Final Report

Management of nematodes – a workshop to identify vegetable industry needs

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Management of nematodes – a workshop to identify vegetable industry needs (VG23015)

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Public summary

The HIA Nematode Management Stakeholder Engagement Project was initiated to address the persistent challenges posed by nematodes to productivity and profitability in Australia's vegetable industry. Nematodes, particularly root-knot nematodes and lesion nematodes, are a major concern for horticultural producers, often leading to yield losses, reduced crop quality, and significant economic impacts. Recognising the urgency of improving nematode management, Hort Innovation (HIA), in collaboration with AUSVEG, sought to engage stakeholders and prioritise investment strategies to enhance nematode control practices across the vegetable sector.

This project utilised a participatory, mixed-method engagement model structured into three phases, delivered across eight sprints. The key activities included a desktop review, a series of online 'workshop-webinars', and a prioritisation survey and workshop with vegetable industry stakeholders. Many participants, including growers, researchers, agronomists, and supply chain partners, shared their insights through interactive tools such as Mentimeter and surveys. These inputs were analysed to identify critical challenges, validate assumptions, and define strategic priorities for nematode management practices. The methodology ensured alignment with industry needs, balanced evidence-based decision-making, and fostered collaboration across the vegetable value chain.

The outcomes of the project provide actionable recommendations to address nematode management challenges. These include the development of advanced diagnostic tools for early detection, integrated pest management (IPM) strategies combining chemical, biological, and cultural controls, and improved grower education programs tailored to specific crops. By enhancing nematode control methods, the project aims to reduce yield losses, improve soil health, and support sustainable farming practices. Furthermore, the insights gathered will guide future investment, enabling HIA to prioritise high-impact activities that meet the practical needs of growers and industry participants.

The project has generated a robust strategic plan for nematode management, including investment pathways and recommendations based on extensive stakeholder feedback and represents a significant step towards proactive approaches to managing nematodes, ultimately empowering growers and enhancing industry resilience.

Keywords

Nematodes, Vegetable industry, Management strategies, Stakeholder engagement, Industry needs, grower needs, Research Agreement, Recommendations, Monitoring and evaluation.

Introduction

The HIA Nematode Management Stakeholder Engagement Project was commissioned to identify and prioritise opportunities for improving nematode management strategies across the Australian vegetable industry. Recognising that effective nematode control is a persistent challenge impacting productivity and profitability across the supply chain, Hort Innovation (HIA), in collaboration with AUSVEG, sought to engage key stakeholders to inform future investment decisions and maximise impact.

This project builds on previous investments, including projects such as PW17001, PW22000-1, MT22012 and VG23007, and aligns with HIA's strategic objectives to drive evidence-based solutions to on-farm problems. The project is grounded in a participatory, mixed-methods engagement model that enables the voices of growers, researchers, agronomists, and other value chain participants to shape the priorities for nematode management practices from the grower's perspective.

The methodology, codesigned with AUSVEG, was structured in three phases, delivered across eight sprints, combining desktop research with a series of online 'workshop-webinars' to engage participants and capture diverse perspectives. Drawing on lessons from a recent, similar project delivered for the Fisheries Research and Development Corporation (FRDC), this approach ensures alignment with stakeholder engagement best practice principles and supports the development of a robust, industry-informed investment strategy.

The scope of this project focused on maximising the return on investment (ROI) of HIA's R&D initiatives by identifying strategic priorities, gaps in current management practices, and opportunities to enhance adoption. While it was assumed that improved nematode management is a critical need, the process was designed to surface evidence-based insights that could also challenge this assumption, ensuring all recommendations are grounded in sector needs and practical realities.

The following report outlines the project methodology and presents the outcomes of the stakeholder engagement process, including post-workshop analysis and development of a strategy to present industry needs in a usable format. The findings will support HIA and AUSVEG in shaping a future-focused investment pathway in nematode management, underpinned by stakeholder needs and aimed at delivering tangible on-farm impact.

Methodology

The proposed methodology (Figure 1), co-designed with AUSVEG, was structured into three phases and subdivided into sprints for effective management and delivery (Appendix A). The key elements of the mixed-method approach included a desktop review, online workshop-webinars (design to be engaging), and a prioritisation workshop with AUSVEG. Combining these elements delivered highly relevant outputs and enabled maximum industry engagement. All key stakeholders across the vegetable value chain were able to offer critical insights. The reporting will enable HIA to make the most informed decisions regarding investment for maximum impact on nematode management practices.

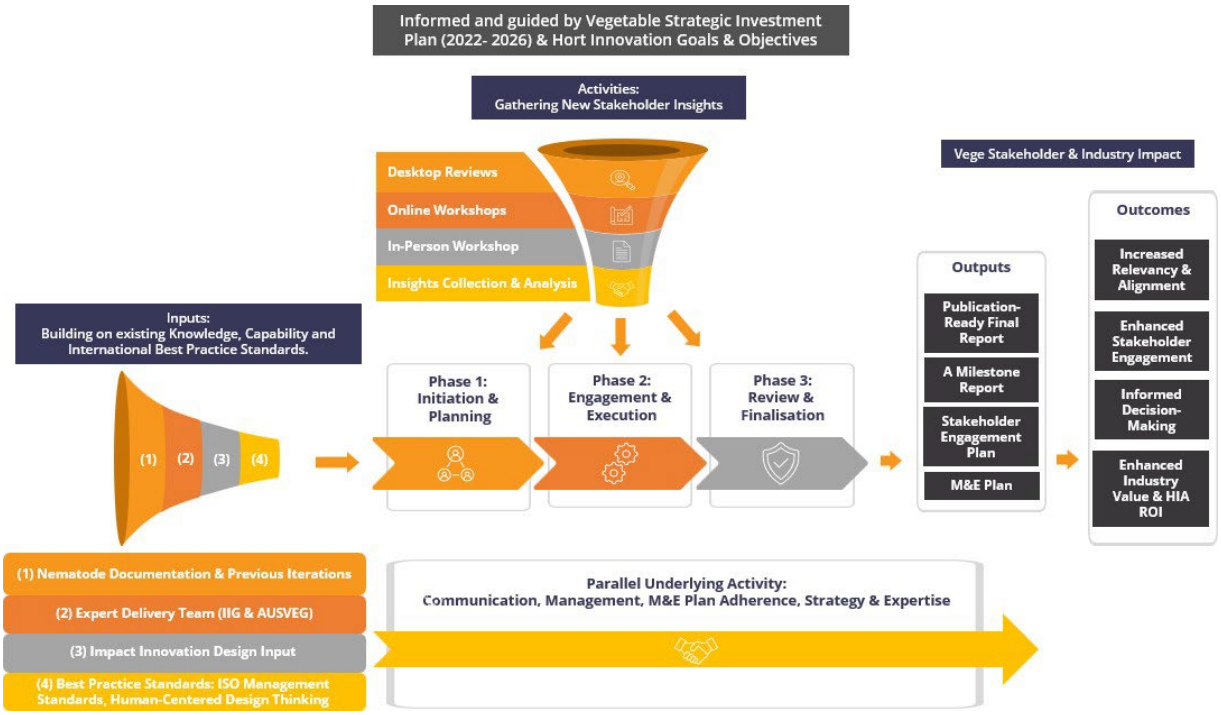

Figure 1: Project Logic Diagram of Methodology.

This method enabled broad industry participation, and aligned with the Department of Agriculture, Fisheries and Forestry's stakeholder engagement best practice principles, and facilitated the development of a robust investment strategy.

The review assessed key areas including: current challenges and issues faced by stakeholders, the effectiveness of existing nematode management strategies (e.g., chemical, biological, and cultural controls), research and innovation gaps (e.g., emerging technologies, resistant varieties), and industry priorities for future investment. Online workshops facilitated by Impact Innovation Group (IIG) ensured active engagement and representation from a broad range of vegetable industry stakeholders, including nematology researchers, agronomists and extension officers, growers, and industry organisations (e.g. AgChem Suppliers) in the gathering of comprehensive insights. The webinars supported IIG in the identification of critical challenges and priorities for investment in nematode management within the vegetable industry. Outcomes from these workshops were analysed to define the industry needs to be addressed in a subsequent survey and prioritisation workshop (outcome pending survey engagement from AUSVEG stakeholders – Phase 2, Sprint 5, in-person workshop replaced with online survey and workshop as approved by HIA).

The prioritisation survey and online workshop (expected to be finalised by 20/6) used the insights gained to prioritise investment areas in nematode management. The selection of participants (i.e., industry representatives) identified by AUSVEG for this survey and workshop ensured that the prioritisation process was informed by those with suitable expertise offering strategic perspectives to support decision-making - ensuring the critical needs of the industry were addressed, with strategic input guiding high-impact investment decisions.

The final outcomes formed the basis for outlining defendable, structured, and clear investment direction based on grower priorities.

Impact Plan

To help develop a deeper understanding of grower concerns and formulate priorities for further investment, IIG composed a Step-by-Step Impact Plan. Table 1 outlines the process used to build the impact plan for HIA. The impact plan informed and directed the data collection (i.e. question structure) and follow-on analysis that will help build an investment recommendation for HIA.

