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D20 Practice Abstracts M18

Release of practise abstract from WP1, WP2, WP3, WP4, and WP5 after EIP model

NEM EMERGE

AN INTEGRATED SET OF NOVEL APPROACHES TO COUNTER THE EMERGENCE AND PROLIFERATION OF INVASIVE AND VIRULENT SOIL-BORNE NEMATODES

WP6

Type of deliverable: R — Document, report

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NEM-EMERGE Consortium

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1	Wageningen University	WU	Netherlands
2	Hilbrands Laboratorium B.V.	HLB	Netherlands
3	Kmetijski Institut Slovenije - Agricultural Institute of Slovenia	KIS	Slovenia
4	Julius Kuhn-Institut Bundesforschungsinstitut Fur Kulturpflanzen	JKI	Germany
5	Universitat Politecnica de Catalunya	UPC	Spain
6	Ondokuz Mayis Universitesi	OMU	Turkey
7	Enza Zaden Research & Development BV	ENZA	Netherlands
8	Institut National De Recherche Pour L'agriculture, L'alimentation Et L'environnement	INRAE	France
9	Stichting Wageningen Research	WR	Netherlands
10	Innovation des Producteurs de Plants de Pomme de Terre	INOV3PT	France
11	Universidad de Castilla - La Mancha	UCLM	Spain
12	International Institute of Tropical Agriculture	IITA	Nigeria
13	Novonesis	NOVONESIS	Denmark
14	Agence Nationale de La Sécurité Sanitaire de L’alimentation de L’environnement et du Travail	ANSES	France
15	Johann Heinrich Von Thueneninstitut, Bundesforschungsinstitut fuer Laendliche Raeume, Wald und Fischerei	THUENEN	Germany
16	Elhuyar Fundazioa	ELHUYAR	Spain
17	The James Hutton Institute	JHI	UK
18	The University of Exeter	UNEXE	UK
19	Nederlandse Voedsel en Warenautoriteit	NVWA	Netherlands

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Executive summary

This deliverable presents a summary and the full content of the first five Practice Abstracts developed under the NEM-EMERGE project. An additional ten abstracts are planned for delivery in two future batches, scheduled for Months 36 and 48 of the project timeline, ultimately resulting in a comprehensive set of 15 Practice Abstracts by the project's conclusion in December 2028.

Each batch will consist of one Practice Abstract per technical work package (Work Packages 1 to 5), ensuring that key insights and practical outcomes from each area of work are shared with relevant stakeholders. These abstracts are designed to provide useful, actionable knowledge tailored to the needs of practitioners.

A Practice Abstract is a concise summary that outlines essential information, practical recommendations, and innovative practices intended to support end-users in their day-to-day activities. All abstracts produced by NEM-EMERGE will follow the common format established by the EU CAP Network, as found on the EIP-AGRI website. This includes project-specific information such as partner contact details and other relevant data. The resulting innovative knowledge and easily accessible end-user material from this project will feed in the EU CAP Network website

The complete set of 15 Practice Abstracts will consolidate the outcomes, methods, and recommendations developed by the responsible project partners, offering practical, ready-to-use knowledge for implementation in the field. common format ("Practice Abstracts"), including the characteristics of the project (e.g. contact details of partners, etc.).

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Introduction to the deliverable

NEM-EMERGE, “An integrated set of novel approaches to counter the emergence and proliferation of invasive and virulent soil-borne nematodes”, is a project committed to providing a spectrum of sustainable, science-based solutions for both the conventional and organic farming sector, to prevent crop losses caused by root-knot nematodes (RKN) and potato cyst nematodes (PCN), the nematodes ranking 1 and 2 in the Top 10 of high-impact plant-parasitic nematodes. RKN alone accounts for about 5% of global crop losses, and recent reports document the emergence of new RKN and PCN problems in tomato and potato cropping across Europe and beyond due to two independent drivers: global warming and genetic selection. Consequently, there is an urgent need for novel, durable control strategies that enable adequate responses to prevent crop losses in the EU and beyond.

