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Root-Knot Nematodes *Meloidogyne* spp. as Emerging Pests

S. Širca, P. Strajnar, B. Gerič Stare, M. Knapič, U. Žibrat, H. J. Schroers and G. Urek

Plant health for sustainable agriculture

CONFERENCE, 11 – 12 May 2015, Ljubljana, Slovenia

Meloidogyne spp.

- Root-knot nematodes - one of the most polyphagous and damaging genera of PPNs
- RKNs are biotrophic endoparasites, able to infest virtually any species of higher plant
- Cosmopolitan distribution
- Typical symptom is the formation of galls at nematode feeding sites

Meloidogyne spp.

Meloidogyne about 100 species, regulated:

- In Europe Q list (EPPO):
  - *M. chitwoodi* (A2)
  - *M. fallax* (A2)
  - *M. enterolobii* (A2)
  - *M. ethiopica* (Alert - early warning, 2011)
  - *M. mali* (Alert - early warning, 2016)

- "Tropical group " RKN species in Europe: greenhouses all over Europe, open field mainly in Mediterranean climate (vegetables, grapevine, fruit plants). Tropical group RKNs few species in Europe:
  - *M. incognita* **WIDESPREAD** (resistance breaking populations)
  - *M. javanica* **WIDESPREAD**
  - *M. arenaria* **WIDESPREAD**
  - *M. hispanica* (greenhouse and open field, Prunus – Spain, Portugal)
  - *M. enterolobii* (greenhouse Switzerland), resistance breaking populations
  - *M. ethiopica* (greenhouse SLO, Turkey; open field Greece, Turkey, Italy)

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2014)

RESEARCH PAPER

The global spread of crop pests and pathogens

Daniel P. Bebber[1], Timothy Holmes[2] and Sarah J. Gurr[1,3]*

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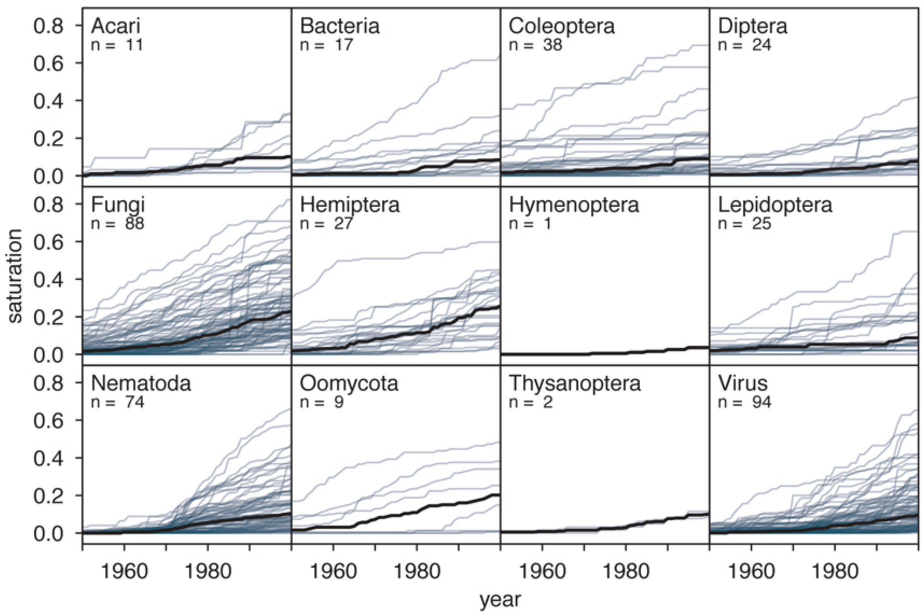

Fig. S2. CPP category saturation over time. Saturation (fraction of countries inhabited, that produce the host crops of the CPP) for 410 CPPs, for which temporal data were available. Blue lines denote individual CPPs (numbers given by n), black lines show median per year.

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2014)

RESEARCH PAPER

The global spread and pathogens

Daniel P. Bebber[1], Timothy Holme

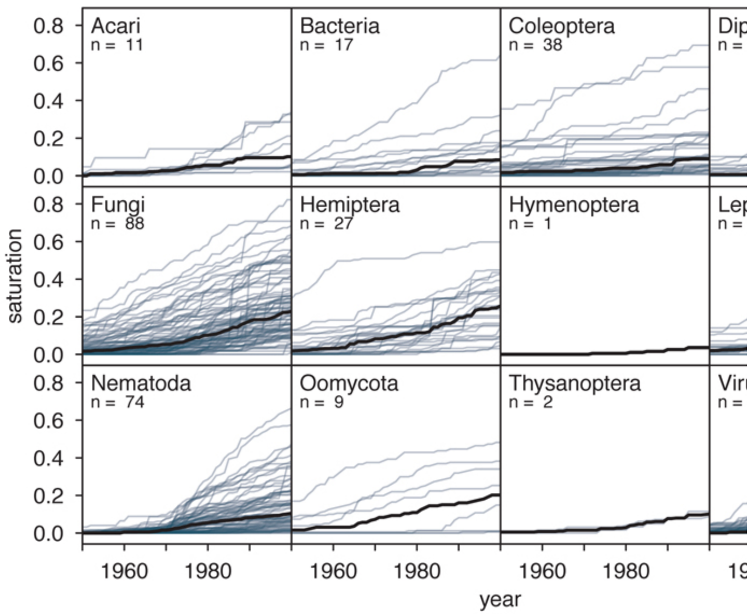

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Table S2. Pest and pathogen saturation. The fifty most rapidly-spreading pests and pathogens, as measured by saturation rate (y^{-1},1970-2000), are listed.

