire PRA area. It is difficult to estimate the influence of pests on outdoor crops, but we can observe losses in the protected cultivation (with soil as natural growing medium). Epidemiological studies such as the assessment of the damage potential of both pest species for major crops such as potatoes, corn, soybean, grapevine, fruit trees etc. in the PRA area climate would enable informative phytosanitary decisions. Several tomato and pepper varieties exhibit resistance and tolerance against RKN however the resistance breaking populations of *M. luci* have already been reported from Turkey.

The main source of uncertainty within the risk of management is lack of efficient pests control measures. Because of limiting chemical pesticide usage trend, more environmentally friendly approaches will be use in the future. Performing pest management studies of genetic resistance sources and applications of soil amendments formulation like essential oils or biomasses from plants with biocidal properties, as well as microbial bio-nematicides based on nematode-parasitic fungi or bacteria are therefore of the utmost importance.

18. Remarks

The biggest concern for *M. luci* is the spread at the open field agricultural production area (see 9. likelihood of establishment outdoors in the PRA area). The ability of *M. ethiopica* to overwinter in the open field in continental and Mediterranean climate has not been tested yet. Because of the polyphagous nature of both pests and limited management options the pests (in case of a wide spread) would be very difficult to control. In addition, the climate changes are in favour of such tropical pests which complete more reproduction cycles at higher summer temperatures and thus cause greater damage.

19. REFERENCES

- Aballay E, Persson P & Mårtensson A (2009) Plant-parasitic nematodes in chilean vineyards. *Nematopica* **39**, 85-97.
- Aydinli G, Mennan S, Devran Z, Širca S & Urek G (2013) First report of the root-knot nematode *Meloidogyne ethiopica* on tomato and cucumber in Turkey. *Plant Dis.* **97**, 1262.
- Aydinli & Mennan (2016) Reproductive ability of *Meloidogyne ethiopica* populations on tomato plant with resistance Mi gene. In: 32nd Symposium, Braga, Portugal, Universidade do Minho, 28th Aug. - 1st Sept. 2016: abstract book, 32nd ESN (European Society of Nematologists) Symposium. [S.l.]: European Society of Nematologists., p. 159.
- Bellé C, Brum D, Groth M Z, Barros D R, Kaspary T E, Schafer J T & Gomes C B (2016a)