Table 1: Impact Plan for Hort Innovation – Management of Nematodes

Step	Process	Approach
1	Develop the Logic Model	1. Create a structured logic model to outline the problem, its components, and the expected outcomes for growers.
2	Formulate Key Evaluation Questions	2. Identify critical questions to validate assumptions or gather required data. 3. Conduct desktop research (e.g., "Nematodes in Australia") to gather preliminary insights.
3	Map Challenges Using Analytical Tools	4. Utilise tools such as Fishbone Diagrams, Root Cause Analysis, or PESTLE frameworks to present and map challenges visually.
4	Summarise and Validate Existing Knowledge	5. Consolidate known information, identifying gaps or assumptions. 6. Validate this knowledge through further research or consultation.
5	Collect Insights via Stakeholder Engagement	7. Use tools like Mentimeter during webinars to gather real-time feedback and insights from participants.
6	Analyse Insights and Define Challenges	8. Perform thematic analysis on collected insights within the challenge map. Clearly define challenge statements and outline the scope of the identified issues.
7	Prioritise Challenges in Workshop	9. Disseminate a survey and facilitate a workshop to prioritise the most impactful challenges or investments based on the thematic analysis.
8	Determine Investment Requirements	10. Establish the investment strategy required for HIA (Horticulture Innovation Australia) to address these priority challenges effectively.

A key driver in the Impact Plan was focussed on there being a lack of information about the grower's experience with nematode management – making it critical to challenge all stakeholders from the growers' perspectives. This informed the decision that IIG undertook a root cause analysis to build informed questions to ask during the workshops and validate questions around grower experiences.

Desktop Review

A desktop review was conducted as per step 2 in the Impact Plan (Table 1) – this enabled IIG to clarify the challenge being characterised, identify critical questions needing validation from the grower perspective and relate them to Nematode Management Practices in Australia.

Stakeholder Plan

A stakeholder plan was prepared to support the project team in coordinating the key project activities, dates, draft material and other details. The key project stakeholders included AUSVEG and HIA.

See Appendix B: Stakeholder and Communication Plan for additional detail on key project Stakeholder information.

Webinars and Workshops

A root cause analysis was conducted to map the challenges visually and to develop the content necessary to inform the

process of collecting feedback and insights from webinar and workshop participants via the Mentimeter Platform – see Appendix C for questions and results. Webinars and workshops were scheduled as per Table 2 and specific target audiences included in each to ensure broad stakeholder participation and drive the focus to be around the group in question.

Table 2: Webinar and Workshop scheduling plan

Event	Target Audience	Date	Time
Webinar 1 Name: Share Your Insights -Shaping Research Priorities for Nematode Management	Researchers (including government researchers)	Tuesday, February 11, 2025	11 am AEDT 10 am AEST
Webinar 2 Name: Share Your Insights - Industry Perspectives on Nematode Management Strategies	Agronomists, Extension Officers & Supply Chain Partner (i.e. AgChem Companies, Input Suppliers, & Key Value Chain Players)	Tuesday, February 25, 2025	1 pm AEDT 12 pm AEST
Webinar 3 Name: Share Your Insights - Addressing On-Ground Challenges in Nematode Management	Vegetable Growers	Tuesday, March 4th, 2025	5 pm AEDT 4 pm AEST
Prioritisation Workshop Name: Shaping the Future: Industry-Led Prioritisation for Nematode Management *Location - Online*	AUSVEG extension network	Anticipated to be week of 23 June 2025	TBC

Prioritisation Survey

Outputs from the 3 webinars conducted with different stakeholder groups were analysed to identify priority areas across all groups. The data collected was collated into an online survey, using Alchemer, subsequently circulated to AUSVEG to enable sharing with identified participants to guide final strategy development. The survey is currently with AUSVEG for completion during the week of 16 June 2025. See Appendix D for further information.

Data collected from the survey will be analysed further to identify priorities from AUSVEG extension experts to inform the content of what will be reviewed in the final Prioritisation Workshop. The data from this final workshop will be subjected to further analysis by the IIG team to prepare a strategy document outlining investment direction based on the vegetable industries priorities with regards to Nematode Management Practices, for HIA's review.

Deliverables (Results and discussion)

This section reports on the four key deliverables of this project:

1. ***Comprehensive assessment of historical and present investments in nematode management.***

Australia has a long history of research on nematodes, focusing largely on the scientific characterisation and identification of species. Significant literature exists on their biology, lifecycle, prevalence, diagnostics, and impact on horticulture, as well as management trials using chemical, non-chemical, and Integrated Pest Management (IPM) approaches.

Effectively applying this knowledge to manage nematodes and protect horticultural profitability remains a challenge for the industry. From available literature, we can present the following summary.

A Focus on Management:

Much of the information provided from research projects is in the form of fact sheets, which often require additional resources to review and implement any suggestions. In many cases, the insights in fact sheets are generic and need expert support or advanced agronomy skills to be applied on-farm.

1.1 The Challenge: Industry perspective

Horticulture producers in Australia frequently encounter nematode problems, particularly with plant-parasitic species like root-knot nematodes (Meloidogyne spp.) and root-lesion nematodes (*Pratylenchus* spp.). While exact national statistics vary, several key findings offer insight into how often these problems occur:

Frequency:

Queensland and Northern NSW (warm climates): Up to 70% of vegetable farms have been found to host damaging populations of root-knot nematodes. According to Queensland Government reports, RKN are widespread in cucumber, tomato, capsicum, and carrot production systems.

Southern and Western Australia: Root-lesion nematodes (RLN) are common across many horticulture and cropping zones. The GRDC reports that RLN are frequently found in over 50% of paddocks in monitored areas in the southern grain region. These species also affect legumes and vegetables, particularly where crop rotation is poor.

Survey Evidence: Surveys conducted by the Australian vegetable industry (AUSVEG, Hort Innovation) show that 40–60% of growers report nematodes as a regular or seasonal issue. The issue is especially persistent in sandy soils, which promote nematode movement and root penetration.

Prevalence:

- Nematodes affect a wide range of crops, including vegetables, fruits, and ornamentals.
- Root-knot nematodes (*Meloidogyne* spp.) and lesion nematodes (*Pratylenchus* spp.) are among the most problematic species for horticulture.
- In certain crops like carrots, potatoes, and tomatoes, nematode-related losses can reach up to 10-20% of yield if left unmanaged.
- Soil type: Sandy soils often have higher nematode populations due to better aeration.
- Crop rotation: Monoculture practices exacerbate nematode problems by allowing populations to build up.
- Climate: Warmer climates, such as in many parts of Australia, are conducive to nematode reproduction and activity.

Impacts:

- Stunted growth, poor yield, and root damage are common symptoms.
- Some nematodes are vectors for other plant pathogens, compounding the damage
- Chemical nematicides are effective but can be costly and have environmental concerns.

Yield losses can range from 10% to over 50% if nematode populations are not managed. Nematodes are often under detected due to their microscopic size and root-based damage, leading to chronic underperformance in fields.

In summary, nematode problems are common and recurring for a substantial portion of horticulture producers in Australia—particularly those in warmer climates, sandy soils, or monoculture systems. Active management is required in most regions to prevent yield loss and crop failure.

1.2 A Summary of Previous and Related work

PW17001 Integrated farm management (IFM) to control nematodes in sweet potato crops

From 2018 to 2023, this project advanced nematode and soil health management in Australia's sweet potato industry through research, field trials, and extensive grower education. Key achievements include:

- Comprehensive Surveys: First nationwide nematode survey in sweet potato soils identified key pest species, including a new detection of reniform nematode and alerts on guava root-knot nematode.
- Management Strategies: Field trials evaluated cover crops, organic amendments, tillage practices, and nematicides. Thirty-six cover crops and 15 sweet potato cultivars showed resistance to root-knot nematodes.
- Soil Health: Long-term trials confirmed that high organic inputs improve soil carbon, support beneficial organisms, and suppress nematode populations.
- Virus and Weed Control: Improved diagnostics and herbicide trials helped address virus risks and the nematode-host potential of weeds.
- Industry Impact: Masterclasses and extension activities built grower awareness and resilience, leading to improved pest, disease, and soil management practices**.**

PW22000-1 Understanding races of nematodes in sweet potato /PW22000-2 Pest management for the Australian sweet potato industry (in progress)

This project focuses on understanding nematode diversity in Australian sweet potato-growing soils to develop better control strategies and improve virus diagnostics. It includes surveillance and testing of nematode populations and their pathogenicity, as well as screening new rotation crops and sweet potato cultivars for resistance. The project will also enhance virus detection methods for faster and more accurate field diagnostics. Outcomes aim to reduce crop losses, support sustainable pest management, and boost industry preparedness against biosecurity threats.

MT22012 Industry Preparedness for exotic root-knot nematode (*Meloidogyne enterolobii*) (In progress)

This research aims to develop faster, cheaper, and more accurate identification tools for root-knot nematodes in Australia, using molecular screening and AI-based image recognition. The project responds to the 2022 detection of the Guava Root-Knot Nematode (*Meloidogyne enterolobii*), a highly damaging, resistance-breaking pest with a broad host range and major biosecurity risk. Traditional identification methods are slow and require expert interpretation, while DNA extraction from historic specimens has been limited by formalin preservation. The project will overcome this using a new CSIRO technique for DNA recovery from old samples and will build an AI tool to identify nematodes from perineal pattern images, enabling rapid, species-level diagnosis critical for trade, quarantine, and pest management.

VG23007 Guava root-knot nematode identification and management (In progress)

Hort Innovation, in collaboration with the Queensland Department of Agriculture and Fisheries (QDAF), is funding a project to improve Guava Root-Knot Nematode (GRKN) management in Australia's vegetable industry. The project involves nationwide surveys to map root-knot nematode species, development of faster and more accurate diagnostic tools, and greenhouse trials to assess resistant cover crops and commercially viable nematode control options. The project runs until July 2026 and aims to tailor nematode management strategies to specific regions and production systems. Dr. Desaeger, an expert guest from the US and reported as part of VG23007, outlined five key pillars for Integrated Nematode Management (INM):

I. **Crop Rotation**: Use non-host crops, including cover crops, to break pest cycles and improve soil health.
II. **Resistant Cultivars**: Select nematode-resistant or tolerant varieties and adjust planting times to reduce pressure.
III. **Soil Health**: Build beneficial soil biology to naturally suppress nematodes and boost plant resilience.
IV. **Targeted Chemicals**: Apply selective nematicides like fluensulfone to reduce pests while preserving beneficials.
V. **Monitoring**: Identify nematode species and populations to guide management decisions and prevent spread.