Pest	Category	Host genera	Countries 2000	Countries saturated	Saturation 2000	Saturation rate
Meloidogyne incognita	Nematoda	208	143	193	0.7409	0.0226
Meloidogyne javanica	Nematoda	206	113	193	0.5855	0.0207
Cucumber mosaic virus	Virus	114	124	194	0.6392	0.0199
Phoma caricae-papayae	Fungi	1	31	57	0.5439	0.0197
Didymella lentis	Fungi	1	26	50	0.5200	0.0190
Erysiphe cruciferarum	Fungi	4	86	191	0.4503	0.0173
Cherry leaf roll virus	Virus	13	33	43	0.7674	0.0173
Meloidogyne arenaria	Nematoda	48	98	194	0.5052	0.0167
Blumeria graminis	Fungi	84	98	124	0.7903	0.0164
Cacopsylla pyri	Hemiptera	1	42	84	0.5000	0.0163
Podosphaera aphanis	Fungi	4	58	74	0.7838	0.0160
Citrus tristeza virus	Virus	3	105	145	0.7241	0.0154
Potato virus Y	Virus	11	85	184	0.4620	0.0147
Sporisorium scitamineum	Fungi	1	75	98	0.7653	0.0145
Grapevine fanleaf virus	Virus	3	52	90	0.5778	0.0144
Cacopsylla pyricola	Hemiptera	1	35	84	0.4167	0.0144
Burkholderia caryophylli	Bacteria	5	27	70	0.3857	0.0137
Mycosphaerella fijiensis	Fungi	1	73	124	0.5887	0.0130
Leucoptera meyricki	Lepidoptera	1	6	75	0.0800	0.0130
Diaspidiotus ostreaeformis	Hemiptera	18	48	101	0.4752	0.0128
Carnation mottle virus	Virus	4	40	91	0.4396	0.0125
Helicotylenchus multicinctus	Nematoda	30	94	193	0.4870	0.0116
Liriomyza huidobrensis	Diptera	35	73	193	0.3782	0.0116
Helicotylenchus dihystera	Nematoda	127	101	195	0.5179	0.0114
Alfalfa mosaic virus	Virus	55	71	193	0.3679	0.0113
Ditylenchus dipsaci	Nematoda	55	81	193	0.4197	0.0111
Sitobion avenae	Hemiptera	83	79	180	0.4389	0.0110
Corcyra cephalonica	Lepidoptera	18	71	189	0.3757	0.0108
Rotylenchulus reniformis	Nematoda	143	79	195	0.4051	0.0108
Cochliobolus sativus	Fungi	39	108	190	0.5684	0.0108
Dasineura pyri	Diptera	1	28	84	0.3333	0.0107
Gibberella avenacea	Fungi	48	64	192	0.3333	0.0107
Meloidogyne hapla	Nematoda	125	78	194	0.4021	0.0107
Aphis spiraecola	Hemiptera	37	96	194	0.4948	0.0107
Pratylenchus coffeae	Nematoda	45	74	192	0.3854	0.0107
Aceria guerreronis	Acari	2	36	83	0.4337	0.0106
Zucchini yellow mosaic virus	Virus	9	69	159	0.4340	0.0106
Cochliobolus lunatus	Fungi	148	95	194	0.4897	0.0104
Aculus schlechtendali	Acari	2	34	92	0.3696	0.0103
Pratylenchus penetrans	Nematoda	270	63	194	0.3247	0.0103
Puccinia hordei	Fungi	2	62	100	0.6200	0.0103
Aleurodicus dispersus	Hemiptera	68	63	194	0.3247	0.0101
Metopolophium dirhodum	Hemiptera	88	71	191	0.3717	0.0101
Pea seed-borne mosaic virus	Virus	3	45	112	0.4018	0.0097
Cronartium ribicola	Fungi	3	36	36	1.0000	0.0097
Phomopsis viticola	Fungi	2	43	90	0.4778	0.0096
Podosphaera pannosa	Fungi	5	104	168	0.6190	0.0095
Phenacoccus madeirensis	Hemiptera	138	56	193	0.2902	0.0095
Colletotrichum truncatum	Fungi	32	68	192	0.3542	0.0094
Fusarium oxysporum f.sp. *niveum*	Fungi	1	41	111	0.3694	0.0092

Emerging pests

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1. Global market

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5. Wide host range & extreme reproduction potential

Emerging pests

1. Global market
2. Lack of natural resistance
3. Global worming
4. Environmentally friendly plant protection (in Europe)
5. Wide host range & extreme reproduction potential
6. Fast adaptations (e.g. *Mi* – gene resistance breaking)

   most reproduce by obligatory mitotic parthenogenesis, possess aneuploid genomes, hybrid taxa

Damage

Three major factors:

- the host plant
- the level of initial population
- growth conditions (the temperature)

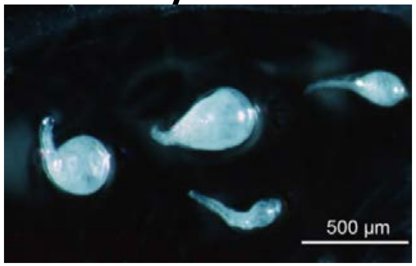





M. incognita on potato tubers; Open field (2014), 80% of harvest damaged

M. ethiopica

- *M. ethiopica*, first time in Europe in Slovenia, later reported from Turkey, Greece, Italy
- Severe infestation symptoms: wilting, stunting, early flower & fruit drop
- wide host range (~90 sp.), woody, herbaceous, mono & dicotyledones



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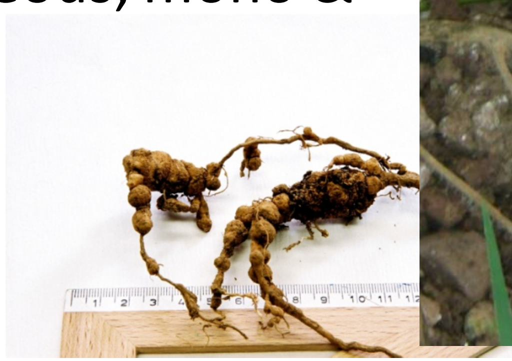

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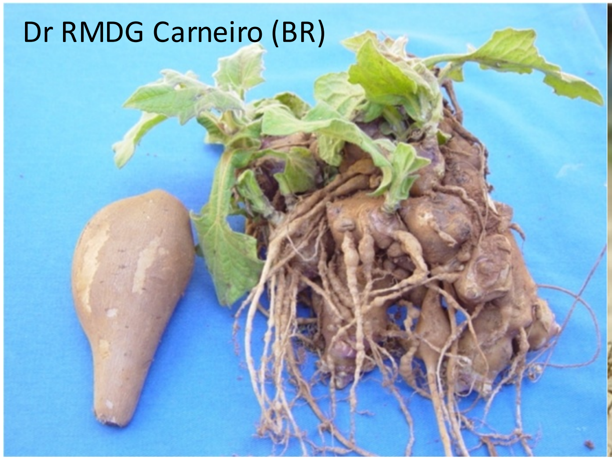
S. America, Africa



Africa

- described from Tanzania
- Present: Ethiopia, Kenya, Mozambique, South Africa, Zimbabwe
- no reports on damage

S. America

- In Chile occurs over a range of ca 1000 km on grapevine (*Vitis vinifera*), kiwi (*Actinida deliciosa* C.) and potatoes in 80% of samples (Carneiro et al., 2007) collected in this area – major RKN pest
- Brazil – wide distribution
- Peru – detected

“Get to know your enemy”

- Open field survival
- Reproduction cycle, modelling
- Germplasm screenings
- Bio control
- Early detection