NEM-EMERGE will assess the impact of global warming on both the spread of RKNs and the inactivation of tomato plant innate resistance at high soil temperatures. The second driver that plays a central role in NEM-EMERGE is genetic selection. Both in case of RKN and PCN, intensive and prolonged use of a small set of host plant resistances has resulted in the appearance of virulent populations. NEM-EMERGE aims to develop markers for virulence for both plant parasites. Detection of the occurrence of virulent individuals will allow for the generation of risk assessment models. Next to this, novel sources of plant resistance that are effective against the virulent populations will be identified and characterized. Finally, the ability of soil microbiomes to control nematode spread will be explored and promoted.

This document illustrates the plan for the dissemination and exploitation including communication activities for the NEM-EMERGE project and sets the strategy and set of actions necessary for these commitments. This plan will ensure that all communication and dissemination needs that have been identified for project are considered and coordinated. To this end, it provides a draft plan for the actions that will be taken all along the duration of the project.

This deliverable, comprising the first set of Practice Abstracts, forms part of Work Package 6 (WP6) – *Adoption, Dissemination, and Exploitation of NEM-EMERGE Findings, Including Communication Activities*. WP6 is dedicated to maximizing the visibility and uptake of the project’s results.

From the outset of the Grant Agreement, it was established that Practice Abstracts would be delivered in three batches, aligned with the project’s reporting periods. Each batch consists of one Practice Abstract per technical work package (Work Packages 1 to 5), resulting in five abstracts per batch. In total, 15 Practice Abstracts will be produced and delivered by the end of the project.

Uploading them to the EIP-AGRI platform and making them available to its users is fully in line with the project’s objectives, as it brings together innovation actors (farmers, advisors, researchers, businesses, NGOs, etc) and helps to build bridges between research and practice.

In order to make this information exchange smoother among actors, the EIP-AGRI has established a common format for submitting the practice abstracts, which facilitates knowledge flows on innovative and practice-oriented projects from the start till the end of the project. The use of this format also enables farmers, advisers, researchers and all other actors across the EU to contact each other. Furthermore, this common format includes a guidance which defines the length that the description text should have, as well as the option to add the text in the native language(s) that has(ve) been used when carrying out the activity that is described.

NEM-EMERGE has designed a specific template following the common format and guidance established by the EIP-AGRI, to make the practice abstracts more eye-catching (see below), and has included a dedicated block on the Results page of the website to publish them.

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NEM EMERGE

AN INTEGRATED SET OF NOVEL APPROACHES TO COUNTER THE EMERGENCE AND PROLIFERATION OF INVASIVE AND VIRULENT SOIL-BORNE NEMATODES

Species Distribution Modelling Reveals Invasion Risk of Tropical Root-Knot Nematodes in European Agriculture

As winters become milder, tropical root-knot nematodes (RKN) will expand their ranges from the Mediterranean region in northern directions. Our species distribution modelling predicts in considerable detail more northern European regions that are favourable for tropical RKN establishment. Due to their extreme wide host range, tropical RKNs might develop into a significant threat as well to crops that are produced in these regions. Early detection and proactive management strategies are essential to mitigate potential yield and quality losses.

Main Outcome: Farmers and agricultural advisors should monitor the presence of RKN infestations (*e.g.,* the presence of galled roots), especially in regions identified as high-risk by our models (see interactive maps at https://nem-emerge.eu/interactive-maps/ Tropical_new.html). Growing resistant plant varieties or poor hosts, and application of soil health promoting practices can reduce the likelihood of tropical RKN establishment and spread.

Expected Impact: Our assessment of invasion risks of tropical RKNs is not intended as an alarm bell, it rather allows farmers, agricultural advisors and plant breeders to prepare themselves. The range of expansion of tropical RKNs is a relatively slow but barely stoppable process. Monitoring is essential. We also envision a crop range-shift strategy, where vulnerable crops are produced in the areas with low invasion risk (grid cells of the interactive map).

Target Audience: Farmers, agricultural advisors, plant breeders and agricultural policymakers.