1.3 The challenge from a grower's perspective

The project focused on managing nematodes. Although R&D activities provided excellent scientific data, translating these 'insights into reliable practices isn't always effective. We analysed previous research and summarised the nematode challenge from a grower's perspective, using a design-led thinking approach to understand the customer's needs. This approach enabled us to structure the indsutry engagement to maintain the focus on the grower's needs. From a

production management perspective, this means reviewing the readily available information from the awareness of nematodes issues (detection and diagnostics), decision making when to address an issue (risk and financial consequences), treatment availability and effectiveness and regulatory or support channels. Essentially, aiming to understand the current 'lived experience' of someone who needs manage crops for nematodes.

To this end, Appendix E is from a root cause analysis of the nematodes in Australian horticulture. This analysis was used to develop the line of questioning for the webinars to gather information from a broad set of stakeholders on the assumptions and questions.

Technological and Management Options

- **Challenges:**
  - Limited availability of nematode-specific management tools tailored to vegetable crops.
  - Reliance on chemical nematicides, which may be expensive, face regulatory restrictions or lose effectiveness over time.
  - Lack of integration of alternative solutions such as biological controls or resistant crop varieties.
- **Assumed Causes:**
  - Gaps in research and development for cost-effective and practical tools.
  - Barriers to commercialisation of innovative solutions (e.g., high costs, lack of field trials).
  - Insufficient communication of available technologies to growers.
- **Questions to Validate:**
  - What tools or methods do you currently use for nematode management?
  - Are there specific tools or technologies you feel are missing or inaccessible?
  - What would make adopting new technologies easier for your farm?

Cost Burden to Growers

- **Challenges:**
  - Economic losses due to reduced yields and crop quality from nematode infestations.
  - High direct costs for chemical treatments and indirect costs such as reduced soil fertility.
  - Difficulty in quantifying nematode-related losses, making cost-benefit decisions harder.
- **Assumed Causes:**
  - Limited access to cost-effective, scalable management solutions.
  - Insufficient economic incentives (e.g., subsidies) to encourage sustainable practices - long-term pest management strategies, such as Integrated Pest Management (IPM), biological controls, or resistant crop varieties.
  - Lack of granular data on the financial impact of nematodes by crop type or region.
- **Questions to Validate:**
  - How do nematodes impact your farm financially (e.g., yield loss, treatment costs)?
  - What cost barriers prevent you from implementing better management practices?
  - Would financial incentives or support encourage you to adopt sustainable strategies?

Diagnostics and Detection Mechanisms

- **Challenges:**
  - Diagnostic tools are often expensive or unavailable, especially in remote regions.
  - Detection often occurs reactively (after significant damage) rather than proactively.
  - Limited knowledge or capacity among growers to interpret diagnostic results.
- **Assumed Causes:**
  - High cost of advanced diagnostic technologies and limited local distribution.
  - Lack of awareness or training for growers on using diagnostic tools effectively.
  - Gaps in extension services to support diagnostics and interpretation.
- **Questions to Validate:**
  - How do you currently detect and confirm nematode problems on your farm?
  - Are diagnostic tools accessible and easy to use for you?
  - What would help you identify nematode issues earlier and more effectively?

Regulatory and State Challenges

- **Challenges:**
  - Quarantine and movement restrictions due to nematodes can limit market access for affected growers.
  - Regulatory requirements (e.g., mandatory testing, certifications) add costs and complexity.
  - Variability in state-level policies may confuse or burden growers.
- **Assumed Causes:**
  - Regulations focused more on containment than prevention or management.
  - Limited grower representation in shaping policies.
  - Disparities in regulatory approaches across different states or regions.
- **Questions to Validate:**
  - How do state or national regulations impact your ability to manage nematodes?
  - Are there specific regulatory challenges that you find burdensome?
  - How could regulations better support your efforts to manage nematodes sustainably?

Barriers to Adoption of IPM Strategies

- **Challenges:**
  - Growers perceive integrated pest management (IPM) as complex and resource-intensive.
  - Limited trust in alternative solutions like biological controls or crop rotations.
  - A lack of demonstrations or success stories tailored to local conditions.
- **Assumed Causes:**
  - Insufficient outreach and training on IPM principles.
  - Economic pressure for short-term yield optimisation over long-term strategies.
  - Fear of inconsistent or unpredictable results from IPM practices.
- **Questions to Validate:**
  - What prevents you from adopting IPM strategies for nematode management?
  - How could IPM practices be made more practical or affordable for you?
  - What examples of successful IPM practices would build your confidence in adopting them?

Climate and Environmental Factors

- **Challenges:**
  - Climate variability exacerbates nematode problems by creating favourable conditions for outbreaks.
  - Drought or excessive rainfall affects soil health and may compound nematode issues.
  - Climate-driven shifts in growing seasons may increase nematode prevalence.
- **Assumed Causes:**
  - Lack of localised research on climate-nematode interactions.
  - Limited region-specific recommendations to adapt management practices to climate conditions.
  - Overreliance on practices that do not account for environmental variability.
- **Questions to Validate:**
  - How has climate variability or extreme weather affected nematode problems on your farm?
  - What environmental factors most influence your pest management practices?
  - What support or information would help you adapt to changing climatic conditions?

Soil Health and Farming Practices

- **Challenges:**
  - Soil degradation, compaction, and reduced organic matter exacerbate nematode problems.
  - Monoculture farming depletes soil resilience, making it more prone to nematode infestations.
  - Overuse of chemical inputs negatively impacts soil biology and structure.
- **Assumed Causes:**
  - Economic pressure to maximise short-term productivity over long-term soil health.
  - Lack of accessible education or support on sustainable soil practices.
  - Insufficient adoption of practices like cover cropping or organic amendments.
- **Questions to Validate:**
  - What challenges do you face in maintaining healthy soil while managing nematodes?

- How do your farming practices impact nematode prevalence?
- What tools or advice would help you improve soil health and reduce nematode risks?

Collaboration and Knowledge Sharing

- **Challenges:**
  - Limited platforms for growers to share experiences or learn from peers.
  - Weak communication between growers, researchers, and policymakers.
  - Research findings often fail to translate into actionable solutions for growers.
- **Assumed Causes:**
  - Fragmented stakeholder networks with inconsistent engagement opportunities.
  - Research priorities are sometimes misaligned with grower needs.
  - Lack of centralised systems to disseminate knowledge effectively.
- **Questions to Validate:**
  - How do you currently access information or support for nematode management?
  - What could improve collaboration between growers, researchers, and other stakeholders?
  - How can research findings be made more actionable for your farm?

2. *Facilitation of a workshop with active engagement and representation from vegetable industry stakeholders.*

A series of Workshop-webinars were facilitated by IIG that yielded results as per Appendix C. An analysis of the outputs from these webinars yielded the insights as detailed in Appendix F.

The analyses across the 3 workshop-webinar cohorts of vegetable industry stakeholders show:

1. RESEARCHER Insights Analysis:

The analysis reveals that nematode issues often go unnoticed until significant crop damage occurs, mainly due to reactive rather than proactive detection methods. Many growers detect problems only at harvest or after noticeable yield loss, despite early nematode activity. Economic thresholds for action vary by crop, with decisions influenced by the cost-benefit of management and crop sensitivity. Diagnostic methods include visual inspections, traditional morphological identification, and molecular techniques; however, these are often applied too late. Early, integrated diagnostics and routine soil sampling are needed. Current management strategies, such as fumigation, chemical controls, and crop rotations, show variable effectiveness, with many relying on short-term fixes rather than sustainable solutions. The responses highlight challenges in accurate species identification, sampling issues, and a lack of extension services.

Ultimately, a shift toward early detection, improved diagnostics, integrated management practices, and enhanced grower education is seen as essential for sustainable nematode management in vegetable production.

2. SUPPLY-CHAIN Insights Analysis:

Effective nematode management requires a combination of diagnostics, education, research, and integrated management strategies. Current challenges include limited expertise, high treatment costs, regulatory barriers, and reliance on chemicals. While tools like crop rotation, fumigation, and biological controls exist, their effectiveness varies due to misapplication and lack of industry adoption. A multi-faceted approach, including better training, regulatory support for biological controls, and data-driven IPM strategies, is essential for long-term success.

3. GROWER Insights Analysis:

The analysis highlights that nematode issues often become evident only when crops are stressed—typically late in the season—and that current detection methods (visual inspections, soil tests, and molecular diagnostics) tend to identify problems after significant damage has occurred. Management decisions are largely influenced by historical issues, prompting pre-emptive measures in affected fields, though many interventions remain reactive. Existing control tools, such as fumigation and resistant cultivars, offer short-term relief but face challenges like environmental harm and limited

availability (especially for brassicas). Overall, there is a pressing need for improved early detection methods, enhanced grower education, and the development of sustainable, targeted treatment options to better manage nematode impacts in crop production.

In summary, while there is broad agreement on the need for earlier detection, integrated management, and industry-wide education, differences remain in how and when growers act, the effectiveness of available treatments, and the role of biological versus chemical solutions.