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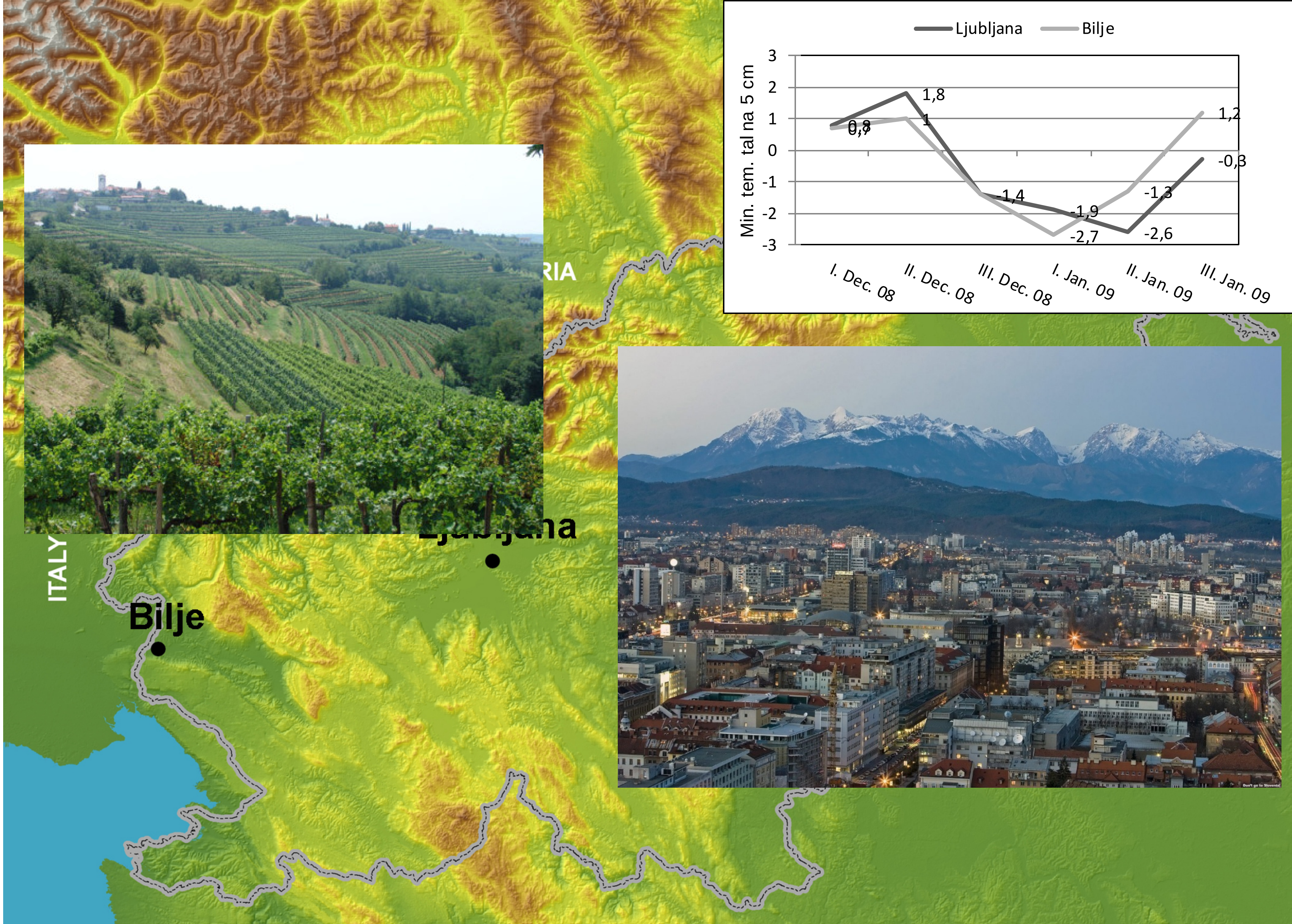
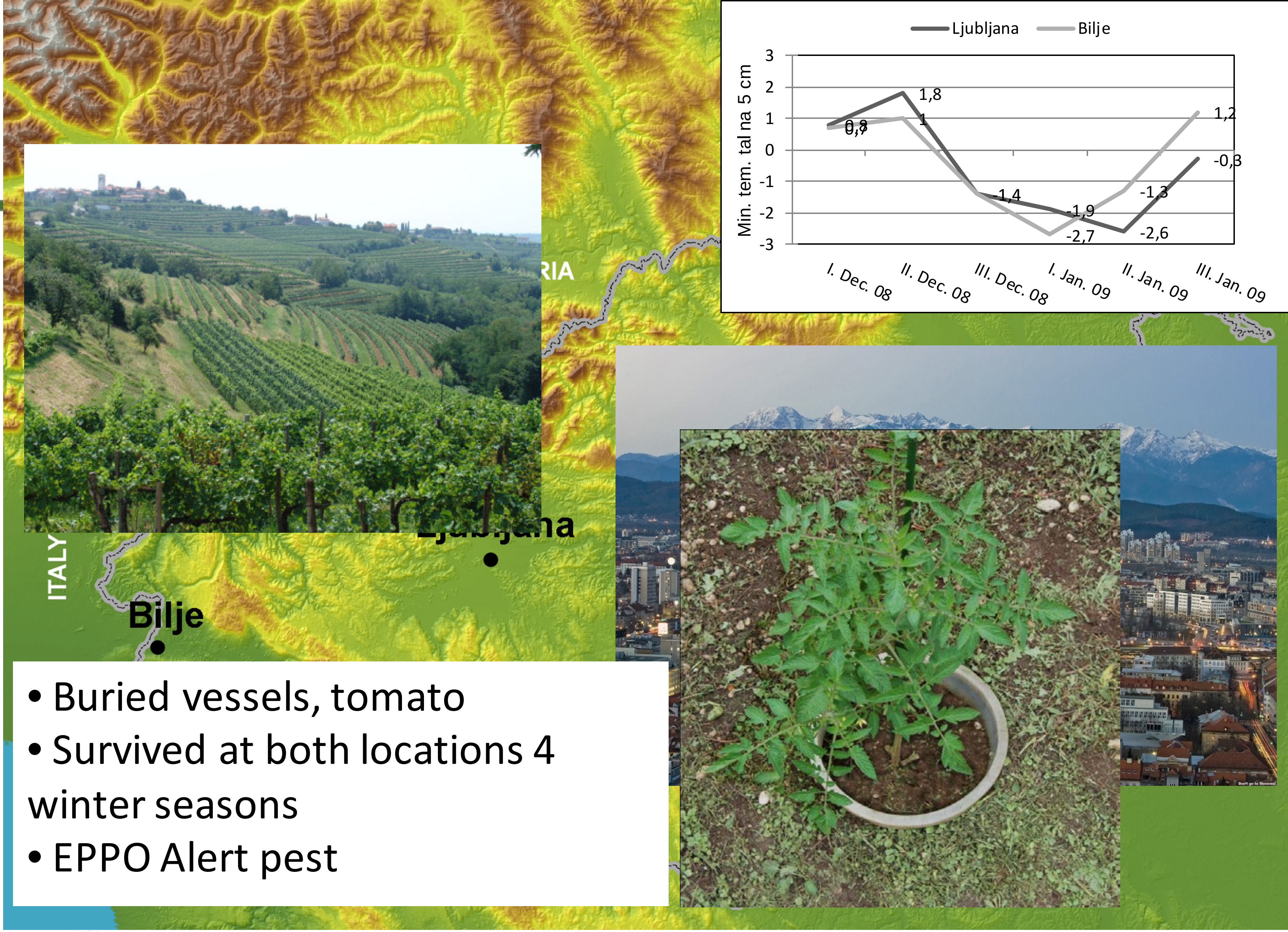
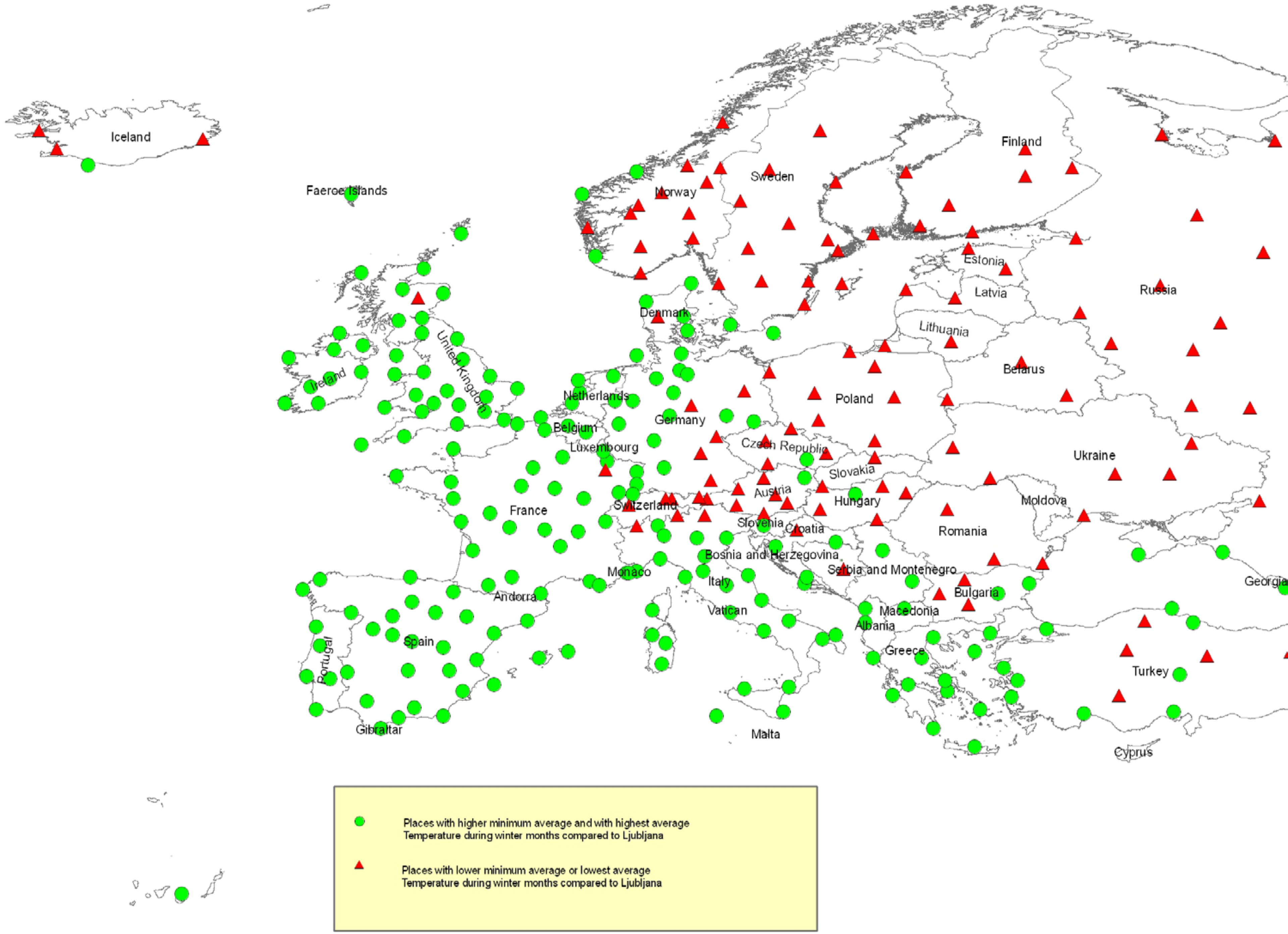
AUSTRIA
HUNGARY
ITALY
Ljubljana
Bilje