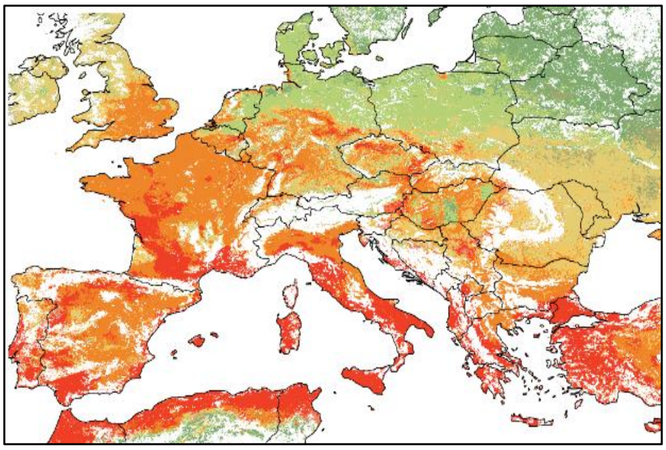

Figure 1: Potential root-knot nematode threat or invasion risk in Europe agriculture. Colours: Red (high risk), orange (moderate risk) and green (low risk).

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Global warming: lifting the inactivation of host plant resistance under elevated soil temperatures

Vegetable crop production is often hindered by pest and diseases, leading to yield and quality losses and income insecurity for growers. Root-knot nematodes (RKN) - microscopic wormlike plant parasites - affect the production of numerous crops. In tomato and pepper, the use of RKN-resistant varieties is one of the most sustainable and economically viable control strategies. **However, global warming jeopardizes this control handle as high soil temperatures render several crop resistance genes ineffective**. This happened to a major tomato resistance gene (*Mi1.2*), and this gene is no longer effective in protecting tomato plants from RKN at soil temperatures above 28ºC. It is noted that this plant pathogen itself is perfectly able to handle these high soil temperatures. So global warming has an unexpected side effect: it poses a significant threat to tomato production, especially in Mediterranean countries.

Within Nem-Emerge novel heat-stable resistances to RKN in tomato will be developed. We investigate the molecular and physiological **mechanisms that confer heat-stability to resistance genes** against pests and diseases and apply this knowledge to obtain **new tomato varieties with heat-stable, broad-spectrum resistance and high horticultural value in the near future.**

In conclusion, we will address a current key challenge posed by global warming by restoring the effectiveness of **root-knot nematodes resistance in tomato under elevated temperatures.**

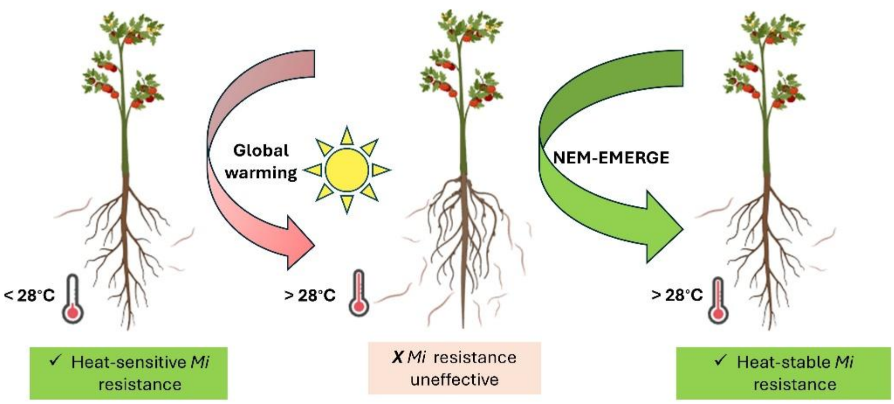

Figure 1: *Mi* resistance protecting tomato against root-knot nematodes (left), global warming jeopardizes this protection (middle), Nem-Emerge develops ways to fix the heat instability of host plant resistance (right).

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PRACTICE ABCTRACT

Uncontrolled emergence: populations of root-knot nematodes are overcoming resistance in tomato

Root-knot nematodes cause more than € 500 million economic losses to the annual tomato production in Europe. Massive deployment of a single resistance gene in tomato has led to the emergence of nematode populations that overcame the resistance.

Early detection of resistance-breaking nematode populations is essential to prevent their uncontrolled spread. Molecular diagnostic tools for the detection of resistance-breaking populations are currently missing. This could lead to the unnoticed range expansion of these virulent populations.