3. *Identification of critical challenges and priorities for R&D investment in nematode management.*

From the analysis of the extensive stakeholder feedback and insights, which were developed from the desktop research and then curated to validate and understand contemporary industry needs, the following areas were identified as the critical challenges:

1. **Diagnosis & Early Detection**
    - Visual assessments, soil testing, and DNA sampling are commonly used although often detect nematode issues too late.
    - Diagnostic expertise is essential, but accessibility and turnaround time pose challenges.
    - An integrated approach (molecular testing + visual + soil sampling) is seen as necessary for early and accurate detection.
2. **Challenges in Management & Decision-Making**
    - Limited chemical options, loss of older products, and high treatment costs hinder effective management.
    - Growers often rely on historical issues to make pre-season, preventative decisions, but many react too late.
    - Economic thresholds vary by crop, with some growers intervening only after significant damage occurs.
3. **Management Strategies & Effectiveness**
    - Crop rotation, soil fumigation, and chemical nematicides are widely used, but effectiveness varies.
    - Newer biological options exist but are underutilised due to the limited availability of research outcomes, and regulatory barriers.
    - Integrated Pest Management (IPM) combining chemical, biological, and agronomic strategies is widely seen as the best approach.
4. **Limitations of Current Treatments**
    - Treatments are ineffective if misapplied, used in isolation, or not supported by proper irrigation and soil conditions.
    - The high cost of effective nematicides limits accessibility.
    - There is a lack of trust and awareness around biological solutions, slowing adoption.
    - If preventative measures are not completed pre-planting, once nematodes are detected it is often too late to react due to the scale of the issue and lack of available mid-crop treatments.
5. **Gaps & Areas for Improvement**
    - Education and training on best practices are widely needed across different crop segments.
    - More research is required on biological control options and their effectiveness in local conditions.
    - Regulatory reforms are necessary to facilitate newer, environmentally friendly solutions.
    - Stronger adoption of IPM strategies to reduce reliance on chemical treatments alone.
6. **Desired Outcomes & Future Improvements**
    - Comprehensive education programs tailored to specific crops.
    - IPM programs that integrate chemical, biological, and cultural strategies.
    - Data-driven guidelines to help growers implement the most effective nematode control methods.
    - Regulatory support to accelerate the adoption of new biological control agents and alternative management tools.

Contrasting Insights from stakeholder feedback

1. **Timing of Problem Detection**
    - Some responses emphasise early detection during the juvenile stages, while others indicate that issues become apparent only at harvest or mid-season.
    - Some growers proactively test pre-season, while others rely on visual cues, leading to delayed interventions.
2. **Thresholds for Action**
    - Some growers intervene at the first sign of an issue, especially in crops where cosmetic damage affects marketability.
    - Others only act when economic thresholds (e.g., 20% yield loss) are exceeded, delaying treatment.
3. **Effectiveness of Current Treatments**
    - Some responses highlight short-term effectiveness of fumigation and nematicides, while others emphasise their long-term unsustainability and environmental impact.
    - Certain respondents believe newer biological treatments show promise, while others remain sceptical due to inconsistent results.
4. **Regulatory & Research Priorities**
    - Some advocate for fast-tracking biological control approvals, while others stress the need for better diagnostics and chemical solutions.
    - Some view IPM as the key solution, while others feel that without better chemical options, management will remain ineffective.

In summary, while there was broad agreement on the need for **earlier detection, integrated management, and industry-wide education**, differences remain in **how and when growers act, the effectiveness of available treatments, and the role of biological versus chemical solutions**.

4. Preparation of a succinct report outlining clear investment direction based on industry priorities.

The following outlines the strategic investment arising from the project. A standalone version of the material below will be prepared for submission with the final version of this report (due 26th June). (The prioritisation of investment was being executed by AUSVEG at the time of preparation of this final draft.). It is envisaged that the document will include a summary of the information contained in this report, regarding the context and approach, and then be reviewed by HIA for desktop design and publishing to deliver a valuable resource for the sector.

Draft Strategic Plan for Nematode Management

Vision: Increased grower profitability through innovative, science-driven, and sustainable nematode management solutions through targeted research, technology development, and industry collaboration.

Strategic Investment Objectives (numbering for referencing only, not prioritised):

1. Education & Adoption Support

Priorities:

- Undertake technical and impact review of nematode related R&D in progress and identify existing initiative that need additional resources for impact, in-line with this strategy.
- Review and scale effective management methods to others.
- Develop and facilitate a ‘community of practice’ as resource to manage and use the broad knowledge and variability of the nematode challenges.

Key Outcomes:

- Increase value of previous R&D investment
- Faster impact for more growers
- Ongoing insights for more effective management of nematodes and R&D investment strategy.

2. Advanced Diagnostics & Early Detection

Priorities:

- Develop rapid, cost-effective field diagnostic tools (e.g., biosensors, AI-powered image analysis, portable DNA testing).
- Improve molecular diagnostics to differentiate between active and inactive nematode populations.
- Standardise soil sampling and testing methodologies for consistent, early detection.
- Investigate remote sensing and spectral imaging for large-scale nematode detection.

Key Outcomes:

- Faster and more precise nematode identification.
- Field-ready, grower-accessible diagnostic kits.
- AI-assisted, data-driven detection models.

3. Nematode Lifecycle & Population Dynamics

Priorities:

- Study the full lifecycle of key nematode species under different environmental and agronomic conditions.
- Identify environmental stressors that trigger nematode outbreaks.
- Develop predictive models for nematode population dynamics based on climate and soil conditions.
- Characterise population dynamics with economic thresholds for risk-based decision support.

Key Outcomes:

- Clear intervention points for more effective management strategies
- Data-driven forecasting for proactive nematode control.
- Improved decision making and reduced reliance on reactive treatments.

4. Development of Biological & Non-Chemical Control Solutions

Priorities:

- Investigate biocontrol agents (e.g., nematophagous fungi, bacteria, predatory nematodes).
- Explore plant-based nematicides and natural metabolites as alternatives to synthetic chemicals.
- Assess the effectiveness of soil microbiome manipulation in reducing nematode populations.
- Develop bio-stimulants that enhance plant resistance against nematodes.

Key Outcomes:

- Viable biological control products tailored for specific crops and nematodes.
- Environmentally friendly alternatives to fumigation and synthetic nematicides.
- Regulatory approval pathways for new biological solutions.

5. Integrated Pest Management (IPM)

Priorities:

- Optimise crop rotation strategies for different nematode species.
- Investigate soil amendments (e.g., biochar, compost, cover crops) for nematode suppression.
- Evaluate intercropping and companion planting methods that deter nematode infestations.
- Improve irrigation and nutrient management practices to enhance plant tolerance to nematodes.

Key Outcomes:

- Improved IPM models integrating multiple control strategies.
- Sustainable, cost-effective solutions accessible to growers.
- Reduced environmental impact from nematode management practices.

6. Precision Agriculture & Digital Solutions

Priorities:

- Develop AI-driven decision-support tools for nematode risk assessment.
- Integrate nematode data into digital farm management platforms.
- Explore automated soil sampling and testing methods using robotics.

Key Outcomes:

- Precision nematode management through real-time data analysis.
- More efficient and scalable monitoring solutions.
- Increased grower adoption of digital tools for proactive decision-making.

7. Regulatory & Policy Support for New Solutions

Research Priorities:

- Conduct trials to generate efficacy data for new biological and chemical products.
- Work with regulatory agencies to streamline approval processes for new nematicides.
- Assess the economic impact of nematode infestations to justify R&D investments.

Key Outcomes:

- Faster approval of innovative nematode control products.
- Stronger policy support for sustainable nematode management.
- Increased funding for nematology research and extension programs.

Conceptual Implementation Timeline (to be confirmed):

Phase	Key R&D Actions	Timeframe
Phase 1: Education & Adoption Support	Build on existing knowledge, investment and practice to scale impact	Ongoing (from Year 1)
Phase 2: Diagnostics & Detection	Develop and validate rapid diagnostic tools, initiate AI-based detection research.	1-3 years

Phase	Key R&D Actions	Timeframe
Phase 3: Lifecycle & IPM Studies	Conduct nematode lifecycle studies, optimise crop rotation and cultural controls.	2-4 years
Phase 4: Biological Control & Alternative Treatments	Develop and trial biocontrol agents, plant-based nematicides, and soil microbiome solutions.	3-6 years
Phase 5: Precision Agriculture & Digital Tools	Integrate AI-driven decision tools and automation into nematode management.	4-7 years
Phase 6: Regulatory & Policy Support	Collaborate with industry and regulators to fast-track approval for new solutions.	Ongoing (from Year 2)

Key Success Indicators:

- ✓ Commercial availability of rapid, field-ready nematode diagnostics.
- ✓ Increased adoption of biological and non-chemical nematode control solutions.
- ✓ Improved grower decision-making through predictive models and AI tools.
- ✓ Regulatory approvals for novel nematicides and biocontrol agents.
- ✓ Industry-wide adoption of precision nematode management practices.

This plan provides a structured pathway, informed by extensive stakeholder insight, to transition nematode management from reactive chemical-based approaches to proactive, sustainable, and technology-driven solutions.

Outputs

A summary of the project's outputs is included in Table 3 below.