ITALY
Bilje
Ljubljana
Bilje
Min. tem. tal na 5 cm
3
2
1
0
-1
-2
-3
1,8
1
1,2
-0,3
-1,4
-1,9
-2,7
-1,3
-2,6
I. Dec. 08
II. Dec. 08
III. Dec. 08
I. Jan. 09
II. Jan. 09
III. Jan. 09



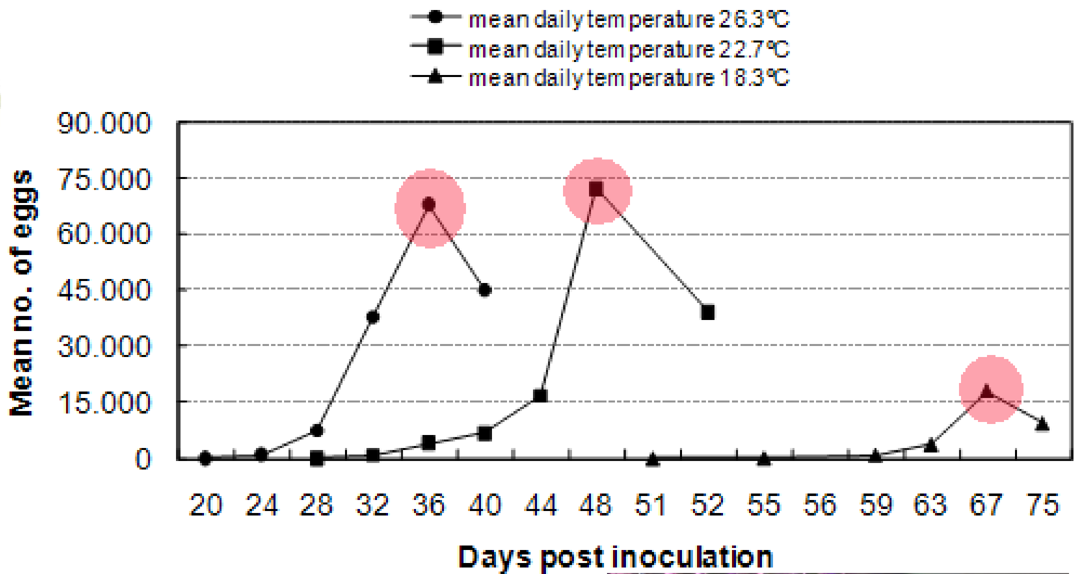
- Buried vessels, tomato
- Survived at both locations 4 winter seasons
- EPPO Alert pest

Data Analyses


Iceland
Faeroe Islands
Norway
Sweden
Finland
Russia
Estonia
Latvia
Lithuania
Denmark
United Kingdom
Ireland
Netherlands
Belgium
Luxembourg
Germany
Poland
Belarus
Czech Republic
Slovakia
Ukraine
Austria
Hungary
Moldova
Switzerland
Slovenia
Croatia
Romania
France
Bosnia and Herzegovina
Serbia and Montenegro
Monaco
Italy
Bulgaria
Georgia
Andorra
Vatican
Macedonia
Albania
Spain
Portugal
Greece
Turkey
Gibraltar
Malta
Cyprus
Places with higher minimum average and with highest average Temperature during winter months compared to Ljubljana
Places with lower minimum average or lowest average Temperature during winter months compared to Ljubljana