- First Report of *Meloidogyne luci* Parasitizing Glycine max in Brazil. *Plant Disease* **100**, 2174.
- Bellé C, Kaspary T E, Schmitt J, Kuhn P R (2016b) *Meloidogyne ethiopica* and *Meloidogyne arenaria* parasitizing *Oxalis corniculata* in Brazil. *Australasian Plant Dis. Notes* **11**, 24.
- Bellé C, Kuhn P R, Kaspary T E, Groth M E, Schmitt J & Kulczynski S M (2017a) Parasitization of the Common Bean (*Phaseolus vulgaris*) by *Meloidogyne ethiopica* in Southern Brazil. *Plant Disease* **101**(3), 510.
- Bellé C, Kaspary T E, Groth M E & Teixeira Cocco K L (2017b) *Meloidogyne ethiopica* parasitizing melon fields in Rio Grande do Sul State. *Brazil. J. Plant Dis. Prot.* DOI 10.1007/s41348-017-0087-7.
- Bellé C, Kulczynski S M, Kuhn P R, Carneiro R M D G, Lima-Medina I, Gomes C B (2017c) First Report of *Meloidogyne ethiopica* Parasitizing Sugarcane in Brazil. *Plant Disease* **101**(4), 635.
- Carneiro R M D G, Almeida M R A & Queneherve P (2000) Enzyme phenotypes of *Meloidogyne* spp. populations. *Nematology* **2**, 645-654.
- Carneiro R M D G, Gomes C B, Almeida M R A, Gomes A C M M & Martins I (2003) First record of *Meloidogyne ethiopica* Whitehead, 1968 on kiwi in Brazil and reaction of different plant species. (Primeiro Registro de *Meloidogyne ethiopica* Whitehead, 1968, em plantas de quivi no Brasil e reação em diferentes plantas cultivadas.). *Nematologia Brasileira*, **27**(2), 151-158.
- Carneiro R M D G, Randig O, Almeida M R A, Gomes A C M M (2004) Additional information on *Meloidogyne ethiopica* Whitehead, 1968 (Tylenchida: Meloidogynidae), a root-knot nematode parasitising kiwi fruit and grape-vine from Brazil and Chile. *Nematology* **6**(1), 109-123.
- Carneiro R M D G & Almeida M R A (2005) [Record of *Meloidogyne ethiopica* Whitehead on yacon and tomato plants in Brasília, DF, Brazil]. *Nematologia Brasileira* **29**(2), 285–287 (portugalski: abst.).
- Carneiro R M D G, Almeida M R A, Cofcewicz E T, Magunacelaya J C & Aballay E (2007) *Meloidogyne ethiopica*, a major root-knot nematode parasitizing *Vitis vinifera* and other crops in Chile. *Nematology* **9**(5), 635-641.
- Carneiro R M D G, Correa V R, Almeida M R A, Gomes A C M M, Deimi A M, Castagnone-Sereno P & Karssen G (2014) *Meloidogyne luci* n. sp. (Nematoda: Meloidogynidae), a root-knot nematode parasitising different crops in Brazil, Chile and Iran. *Nematology* **16**, 289-301.
- Conceição I L, Tzortzakakis E A, Gomes P, Abrantes I & da Cunha M J (2012) Detection of the root-knot nematode *Meloidogyne ethiopica* in Greece. *Eur. J. Plant Pathol.* **134**, 451-457.
- Dias W P, de Freitas V M, Ribeiro N R, Moita A W & Carneiro R M D G (2010) Reaction of corn genotypes to *Meloidogyne mayaguensis* and *M. ethiopica*. *Nematologia Brasileira* **34**(2), 98–105.
- Esbenshade P R & Triantaphyllou A C (1985) Use of isozyme phenotypes for identification of *Meloidogyne* species. *J. Nematol.* **17**, 6-20.
- Esbenshade P R & Triantaphyllou A C (1990) Isozyme phenotypes for the identification of *Meloidogyne* species. *J. Nematol.* **22**, 10-15.
- Gerič Stare B, Strajnar P, Susič N, Urek G & Širca S (2017a) Reported populations of *Meloidogyne ethiopica* in Europe identified as *Meloidogyne luci*. *Plant disease* **101**(9), 1627-1632, ISSN 0191-2917.