Table 3. Output summary

Output	Description	Detail
Detailed Challenge Characterisation	A desktop review to characterise the challenge from the growers experience that informed the development of project tools	Conducted a comprehensive desktop review of relevant project documents and previous projects to inform workshop design and ensure alignment with HIA strategic objectives. This involved collecting and reviewing existing project documentation and research, reviewing previous projects and related work (e.g., PW17001, PW22000-1, MT22012, VG23007), and analysing past and current nematode management strategies and challenges.
Stakeholder Engagement Plan	Collaborate with AUSVEG to design and implement a stakeholder engagement and communications plan for online workshop-webinars. The goal is to involve all relevant stakeholders and value their perspectives throughout the project.	A desktop review and consultations with AUSVEG identified the need to engage with growers, supply-chain stakeholders (including industry, extension officers and agronomists) and researchers relevant to Nematode Management Practices. Identification of 3 cohorts to engage with and develop further understanding A Stakeholder and Communication Plan is provided as Appendix B.
Strategic Plan for Nematode	Preparation of a succinct report outlining clear	Compile and analyse workshop findings into a comprehensive report outlining key priorities, strategies, and pathways to

Output	Description	Detail
Management	investment direction based on industry priorities	greater ROI. This involves examining data and feedback to identify common themes and consensus areas. Guided by ISO Management Standards and program theory, the goal is to extract insights that will inform HIA's investment decisions, strategic planning, and future initiatives in nematode management. Present the final report and findings to HIA, clearly articulating the priorities and strategies to maximise ROI in HIA's investment in nematode management. Formally submit a concise final report for consideration, action, and impact. Deliver the presentation to HIA, including industry priorities and investment mobilisation and allocation recommendations

Outcomes

A summary of the project's outcomes is included below in Table 4:

Table 4. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
Engaged Industry	Focused on the grower experience not research interest, a needs analysis that incorporates strong extension focus. Increased trust in the strategy and ability to invest confidently	As described in Appendices A through D	Workshop-webinar outputs (eg. participant feedback) that were analysed to generate a survey for strategy prioritisation

Recommendations

The final strategy document will provide recommendations.

Intellectual property

'No project IP or commercialisation to report'.

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Appendix A: Overview of Methodology

Phase	Sprint	Purpose	Key Activities
Phase 1: Initiation and Planning	**Sprint 1: Kick-off Meeting**	Establish clear alignment with HIA's goals and expectations: Align HIA and project stakeholders on objectives, approach, and expected outcomes. Establish a shared understanding of project scope, timeline, and responsibilities. Finalise project communication and M&E plan.	➢ Start-up meeting with HIA, Impact Innovation and AUSVEG. ➢ Finalise communication and M&E plan. ➢ Finalise contracts. ➢ Define the purpose of the project's final report and its intended users.
	Sprint 2: Desktop Review	Conduct a comprehensive desktop review of relevant project documents and previous projects to inform workshop design and ensure alignment with HIA strategic objectives.	➢ Collect and review existing project documentation and research. ➢ Review previous projects and related work (e.g., PW17001, PW22000-1, MT22012, VG23007). ➢ Analyse past and current nematode management strategies and challenges.
Phase 2: Engagement and Execution	**Sprint 3: Engagement Plan**	Collaborate with AUSVEG to design and implement a stakeholder engagement and communications plan for online and in-person workshops, ensuring diverse representation and proactive promotion. The goal is to involve all relevant stakeholders and value their perspectives throughout the project.	➢ Develop a stakeholder engagement and communication plan with AUSVEG. ➢ Review previous engagement activities and documentation (if any). ➢ Finalise communication strategy and participant recruitment. ➢ Identify and support HIA to prioritise key stakeholders.
	Sprint 4: Online Workshops	Design and facilitate four 1-hour online workshops to gather insights from various stakeholder groups on nematode management challenges. These workshops will set the stage for the in-person session. The online format is chosen to encourage participation, especially from growers with travel constraints, ensuring their input. Discussions and insights will be facilitated using the interactive tool Mentimeter.	➢ Plan and prepare for four targeted online workshops, segmented as follows - Nematology Researchers, Agronomists and Extension Officers, Vegetable Growers & AgChem Companies, Input Suppliers and other key value chain players ➢ Facilitate each workshop and ensure active participation (Total Engaged = >80). ➢ Analyse and identify initial themes on current challenges and issues. ➢ Prepare a milestone report following publication guidelines.
	Sprint 5: Workshop (updated to include survey)	Design and conduct an workshop with key industry representatives from the vegetable sector to prioritise investment areas in nematode management. This session will validate and prioritise insights from the online workshops, guiding HIA's investment allocation for maximum impact.	➢ Design and prepare materials for the survey and workshop based on initial insights from ➢ Facilitate the workshop, ensuring active participation. ➢ Analyse workshop findings to refine priorities in nematode management.
	Sprint 6: First Draft Report	Compile and analyse workshop findings into a comprehensive draft report outlining key priorities, strategies, and pathways to greater ROI. This involves examining data and feedback to identify common themes and consensus areas. Guided by ISO Management Standards and program theory, the goal is to extract insights that will inform HIA's investment decisions, strategic planning, and future initiatives in nematode management.	➢ Analyse and identify key insights/themes from the online and in-person workshops. ➢ Utilise Theory of Change framework, to pinpoint investment areas to achieve high impact. ➢ Draft the report, integrating workshop insights. ➢ Highlight initial findings to inform investment and resource mobilisation, guided by ISO Innovation Management Standards. ➢ Submit the draft report to HIA for feedback.
Phase 3: Review and Finalisation	**Sprint 7: Finalisation of Report**	Finalise the report, incorporating feedback and ensuring alignment with project objectives and ISO standards. Thoroughly review, refine, and finalise the report to meet HIA's quality assurance standards and fulfil this RFP's objectives and goals.	➢ Review, address, and integrate feedback from HIA. ➢ Finalise the report, ensuring quality and alignment.
	Sprint 8: Presentation & Submission	Present the final report and findings to HIA, clearly articulating the priorities and strategies to maximise ROI in HIA's investment in nematode management. Formally submit a concise final report for consideration, action, and impact.	➢ Prepare the presentation materials. ➢ Deliver the presentation to HIA, including industry priorities and investment mobilisation and allocation recommendations. ➢ Submit the final report to HIA, adhering to publication guidelines.

Appendix B: Stakeholder and Communication Plan

The below activities were identified for the purposes of the Nematode Project Review for effective consultation of the HIA nematode network to inform future strategy.

Section 1: Pre-Webinar Preparation

Activity	Key Messages / Purpose	Frequency	Responsibility	Audience	Output
Webinars Participant List Target	Identify target participants	One-off	AusVEG	Researchers, Growers, Agronomists, Extension Officers & Supply Chain Partners	Finalised list of participants
Prioritisation Workshop Target List	Identify attendees for the prioritisation workshop	One-off	AusVEG	Up to 25 key industry representatives	Finalised list of participants
Engagement Channels	Define channels for outreach	One-off	AusVEG	Various stakeholders	List of channels (email via AusVEG CRM, social media, AusVEG newsletters)
Webinar 1: Eventbrite Set-Up	Create registration & reminders	One-off	IIG	Researchers	Eventbrite page, automated reminder emails
Webinar 2: Eventbrite Set-Up		One-off	IIG	Agronomists, Extension Officers & Supply Chain Partner (i.e. AgChem Companies, Input Suppliers, & Key Value Chain Players)	Eventbrite page, automated reminder emails
Webinar 3: Eventbrite Set-Up		One-off	IIG	Vegetable Growers	Eventbrite page, automated reminder emails
Prioritisation Workshop:		One-off	IIG	AUSVEG Nominated key industry representatives	Eventbrite page, automated reminder emails
Set Up Eventbrite Reminder Schedule	Configure automated reminders (14, 7 days & 2 day prior)	One-off	IIG	All webinar and workshop attendees	Confirm reminders are set up
Webinar 1 Invitations		3 Reminders	IIG (Draft), AusVEG (Release)	Researchers	Email Invitations, Eventbrite link

Activity	Key Messages / Purpose	Frequency	Responsibility	Audience	Output
Webinar 2 Invitations		One-off	IIG (Draft), AusVEG (Release)	Agronomists, Extension Officers & Supply Chain Partner (i.e. AgChem Companies, Input Suppliers, & Key Value Chain Players)	Email Invitations, Eventbrite link
Webinar 3 Invitations		One-off	IIG (Draft), AusVEG (Release)	Vegetable Growers	Email Invitations, Eventbrite link
Social Media & Newsletter Announcements	Promote webinars on social media and newsletter	One-off	AusVEG	Broader audience	Scheduled social media posts and AusVEG newsletter.
Prioritisation Workshop Invitations	Formal invitations to the targeted list (individuals with influence and experience)	One-off	IIG (Draft), AusVEG (Release)	Up to 25 key industry representatives	Email Invitations, Calendar invites

Section 2: Webinar & Workshop Execution

Activity	Key Messages / Purpose	Frequency	Responsibility	Audience	Output
Webinar 1 Consultation	Engage researchers	One-off	IIG	Researchers	Webinar Recording, Feedback Survey
Webinar 2 Consultation	Agronomists, Extension Officers & Supply Chain Partner (i.e. AgChem Companies, Input Suppliers, & Key Value Chain Players)	One-off	IIG	Agronomists, Extension Officers & Supply Chain Partner (i.e. AgChem Companies, Input Suppliers, & Key Value Chain Players)	Webinar Recording, Feedback Survey
Webinar 3 Consultation	Vegetable Growers	One-off	IIG	Vegetable Growers	Webinar Recording, Feedback Survey
Pre-Workshop Reminder Email	Final reminder for the prioritisation workshop	One-off	IIG	Up to 25 key industry representatives	Reminder Email & Calendar Notification
Prioritisation Workshop (Location TBC)	Prioritise nematode management strategies	One-off	IIG, AusVEG	Up to 25 key industry representatives	Workshop Summary Report

Activity	Key Messages / Purpose	Frequency	Responsibility	Audience	Output
Post-Event Thank You & Feedback Survey	Gather post-event feedback	One-off	IIG	All webinar and workshop attendees	Thank you email, Feedback Survey

Key Messages Overall

The following key messages have been developed to ensure consistent communication for the **Hort Innovation Australia (HIA)-led Nematode Management Project**. These messages aim to guide all stakeholder engagements, including emails, social media, and press releases:

1. **Shaping the Future of Nematode Management**:
   The project aims to establish a clear pathway for the future of nematode management in the vegetable sector by leveraging industry expertise and gathering critical stakeholder insights to drive effective solutions.
2. **Addressing Regional and Sector-Specific Challenges**:
   By understanding the region-specific complexities of nematode control, the project focuses on developing biosecurity-driven solutions that are adaptable to local agricultural practices.
3. **Driving Industry-Led, Actionable Recommendations**:
   Through broad stakeholder engagement, the project will deliver actionable recommendations that guide future R&D investments by HIA, ensuring alignment with industry needs and practical implementation.
4. **Prioritising Pathways to Impact and Adoption**:
   The project emphasises creating clear pathways to impact, focusing on the adoption of funded investments by identifying barriers and enablers. Understanding the challenges to adoption will ensure that solutions are both effective and scalable within the industry.
5. **Enhancing Industry Resilience and Sustainability**:
   Outcomes will prioritise innovative R&D strategies that strengthen the long-term resilience, profitability, and sustainability of vegetable production, with a focus on practical, adoptable solutions that stakeholders can readily implement.
6. **Addressing Challenges to Adoption**:
   A key focus of the project is to identify the barriers to the adoption of new technologies and management strategies. By understanding these challenges, the project aims to develop solutions that facilitate greater uptake of innovations, ensuring long-term success.