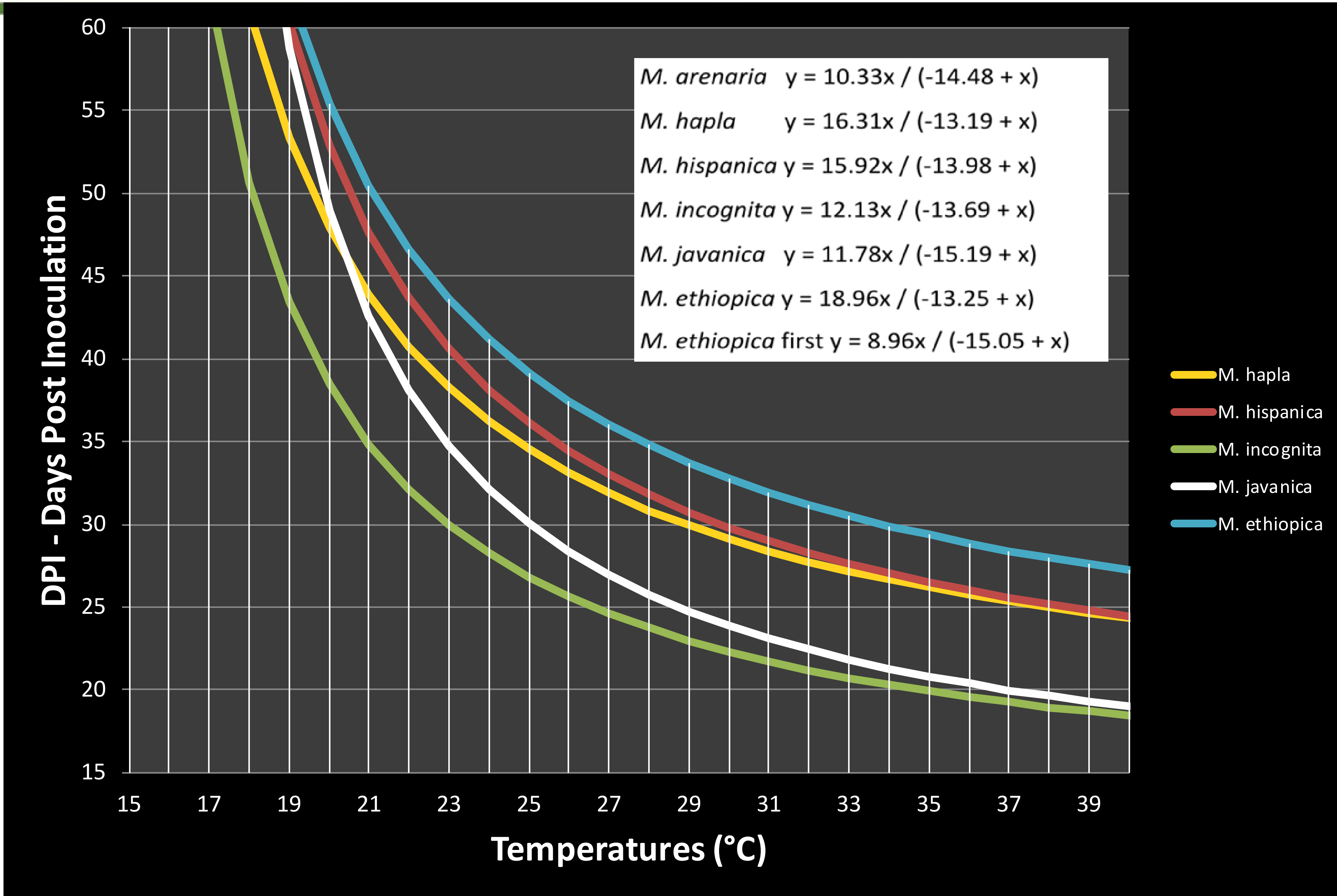
M. ethiopica reproduction cycle

- At 4 main mean daily temperatures:
  13.9, 18.3, 22.7 & 26.3ºC
- Tomato, cucumber & bean
- 13.9ºC, 120 DPI no reproduction
- **Max: 67, 48, 36 DPI**

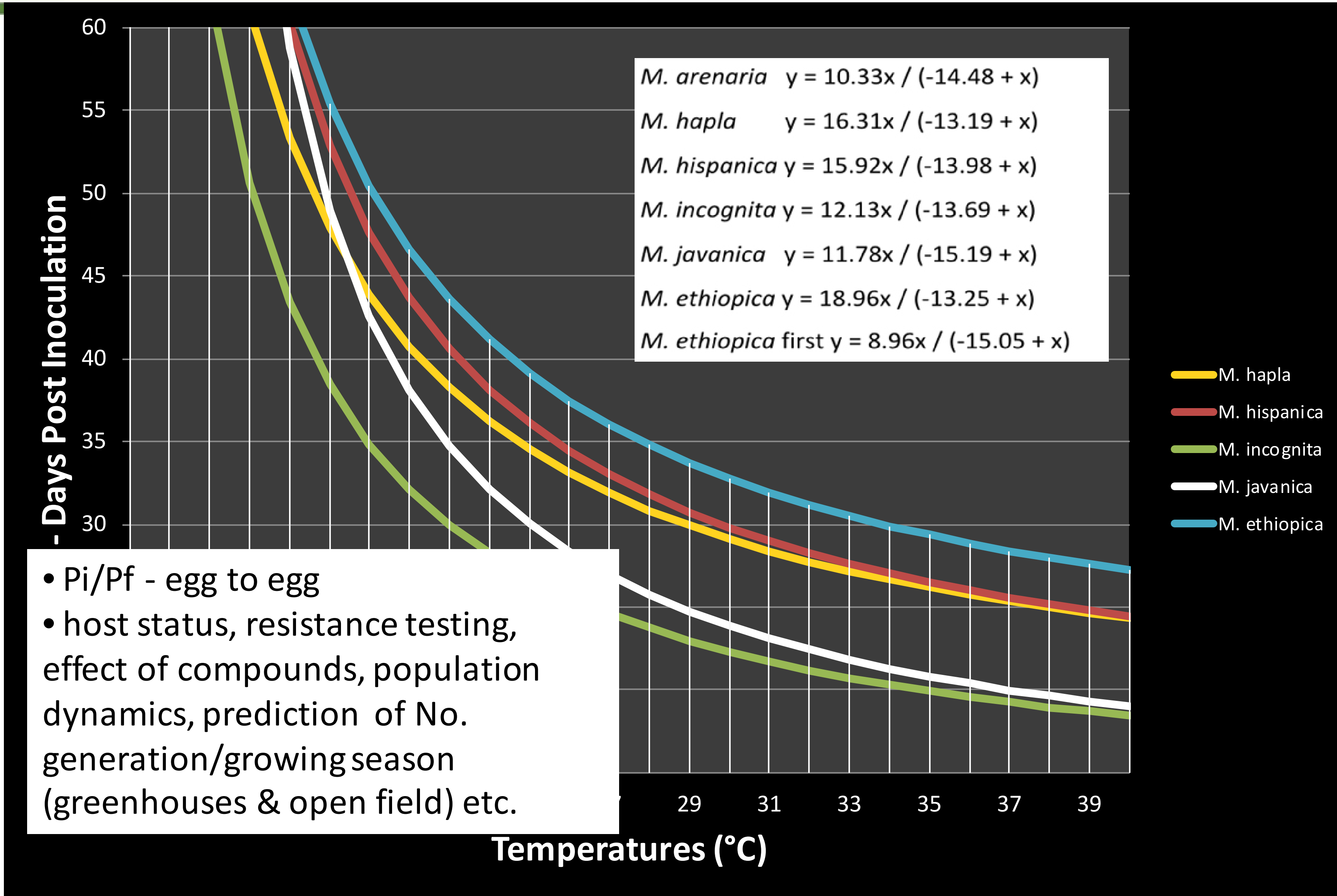


Mean daily temperature (ºC)											
18.3				**22.7**				**26.3**			
Mean no. of eggs				*Mean no. of eggs*				*Mean no. of eggs*			
Day	Tomato	Cucumber	Bean	*Day*	Tomato	Cucumber	Bean	*Day*	Tomato	Cucumber	
51	143	0	786	24	0	0	79	20	73	0	
55	250	0	1600	28	68	10	1335	24	1438	320	
59	1725	175	5672	32	980	435	3195	28	10102	4983	
63	7375	125	17850	36	6150	1850	34575	32	57884	17850	
67	15250	20683	26775	40	11600	1868	49290	36	117475	18150	
75	7675	11025	6050	44	25182	8220	213840	40	69100	20888	
				48	121110	23214	339150				
				52	55090	23202	337650				