In NEM-EMERGE, we are studying the four most damaging root-knot nematode species regarding tomato: *Meloidogyne incognita*, *M. javanica*, *M. arenaria* and *M. luci*. We are collecting virulent (= resistance-breaking) as well as avirulent (= controlled by resistance) populations for each species. By sequencing and comparing the genomes of these virulent and avirulent populations, we aim to identify genomic signatures associated with virulence.

These genomic signatures will enable stakeholders to develop accurate diagnostic tools. Farmers and tomato growers will be invited to use these diagnostic tools as early and widely as possible and to report the presence of virulent populations allowing the timely application of appropriate control measures.

Figure 1: Root systems of a resistant tomato rootstock cultivated in soil infested with a virulent (left) or an avirulent (right) *Meloidogyne incognita* population.

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PRACTICE ABCTRACT

Genetic selection: managing potato cyst nematodes that have overcome current host plant resistances

The best solution to control *Globodera pallida* populations is to grow resistant potato cultivars, but the majority of the resistant cultivars contain the same resistance factor originating from *Solanum vernei*. This resistance gene has been effective for many years, but now we discovered that some ('virulent') potato cyst nematode (PCN) populations can no longer be stopped.

This 'breaking of resistance' can only be solved if we understand what was happened. For this, we need to know more about the nematode itself, about their spreading and about the host plant.

First, we will identify genomic regions linked to virulence of the nematode and develop a diagnostic molecular tool to map the spreading of virulent PCN populations. For this, we will sequence *G. pallida* populations that can overcome the resistance and perform genome scan analyses. Within Nem-Emerge, we have been identifying candidate genomic regions using virulent populations obtained in the laboratory. We have also collected natural populations with various levels of virulence, and are currently analysing them.

In a second step we will develop a proliferation model that will provide information on how virulent nematodes are likely to build up under different management regimes. We have published in 2024 a demo-genetic model considering the population genetic features of *G. pallida*, and the current work is to integrate it into existing decision support systems for farmers.

Last but not least we aim to identify new sources of resistance to control emerging virulent populations. We have decided to deeply study the resistance from *Solanum sparsipilum* which is conferred by a combination of two small genomic regions. After an enrichment step, which allows sequencing to be focused on resistance genes, potato genotypes from the initial cross between susceptible and resistant parents will be sequenced to identify markers linked to each of these regions.

Figure 1: Resistance test performed in the JKI greenhouses

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Cover crop choice: do's and don'ts regarding root-knot nematode management

Cover crops are gaining popularity among farmers, advisors, and policymakers in agriculture. These are fast-growing, non-economic crops grown during the off-season. **Cover crops are used to reduce erosion and nutrient losses, improve soil structure, increase organic matter content, and support beneficial soil life**. Some cover crops can also promote helpful soil organisms that naturally fight harmful nematodes, making them a valuable tool in integrated pest management (IPM).

As long as cover crops grow well under off-season conditions and do not become weeds in the next season, their selection may seem simple. **However, not all cover crops are safe to use in every situation**. Some can serve as food sources for pathogens and help them survive into the next season. In the past, leaving fields fallow during winter helped to reduce plant pathogens. Today, **it's important to understand the health status of your soil to avoid planting cover crops that might support pests.**

This can be illustrated by *Meloidogyne chitwoodi*, a damaging root-knot nematode with quarantine status. Its density can be reduced by choosing cover crops such as fodder radish, perennial ryegrass (see figure below), phacelia, or vetch that are poor hosts and can help manage this nematode. On the other hand, black oat - a popular cover crop -is a very good host for *M. chitwoodi* and may cause its population to increase. If *M. chitwoodi* is not present or not harmful to the following crop, black oat can be safely used. But if this nematode is a known issue, it is better to choose another cover crop (for host status of cover crops see for e.g. best4soil.eu)

Main message: Being informed about the pathogen status of a field is essential. This information should be taken along in the cover crop selection. **There are many cover crops on the market, pick a cover crop that doesn't promote pathogens that might be harmful to the next main crop!**

Figure 1: testing a range of cover crops on their host status regarding the root-knot nematode *Meloidogyne chitwoodi.* black oat (bo), rye (ry), annual ryegrass (ar) and perennial ryegrass (pr).
Figure on right from Cazzaniga et al. Soil Biology and Biochemistry 202 (2025) 109693

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