Segmented Short-Form Communications

These short-form communications can be used to address questions from stakeholders after the webinars or during follow-up engagements.

1. **Researchers**
   - **Key Message**: "The project focuses on identifying research gaps in nematode management to drive future innovations in sustainable control measures."
   - **Response Examples**:
     i. "Our aim is to prioritise research areas where technological advancements can have the most impact, addressing challenges such as resistant nematode strains and sustainable biosecurity practices."
     ii. "Your insights on current research gaps will directly influence HIA's future R&D investments in nematode management."
2. **Vegetable Growers**
   - **Key Message:** "We are addressing practical challenges faced by growers to improve on-ground nematode management strategies and enhance crop profitability."
   - **Response Examples:**
     i. "This project seeks to develop actionable recommendations that align with the needs of vegetable growers, focusing on practical solutions that enhance productivity and biosecurity."
     ii. "Your feedback on effective management practices will help shape sustainable, region-specific strategies for the vegetable sector."
3. **Agronomists, Extension Officers & Supply Chain Partners**
   - **Key Message:** "We are fostering collaboration to improve the adoption of effective nematode management practices and explore innovation opportunities."
   - **Response Examples:**
     i. "We value your expertise and input to ensure that research findings and technologies are effectively adopted and meet growers' needs."
     ii. "Your insights will guide the development of impactful, regionally adapted solutions and innovative products for sustainable nematode management."

Appendix C: Workshop-Webinars Mentimeter Results

Webinar 1: Share Your Insights – Shaping Research Priorities for Nematode Management (Researchers)

Question	Answers
Based on your understanding, when are problems with nematodes experienced?	• Continuous cropping • When it is too late • When looking at harvest products • Monocropping • Warmer months. Times of environmental stress. • When you start experiencing crop loss • Poor chemical application practices • Long after the nematodes have actually arrived. After the loss starts gett5 significant. After other possibilities have been exhausted. • Continuous cropping of same host • Generally too late after making damage • Too late in veg" • "Growers only see the problem once it's manifested at the harvest stage • Whereas the problem initiates at the commencement of reproductive phase in crop at juvenile stage • Continuous cropping advances" • Lack of chemistry rotations • Any time in a crop • In any time of the year • If susceptible crops are planted as rotation crop
Based on your understanding, how big does the problem need to be for action to be taken?	• Obvious yield loss • I guess every grower will have a threshold of crop loss that is acceptable • when it is affecting 20% or more yield loss • When nematodes are above the economic damage threshold • Obvious damage, symptoms • When loss exceeds the economic threshold • Growers of many crops don't know the extent of losses • Highly variable. • Host range information

Question	Answers
	• Very dependant on cost of managment options! Veg vey low threshold to fumigate • All depends upon the crop sensitivity, the species infecting & the crop value or cosmetic tolerance of harvested crop • Live vs Total • Depends on the cropping system and the nematode. There is no simple answer. There are specific crop / nematode relations so knowledge of the system and additional soil constraints is required. • When nematode numbers reaches economic threshold levels • Regular management loosing effectiveness • Some growers proactive • Regular maintinance via diagnostics • Incognita is one of the most damaging, whereas Hapla is not as severe • Molecular and morphological
What tools or diagnostic methods are effective for identifying a nematode issue?	• Morphological • I think we are back to the economics • Predicta B? • Whitehead tray • Traditional extraction, morphological ID. Species specific PCR for RKN • Root symptoms • Measure extent of yield loss • Traditional expertise • Host range information • Integrative morphological and molecular approaches • Morph to genus - viable counts • "Visual • Bio assay Sardi SA Graham Stirling • This comes down to which nematode you are dealing with. Firstly are nematodes a problems then which genera and then species, Cost increases as you get more specific. • DNA testing • Bioassay • Morphology • Species ID as extra info, biosecurity etc • Root health checks

Question	Answers
	• Species-specific PCR • Morphology plus DNA • Sequence data • when growers notice an issue
When is a decision to address the issue of nematodes made?	• Pre sow • I think we are back to economics • before next planting • Ideally pre-plant, otherwise too late • It depends on the population in the soil and sex as most male nematodes don't feed • When have clear indication of impact • Should be pre-planting • Immediately after detection • Pre-plant, months in advance • "Depends upon the methodology used • When it's a visual assessment- at post harvest • When it diagnostic - when results viewed pre plant" • Ideally as a prophylactic vs curative • Depends what can be done. Preventing the problem is better than treating it. Crop rotations are effective if identified early. Growers tend to be cautious and will take the easiest options. • Based on the nematode number per plant • Data of abundance linking with yield • Pre plant of crop • crop rotation • It could be a short or strategic plan after detection • Yes, pre plat trees or crop • For Tomato Capsicum for example with Incognita Javanica sp - then must be done the season before upon crop rotation and diagnostic results • When residual activity of nematicide is an issue
What are the biggest challenges in identifying the presence and impact of	• Mix of pathogens present • Generic symptoms in crops • Grower willingness to provide samples

Question	Answers
nematodes in crops?	• Representative sampling • Sampling methods and preservation • Time required to conduct on ground trials on yield loss • Diagnostics that cover and work for many nematodes • complex nematode communities • Quantifying the potential impact on a crop • "Challenges are being proactive • Using crop rotations • Knowing lifecycle • Knowing target sp • Knowing how to correctly sample • Knowing role of host moisture and soil temp" • Biological vs chemical nematicides • "1. Getting growers to recognise they have a problem • 2. getting a sample of soil / root material" • Because of the soil borne pathogen, nematode symptoms are not obvious • Linking numbers with yield loss • Detection at low levels if crop has a low threshold • Sampling • Advice for cropping options after diagnosis • Nematicides and resistant cultivars • Growers being proactve and monitoring • Getting recognition of problems • Proactive routine testing
Which resources or tools are used most to manage nematodes in crops?	• Fumigation • resistant cultivars • nematicides • Resistant rotations, bare fallows, chemical nematicides • Biological control • Resistant cultivars • education

Question	Answers
	• chemical control • Fumigation • Everything is being used - it depends upon whether growers / suppliers know the BMP • Life cycle and susceptibility to control • "Prevention - rotations • Protection - soil health, chemicals, biological, amendments • Resistance • Inoculum reduction - growing non-hosts" • Integrated nematode management strategy • Fumigation • Crop rotation • Crop rotation • Antagonists • Rotations • resourcing and capacity in diagnostic labs • microbiome management • Known resistance/tolerance • More efforts need to be generated toward bio control options and easier pathway to registration of these • Crop rotation • Managements for other diseases • bare fallow • Integrated control • Rotation if significant issue related to other diseases though • Nematicides • organic amendments • Organic amendments & observations of free living nematodes • Bare fallow • biological fumigants
How effective are the treatment options currently	• Chemical use not sustainable • Depends on the particular nematode • Crop rotations can be effective if utilised correctly

Question	Answers
available to the sector?	• Variable. IPM successful if properly implemented • Not very effective due to mode of application not reaching the target • Variable. Good through to poor. • Variable and the variability is the problem • Maybe this relies on knowing what nematodes are present, crops grown, practices used by grower • no consistency in results • Occasional expensive failures of fumigation • "All options are effective on known antagonists - they just need to be used in a BMP program • Rotations • Crop selectivity • MOA rotation of chemistry • Biofumigation" • Soil microbiome suffering with chemical control options • "Depends on the treatment and how it is applied • Rotations - good • Chemical reducing effectiveness • Amendments -50% • Biological can be good • many soil factors contribute to efficacy" • In most cases nematicides are effective in lighter soil and less effective in heavier soil • Capacity in ECR • Depends on the crop • Sweetpotato challenging as a very long crop cycle • Chemical options generally not • Prolonged understanding of sites through monitoring has been the best • I have had much success in Solanaceous crops and Sweet potatoes • Sensitivity to applications at different growth stages? • Biological control in the field. • E.g. Sweetpotato can only use nematicides early in crop. And have a low threshold for damage • Soil biology can work well but variable and we don't know why • Environmental impacts a concern