Michaelis-Menten models – Reproduction Cycle

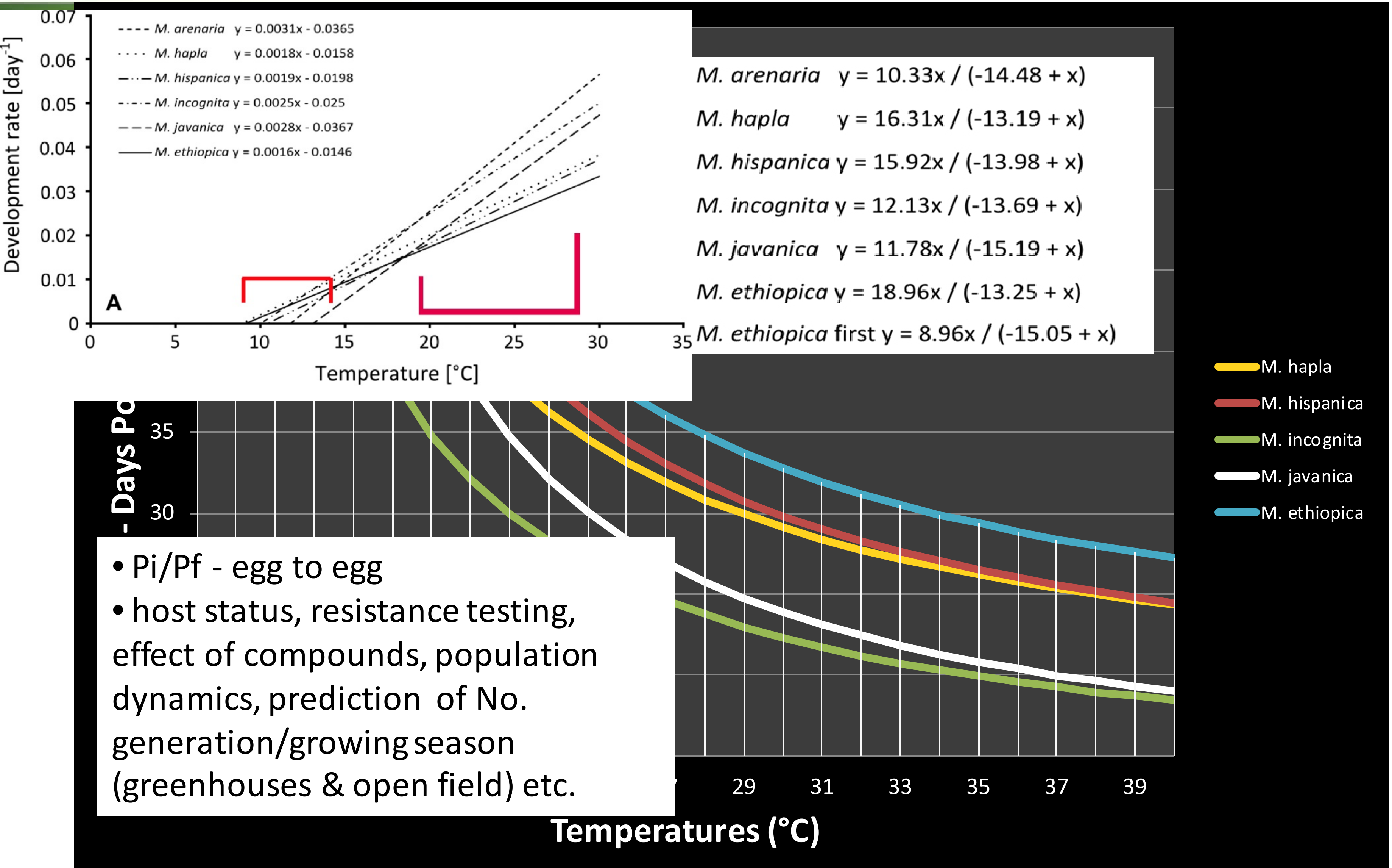


Michaelis-Menten models – Reproduction Cycle



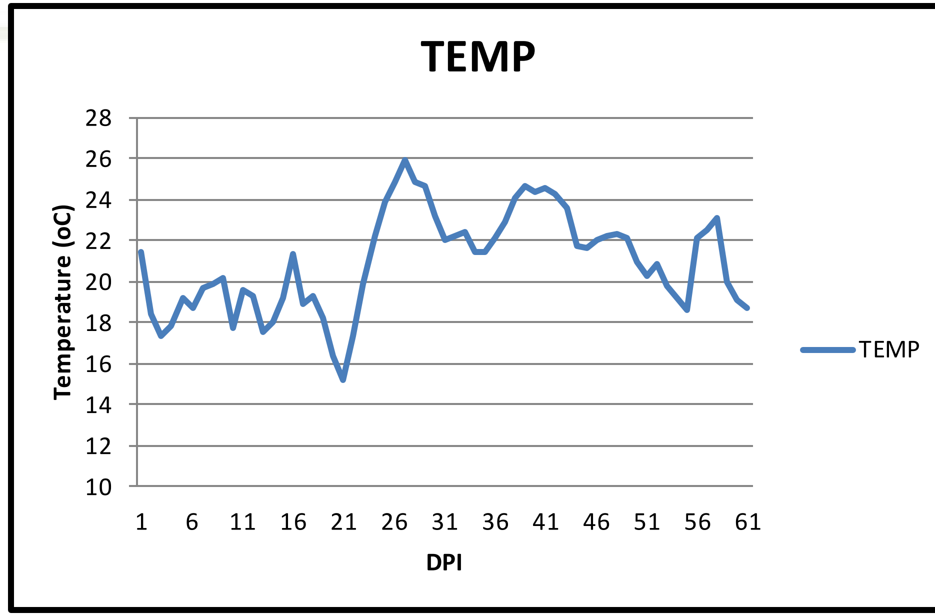
- Pi/Pf - egg to egg
- host status, resistance testing, effect of compounds, population dynamics, prediction of No. generation/growing season (greenhouses & open field) etc.

Michaelis-Menten models – Reproduction Cycle



- Pi/Pf - egg to egg
- host status, resistance testing, effect of compounds, population dynamics, prediction of No. generation/growing season (greenhouses & open field) etc.