- Gerič Stare B, Strajnar P, Širca S, Susič N, Širca S & Urek G (2017b) Record of a new location for tropical root knot nematode *Meloidogyne luci* in Slovenia. Bulletin OEPP, doi: 10.1111/epp.12443.
- Golden A M (1992) Large phasmids in the female of *Meloidogyne ethiopica* Whitehead. Fundamental and Applied Nematology **15**, 189-191.
- Gomes C B, Carbonari J J, Medina I L & Lima D L (2005) Survey of *Meloidogyne ethiopica* in kiwi in Rio Grande do Sul State, Brazil, and its association with *Nicotiana tabacum* and *Sida rhombifolia*. In: Abstract of a paper presented at the 25th Congresso Brasileiro de Nematologia (Brazilian Congress of Nematology) Nematologia Brasileira **29**(1), 114.
- Janssen T, Karssen G, Verhaeven M, Coyne D & Bert W (2016) Mitochondrial coding genome analysis of tropical root-knot nematodes (*Meloidogyne*) supports haplotype based diagnostics and reveals evidence of recent reticulate evolution. Sci. Rep. **6**, 22591, DOI: 10.1038/srep22591.
- Lima E A, Mattos J K, Moita A W, Carneiro R G & Carneiro R M D G (2009) Host status of different crops for *Meloidogyne ethiopica* control. Tropical Plant Pathology **34**, 152-157.
- Lima-Medina I, Gomes C B & Nazareno N X R (2011) Occurrence of *Meloidogyne ethiopica* in potato in the state of Parana. W: 44th Brazilian Congress of Plant Pathology, 36 [ed. Lavras, M.G.], Brazil, 177.
- Lima-Medina I, Somavilla L, Carneiro R M D G & Gomes C B (2013) Species of *Meloidogyne* associated with fig (*Ficus carica*) and host weeds. Nematropica **43**, 56–62.
- Mandefro W & Dagne K (2000) Cytogenetic and esterase isozyme variation of root-knot nematode populations from Ethiopia. Afr. J. Plant. Prot. **10**, 39-47.
- Maleita C M, José Simões M, Egas C, Curtis R H C & Abrantes I M O (2012) Biometrical, biochemical, and molecular diagnosis of Portuguese *Meloidogyne hispanica* isolates. Plant. Dis. **96**, 865-74.
- Maleita C M, Esteves I, Cardoso J M S, José Cunha M, Carneiro R M D G & Abrantes I (2016) First report of *Meloidogyne luci* in Portugal - a potential threat to the potato crop. Page 153 in: 32nd European Society of Nematologists Symposium Abstract Book, Braga, Portugal. Published online (accessed 5 October 2016). http://esn2016braga.com/images/ESN2016_Abstract_Book.pdf
- Medina I L, Coila V H C, Gomes C B, Pereira A S & Nazareno N R X (2014) *Meloidogyne ethiopica* report in Parana state, Brazil, and reaction of potato cultivars to root-knot nematode. Hortic. Bras. **32**, 482-485.
- Murga-Gutierrez S N, Colagiero M, Rosso L C, Sialer M M F & Ciancio A (2012) Root-knot nematodes from asparagus and associated biological antagonists in Peru. Nematropica **42**(1), 57-62.
- O'Bannon J H (1975) Nematode survey in Ethiopia. Institute of Agricultural Research, Addis Ababa, Ethiopia and FAO, Rome, [unpubl.].
- Somavilla L, Gomes C B, Antunes L E C, de Oliveira R P & Carneiro R M D G (2009) [Reaction of different fruit crops to *Meloidogyne ethiopica*]. Nematologia Brasileira Piracicaba **33**(3), 252–255. (portugalski: abs.).

Somavilla L, Gomes C B, Carbonari J J & Carneiro R M D G (2011) Survey and characterization of root-knot nematode species in kiwi in Rio Grande do Sul State, Brazil. (Levantamento e caracterização de espécies do nematoide das galhas em quivi no Rio Grande do Sul, Brasil.). Tropical Plant Pathology, **36**(2), 89-94.

Strajnar P, Širca S, Geric Stare B & Urek G (2009) Characterization of the root-knot nematode, *Meloidogyne ethiopica* Whitehead, 1968, from Slovenia. Russian Journal of Nematology **17**, 135-142.

Strajnar P, Širca S, Knapič M & Urek G (2011) Effect of Slovenian climatic conditions on the development and survival of the root-knot nematode *Meloidogyne ethiopica*. Eur. J. Plant Pathol. **129**, 81-88.

Strajnar P & Širca S (2011) [The effect of some insecticides, natural compounds and tomato cv. Venezia with Mi gene on the nematode *Meloidogyne ethiopica* (Nematoda) reproduction.]. Acta agriculturae Slovenica **97**, 5-10.

Širca S, Urek G & Karssen G (2004) First report of the Root-Knot Nematode *Meloidogyne ethiopica* on Tomato in Slovenia. Plant disease **88**, 680.

Terefe, M., Tefera, T. and Sakhuja, P.K. (2009) Effect of a formulation of *Bacillus firmus* on root-knot nematode *Meloidogyne incognita* infestation and the growth of tomato plants in the greenhouse and nursery. Journal of Invertebrate Pathology **100**, 94–99.

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.

Whitehead A G (1969) The distribution of root-knot nematodes (*Meloidogyne* spp.) in tropical Africa. Nematologica **15**, 315-333.

Appendix 1. Symptoms of *M. luci* infestation.



M. luci infestation of tomatoes in Slovenia in 2015.

(Foto: KIS)



M. luci infested tomato root system.

(Foto: KIS)