Question	Answers
What treatments do you consider to be ineffective and what could be improved?	• Cost benefits • Some biological control products • Some biological/snake oil products • The use of wrong products not meant for nematode control • Better education of some growers on application procedures etc • Chemical because don't get to the nematodes if not applied right • cost/benefit • Deep understanding of soil biodiversity and plant-soil microbiome improve the efficacy of management strategies. • Incorrect identification of pathogen • Organophosphates & Carbamates • There are broad categories of treatments. They need to be applied in specific context to the grower / crop / nematode solution. Problem is unrealistic claims and silver bullet solutions. • If heavy soil, nematicides are not much effective • Bare fallow for some species of nematodes • • Rotation mixes can be problematic if some components are nematode susceptible • We can improve nematode control by relying on trap croos • Biologicals need to be tested rigorously • non-accurate identification of nematodes and nematode diseases • "Using an integrated approach in Sweet potatoes has been effective in lowering Incognita Javanica damages in sweet potato Methane sodium Fluensulfone Etc Biofumigation Identification Diagnostics"
What are the biggest challenges preventing effective management of nematodes?	• Knowledge • Correct species identification • Soil testing. Unsure why majority of growers are not routinely getting their soil tested. Cost? • Getting growers to monitor. Representative sampling • Wrong identification • Growers not fully understanding the extent of the problem and having data on effectiveness of options • Correct identification of the nematodes causing the problems • cost-benefit • Correct identification of nematodes • Apvma log-jam of approving new actives

Question	Answers
	• Reluctance to change grower standard practice • "1. Recognising nematodes as a problem • 2. Species identification • 3. Mixed species • 4. over reliance on chemical solutions • 5. Carry over from previous crop • 6. Continuous cropping" • Lack of resistant cultivars • Grower apathy • Knowledge sharing between companies • Diagnostics too expensive • demo sites on farms • "Correct identification and knowledge of correct sampling • Know the target - know the lifecycle - know the management control" • Turnaround time of test results • Using AI tools for diagnosis and resistance breeding program • Grower misunderstanding of issues • State specific nematode testing facilities (bioassay vs PCR)
What, if anything, is NOT happening with respect to nematode management in general that SHOULD be happening?	• Nematodes ignored by many industries. General surveys needed to understand what species are where and on what crops. • Widespread adoption of monitoring • Constant monitoring • We need to improve identification and link the nematodes to the solutions • Demonstrations on farm of management options • novel bioproducts, fertilizers effects on nematodes, biofumigants, high-tech molecular techniques • Proactive diagnostics, before planning managment strategies • BMP training in specific regions for specific crops to correctly sample • Local testing services with bioassay vs PCR • "1. In-field rapid species diagnostics • 2. Grower centric solutions • 3. Available management solution post planting that do not rely on chemical treating. • 3. New generation solutions e.g. RNAi

Question	Answers
	• 4. Microbi" • Understanding of local conditions and other biolgical pressures • I think we need to look into virus vector nematodes - we have not evaluated established exotics for viruses nor have we evaluated native nematodes of the right groups for endemic plant viruses • Soil testing • Sampling better • Improving soil health • Trap crops • If the lifecycle of target known then the sampling can be targeted correctly • Harmonised sampling methodologies • Nematode identification • Correct training of all levels of supply chain for demonstration of BMP • Non-chemical control options - time for approvals (APVMA)
Do you know of any treatments or practices that the industry is NOT using or adopting, and if so, can you provide any insights into why?	• Long term approaches • Soil testing. Unsure why growers are not submitting their soils for testing. Cost? • The use of trap crops is not being used because there are very few nematologists to provide extension inputs • Antagonists to pests, including other nematodes • economic benefits of management options • Long-term but sustainable strategies are not used generally • Trap crops, time/cost in planning & managment required • "Again knowledge of lifecycle needs more addressing • In sweet potatoes the guru Dr Graham Stirling was excellent • This needs reheating again for industry" • Quicktest for nematode presence • Growers do not realise that nematodes are the cause of problems. Often masked by adding addition inputs (fertiliser and water) or they prophylactic treatments used. • Application of nematicides,, Expensive and environmentally harmful • Companies protecting knowledge • Healthy soil biology --too variable results • Practices improving soil health • General soil health, monitoring free living nematodes. Results are erratic, not well understood

Question	Answers
	• Most of the cases we depends on ancient technology. need to use modern diagnostic and AI technology
With respect to nematodes, what are the big research questions that still need to be addressed for the sector?	• Better biological control • accurate diagnostics • Alternatives to nematicides as a control method • Reliable IPM strategies • More students needs to be trained at both undergraduate and postgraduate levels • What nematode species we have in Australia • Identification of whole community of nematodes including plant-parasitic and free-living nematodes • Species (non-RKN) that impact some veg & tree crops • "LIFECYCLE • SPECIES TRIGGERS • BMP ADOPTION • WORK ON CROP SPECIES SELECTION FOR BIOFUMIGATION • EASIER REGULATORY APPROVAL OF NEW ACTIVES" • Quicker testing of nematode activity (PCR cannot quantify live vs dead) • "Nematodes as constraints to production. • 1. Soil ecological relationships and how to improve general suppression through better cropping practices. • 2. Identifying OS nematode threats • 3. biological control • Interactions with other plant pathogens • Economic thresholds • On-farm biosecurity to avoid new pests, regular monitoring, improving IPM • Biological control • How much variability is there • accurate diagnostics • Regional risks • Taxonomy training • Improving grower awareness of nematode problems
Based on the challenges considered earlier, what are 2 or 3 of the greatest nematode	• Lack of crop Susceptibility info availability • accurate diagnostics

Question	Answers
challenges the vegetable sector faces from your perspective?	• Biosecurity incursions • Improving IPM, Regular monitoring, • Crop losses • Identifying nematodes causing issues • Inability to control a known problem because of lack of reserch knowlege on the pest-host combo • "Regulatory approvals of new actives • Correct species identification • Winning the economics battle vs nematode adaptability / chem resistance" • Effect of methyl isothiocyanate on soil microbiome • "1. Species ID • 2. Ecological nematode management for vegetable producers. • 3. Impact of nematodes with additional soil environmental constraints" • Susceptible rotation crops • Capacity in extension • Fear by growers that they will be shut down if exotic found • Poor quality and yeild loss • Soil health • over-reliance on chemicals • Use of wrong products • Improving diagnostics cheaper faster more accurate • Encoraging predatory nems • Regular survey • Capacity in ECR
What would be a realistic and highly satisfactory outcome for nematode management in the vegetable crops you work with?	• Improving yield but sustainably • Inventory of nematode species (with correct IDs) across region and crop type allowing for resistance crop selection • improved yield from growers affected by nematodes • Suppression of plant-parasitic nematodes though IPM - monitoring, rotations, improving soil health, judicious use of chemical nematicides • To develop a potent biological product capable to impacting both eggs and juveniles • Reduction of recognised losses by10 percent • reduced crop losses and affordable management

Question	Answers
	• Increasing crop yield and improving plant-soil health • "Monitoring, pre-plant & pre-management planning. • Improved yield • Increased knowledge of life cycle, free living etc" • "Industry training on all factors discussed today • BMP • SPECIES ID • ACTIVE EFFICACY • SOIL HEALTH • ECONOMICS" • Quick test easily adopted by growers • Monitoring / risk system that allows growers to be proactive to manage nematodes and reduce reliance on chemicals. • best management guides • Consider nematode management as havoc, similarly as other pests • Improved soil biodiversity • Slot less spent on treatments that won't work • interpretation of monitoring and diagnostics to inform management • Sustainable management, less reliance on residual chemical activity
If you could implement one practice or policy that would have the biggest impact, what would it be?	• Long term sustainable management • Regular soil/plant testing • Regular monitoring • Use of trap crops and monitoring • Accurate frequent monitoring • interpretation of monitoring and diagnostics to inform management • An ecological perspective for management • Monitoring & relationship to management options long/short term • TRAINING OF ALL LEVELS OF THE SUPPLY CHAIN FOR CORECT NEMATODE BMP • APVMA approval pipeline improved (slow approval process) • There is no simple single solution. It comes down to understanding the system and ecological nematode management. No simple solution. • Sustainable approach towards reducing nematode population

Question	Answers
	• Training • Localised testing services • Training nematologists

Webinar 2: Share Your Insights – Industry Perspectives on Nematode Management Strategies (Agronomists, Extension Officers & Supply Chain Partner)

Question	Answers
What tools or diagnostic methods are effective for identifying a nematode issue?	• Visual assessment of damage in previous crop, soil test • Soil sampling DNA from Sardi • soil test. visual, dpird • We rely on visual plant assessments, looking for stunting, galling, and poor root health. Since we grow in the same soil every year, pre-season soil sampling for nematodes is not necessary. • Sending soil samples for expert ID • Understanding symptoms of different species, and if yield reductions are occurring when visual damage may still be low. damage threshold information • Physical damage • we took soil 0-10 on affected field and before and soil was clear • Decisions are made as soon as symptoms appear. If nematodes were present in a field the previous year, preventative treatments are applied before symptoms arise. • Visual inspections
What are the biggest challenges in identifying the presence and impact of nematodes in crops?	• Diagnostics expertise • to kill them, to stop spreading and harvest losses • Turn around time for the result. Knowing who are the experts • Knowing lifecycle of the ID species to know what soil depth, what soil temperature & what soil moisture status • nematicides, metham sodium • Correctly known which species dealing with - Incognita Javanica Hapla Fallax
Which resources or tools are used most to manage	• Crop rotation • Need to use the whole toolbox

Question	Answers

nematodes in crops?	• Diagnostics
	• Correct chemistry
	• Correct placement of chemical actives where Nematodes are
	• no really, hard to measure
	• Soil fumigants are applied to every field we crop, but they are not enough. There are a few newer products, such as Salibro (Corteva) and Velum Prime (Bayer), but results are mixed.
	• Chemistry, soil fumigation, some rotation/green manure crops
	• Rotation, chemical options, green manure.
	• The whole effectiveness of strategies is governed by knowing what you have:
	  ○ ID
	  ○ sensitivity of target to actives
	  ○ species lifecycle
	  ○ synthestic fumigants
	  ○ bio fumigants
	  ○ ITC producing crops