In-vivo Model Testing– *M. ethiopica*



•Outside field conditions; Daily soil T (10 cm)
• accurate prediction
• predictions for agr. production (grenhouses, open field)
• Combining (Seinhorst, 1965) damage prediction

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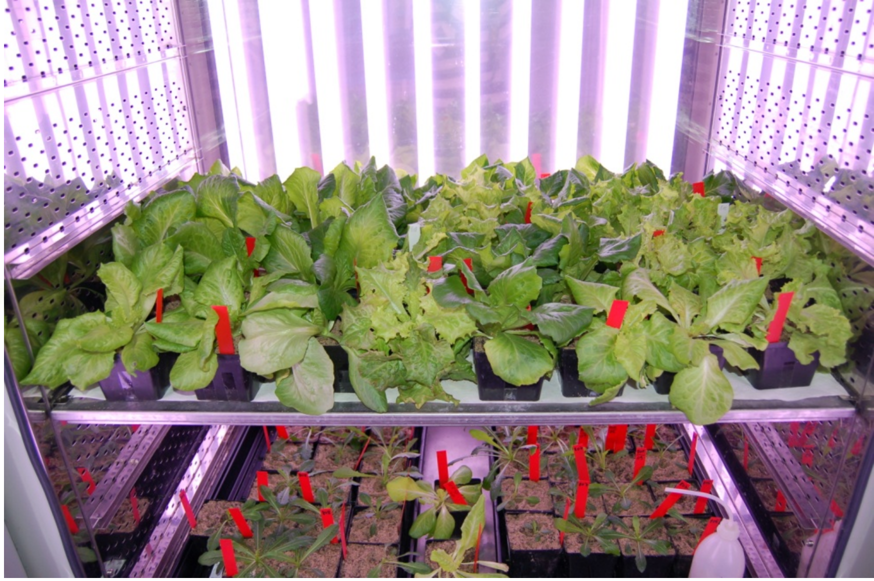
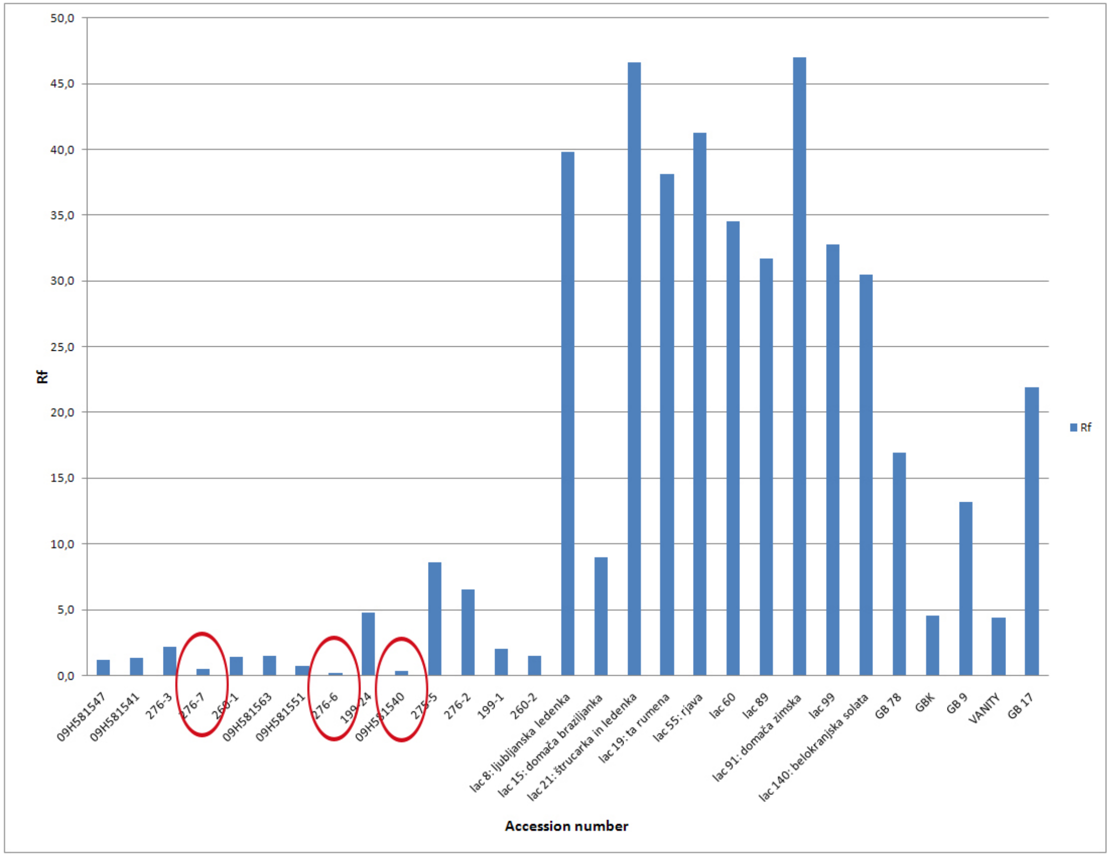
Resistance of Lettuce Accessions –KIS GENE BANK



- Inokulum 3000 egg/plant;
- Rf=Pi/Pf, GI



R = resistant (GI < 2, Rf < 1)
HR = Hipersensitive reaction (GI > 2, Rf < 1)
S = Susceptible (GI > 2, Rf > 1)

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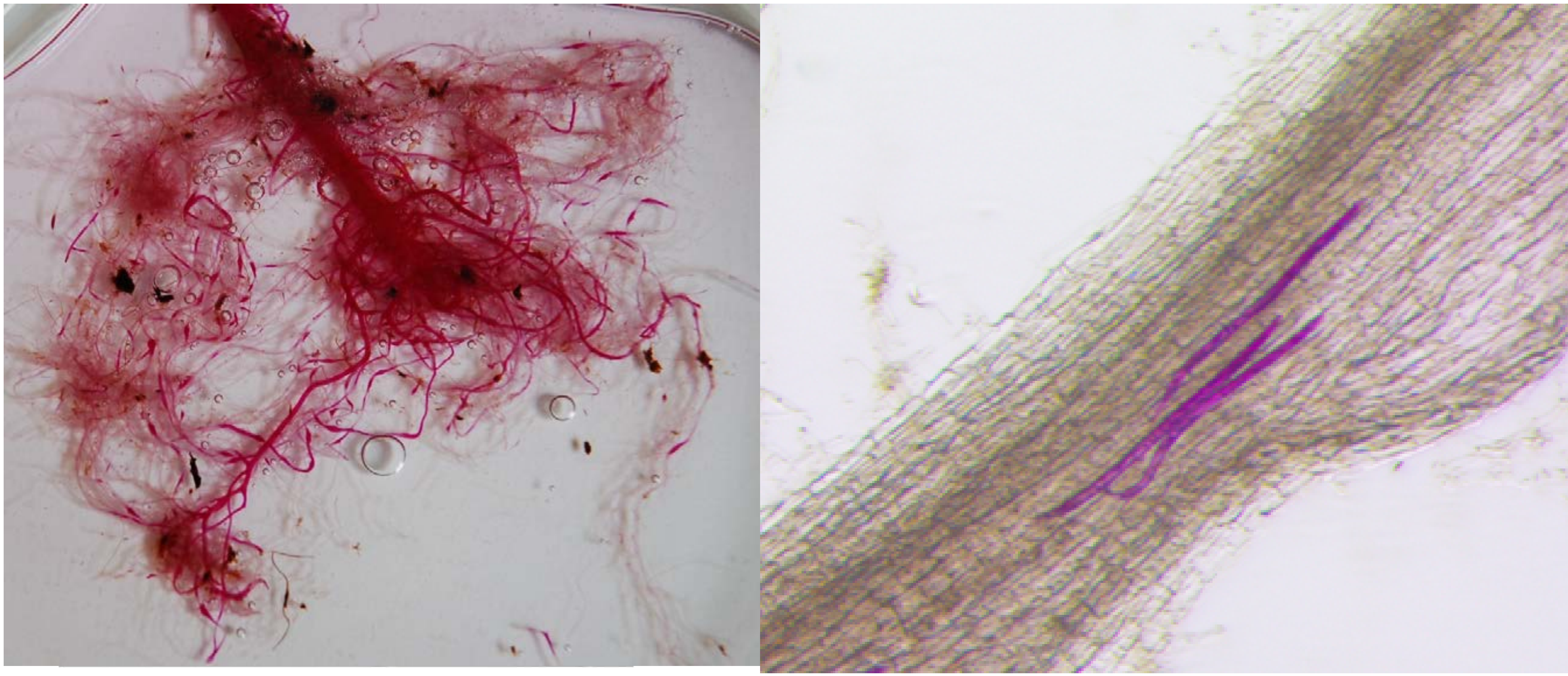
The use of antagonistic fungi for control of RKN

- Studying the interaction between RKN and fungi from the genus *Trichoderma* and *Clonostachys*
- The fungi were isolated from the infested roots with the RKN

Parasitism of *Trichoderma longibrachiatum* on eggs of *Meloidogyne incognita.*

The use of antagonistic fungi for control of RKN

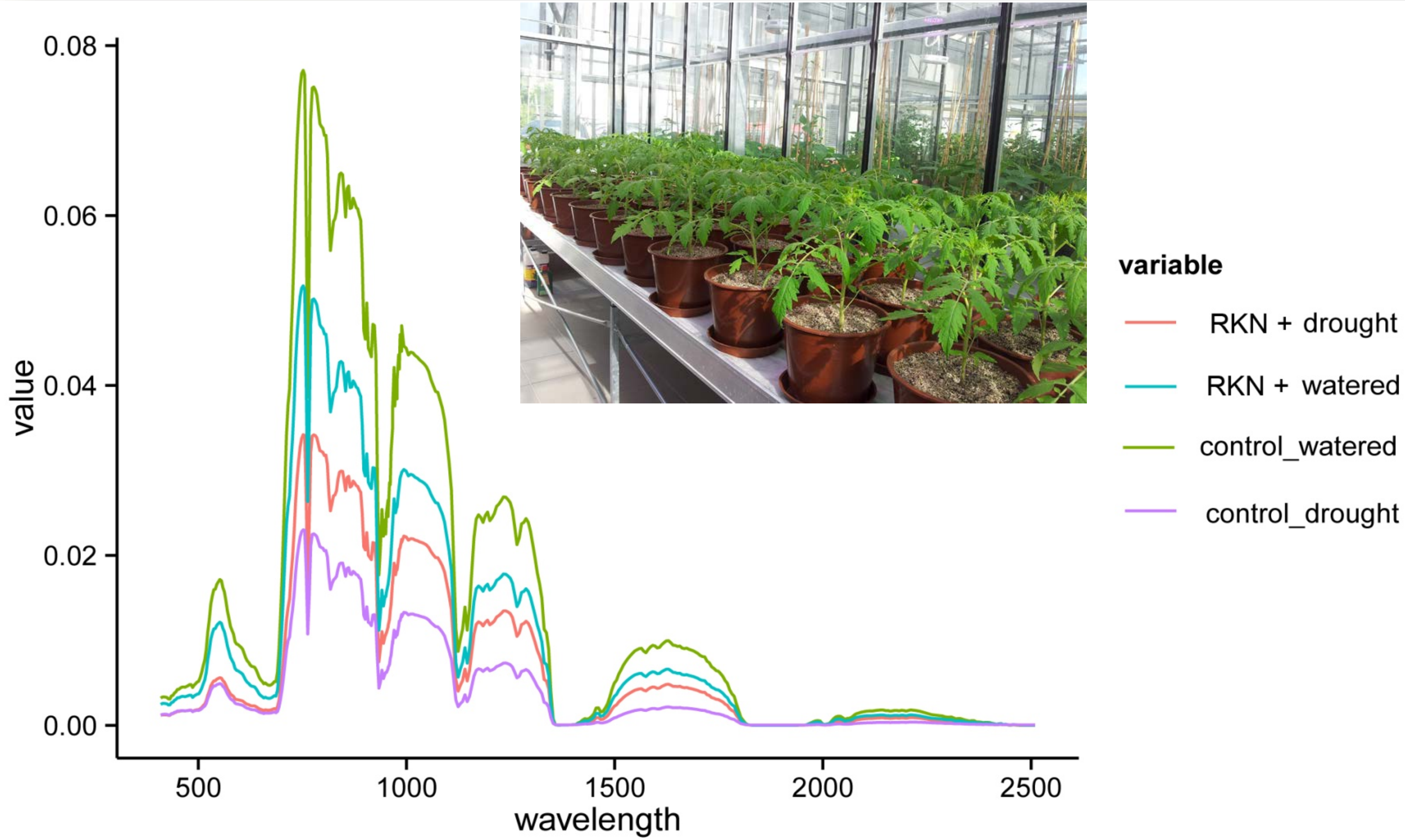


Parasitism of *Trichoderma longibrachiatum* on eggs of *Meloidogyne incognita.*

The use of antagonistic fungi for control of RKN

Remote sensing detection of RKN infestation

P13 POSTER



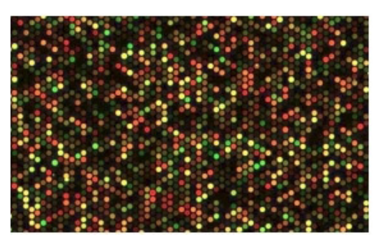
RKN + drought stress analyses

Database of hyperspectral fingerprints

RKN

DROUGHT

Physiological plant response to different and combined stresses



Differential molecular plant response to RKN and drought at water stress conditions

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RKN + drought stress analyses

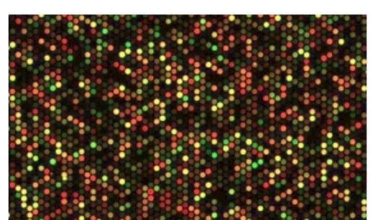
Integrated analyses for holistic understanding combined stress and its management

Database of hyperspectral fingerprints

RKN

DROUGHT

Physiological plant response to different and combined stresses



Differential molecular plant response to RKN and drought at water stress conditions

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RKNs emerging pests

Successful RKN management strategy – a combination/diversification of all efficient approaches:

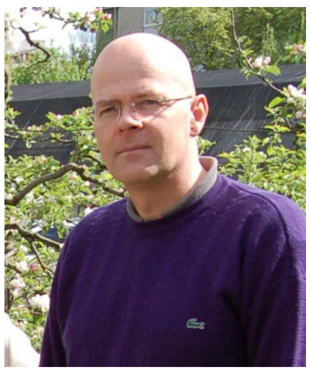
- prevention of spreading, appropriate detection, natural resistance, new biotech solutions, biological control, crop rotation, biofumigants etc.
- DSS for the future

THANK YOU FOR ATTENTION!

Polona Strajnar

Barbara Gerič Stare

Matej Knapič



Gregor Urek

Hans J. Schroers

Uroš Žibrat

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SEVENTH FRAMEWORK PROGRAMME

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