How effective are the treatment options currently available to the sector?	• Effective if used according to label and irrigation management is sufficient • All comes down to knowing how to manage everything in the ideal method, frequency, timing & rates • Few products are available for controlling nematodes in carrots after planting. Soil fumigation helps but does not fully resolve the issue. Alternative treatments have inconsistent results. • Limited. Loss of certain older but effective products. • All have a place in a management strategy but cannot do the job on their own. It is an farming system wide approach. Chemistry, rotation, fumigants, resistant hybrids • Mixed results • Everything can work well or won't work at all if used wrongly • New products with restrictions or prices make them prohibitive
What treatments do you consider to be ineffective and what could be improved?	• If irrigation not meet product requirements • Every treatment will be ineffective is used incorrectly • response of high costly nematicides • The main limitation is the affordability and reliability of available treatments. More research is needed on sustainable, cost-effective solutions. • A lack of perception that biological offer protection, whether they do or not is another question

Question	Answers
	• Each can be ineffective when not used with other tools • Careless fumigation
What are the biggest challenges preventing effective management of nematodes?	• Lack of understanding the nematicides requirements for optimal results • all management strategies can be ineffective when not used correctly • Each crop segment needs training on what they all have in the “toolbox” and how they all are best used" • High costs of effective treatments and the lack of post-planting control options. (Carrots) • Registered nematocides • Lack of rotation. Limited chemical options. Cost • There is not just one simple way to fix the nematode issue on farm • Grower commitment • Crop rotation is not an option due to economic constraints. • A general reliance on using chemistry to fix the problem, not IPM
What, if anything, is NOT happening with respect to nematode management in general that SHOULD be happening?	• Just best agricultural practices like crop rotation, use of cover crops etc • "Each crop segment needs training on how to use all strategies in the Best Practice for each to work • Inc - synthetic chemistry , bio chemistry , diagnostics etc" • Increased focus on genetic resistance in hybrids • More thorough research of available biological control options either on the market or in development in Australian Field conditions and their comparability with chemical controls. Partnering industry • Multi-pronged strategy to take pressure of chemistry and potential resistance. Soil biology also takes a hammering from blanket fumigation
Do you know of any treatments or practices that the industry is NOT using or adopting, and if so, can you provide any insights into why?	• Cover top nit an issue due to year round production • rotation - pressure on using available land to crop and limited availability of land to rotate crops • There is a major issue in getting ITC or Non-host producing crops that are climatically suited to each major cropping segment • Use of newer chemistry with lower environmental impact • Regulatory position of Bio control options, they should be seen differently to synthetics and given a higher environmental profile • Crop rotation is not an option due to economic constraints. • Reliance on chemistry entirely • Lack of industry supported data on effectiveness of control options
What would be a realistic and highly satisfactory outcome for nematode management in	• education and training of good practices • Crop specific training of whole arsenal of management approach for each crop & the extension capacity to be able to deliver this timely

Question	Answers
the vegetable crops you work with?	• The ability to manage nematodes effectively and prevent economic losses in future seasons. • Good data and resources to show what pragmatic strategies can be done by growers • IPM programs, with yield data on programs of different control options including all options (chemical, rotation, cover crop). • Clear guideline of what growers should do to manage nematodes • More streamlined regulatory provision for Biological control agents that can be efficacious • If you could implement one practice or policy that would have the biggest impact, what would it be? • Crop rotation • education, training and demonstrations • "Delivery of extension in each crop segment for best management approach for all options • Encompass best of synthetic chemistry, best application conditions, best diagnostics, best genetics, etc" • If it exists, a quick test to risk assess paddocks ahead of cropping to guide management practices • Targeted nematicides like Velum in combination with biologics and resistant hybrids • IPM programs using compatible biological, chem and rotation control options for each crop • Biological control

Webinar 3: Share Your Insights – Addressing On-Ground Challenges in Nematode Management Strategies (Vegetable Growers)

Question	Answers
Based on your understanding, when are problems with nematodes experienced?	• Start of the season • Harvest • Sugar beet cyst nematodes in brassica crops. When crops are under stress usually salt related due to drought or poor quality water. • Later when galling occurs but management too late • Mid harvest in greenhouse env • Root knot hidden until symptoms occur
Based on your understanding, how big does the problem need to be for action to be taken?	• Minimise potential risk pre season when has been a previous issue in same soil/block • improved soil structure and soil management in advanced to planting • Soil testing needed at early stages • When the issue is identified it is usually too advanced and late. Regardless there are no registered products for brassicas

Question	Answers
What tools or diagnostic methods are effective for identifying a nematode issue?	• Soil tests • "Inspection of roots and seeing the cysts. • Send to laboratory for identification and determining numbers. • DNA test does distinguish whether alive or not" • Symptoms are often too late
When is a decision to address the issue of nematodes made?	• If previous history • When prevention is unavailable • When identified no options for controlling are available
What are the biggest challenges in identifying the presence and impact of nematodes in crops?	• "Knowing what types of nematodes are there • Knowing the symptoms associated with nematodes • Correct diagnosis" • Crop may be damaged before nematode is identified • Fallow crop like sorghum • "Usually identified after the crop is severely affected. • Need a field test kit" • Other symptoms mimicking nematode infection
Which resources or tools are used most to manage nematodes in crops?	• Fumigation but not targeted • "Research findings in nematode diseases • Soil testing" • Nematode resistant or tolerant cultivars • "Brassicas crops don’t have any effective control options. • Fumigation is almost being phased out and not considered a option" • Fumigation for weed and nematode control • Beet cyst no options
How effective are the treatment options currently available to the sector?	• Beet cyst no options • Effectiveness depends on nematodes types and products. • Chemical treatments are effective for the short term but is ineffective and environmentally harmful for long term treatment • "Fumigation is helpful. In reducing numbers • Sugar beet cyst nematodes return if the stress factors are still present • Need options"

Question	Answers
	• Lack of knowledge about nematodes lifecycle affects treatments • Stress factors are out of growers control but could be fixed with quality water ie no salt
What treatments do you consider to be ineffective and what could be improved?	• Every treatment can be ineffective if applied wrongly. We can improve upon that by knowing more about the lifecycle of the nematode and knowing the stage to apply • Require new products to be registered for brassica crops • Barriers to registered products in brassica crops. • Is there any effective cultural controls?
What are the biggest challenges preventing effective management of nematodes?	• Lack of expertise in nematology to provide extension services • Funding and identification tools
What, if anything, is NOT happening with respect to nematode management in general that SHOULD be happening?	• Frequent short courses to educate growers on the importance of nematodes • "The water quality suppled should be fit for purpose. • Registration of new products for other crops investigated for brassicas" • Nematology has been underestimated for long
Do you know of any treatments or practices that the industry is NOT using or adopting, and if so, can you provide any insights into why?	• Not well patronise • how nematode management impacts other production practices • Fumigation crops eg mustard crops are time consuming and not easy
What would be a realistic and highly satisfactory outcome for nematode management in the vegetable crops you work with?	• Provide incentives for short courses on management • implementing sustainable production that meets demand requirements • Cultural controls preventing the nematode. Early identification and a register product that can be used as a preventative or control
If you could implement one practice or policy that would have the biggest impact, what	• More education on nematology • Quality water eg free of Sodium

Question	Answers
would it be?	

Online Prioritisation Workshop: Shaping the Future: Industry-Led Prioritisation for Nematode Management

Results pending facilitation of workshop and analysis of insights.

Appendix D: Strategic Priorities Survey for Nematode Management

We are seeking your input to help us **prioritise** the focus on **industry needs** in the AusVeg-HIA led **nematode management strategy**. The approach will develop a more in-depth perspective on how best to apply learnings from previous workshops, and to define whether activities need to be focused on restructuring existing practices or whether further research is required to support industry nematode management practices.

As part of the review of **industry needs** for the **seven themes** identified and their associated **priorities** included below, please rate the importance, feasibility, viability and impact, along with contextual comment, of the theme priorities based on the questions stated at the start of Section 1.

Please enter your full name and title below: *

Full name	
Title	

Section 1: Detailed Evaluation of Industry Needs

Here we review the **seven themes** which include:

1. Advanced Diagnostics & Early Detection
2. Nematode Lifecycle & Population Dynamics
3. Development of Biological & Non-Chemical Control Solutions
4. Integrated Pest Management (IPM)
5. Precision Agriculture & Digital Solutions
6. Regulatory & Policy Support for New Solutions
7. Education & Adoption Support

For each of the themes, please respond to the questions for all of the identified industry/grower priorities in the table provided. Answer based on a scale of 1 (low) to 10 (high):

- **Importance:** How important (1-10) is this priority to you (and growers you know) in advancing effective nematode management practices
- **Feasibility:** If this identified priority becomes available as a recognised industry-leading solution to nematode management practices, would it be likely to integrate (1-10) well with your available processes, practices and/or infrastructure?
- **Impact:** What is the potential industry impact (1-10) if this approach in the management of nematodes was successfully addressed and adopted?
- **Comments:** Please provide context as to why you scored each of these 4 categories the way you did.

Theme 1: Advanced Diagnostics & Early Detection

The objectives of this theme are the development of faster and more accurate methods for identifying nematodes, including the creation of practical diagnostic kits that can be easily used by growers in the field. Additionally, advanced AI-assisted models will support data-driven detection, enabling more timely and informed management decisions.

Industry/Grower Priorities:
1.1 Develop rapid, cost-effective field diagnostic tools (e.g., biosensors, AI-powered image analysis, portable DNA testing).
1.2 Improve molecular diagnostics to differentiate between active and inactive nematode populations.
1.3 Standardise soil sampling and testing methodologies for consistent, early detection.
1.4 Investigate remote sensing and spectral imaging for large-scale nematode detection.

Taking into consideration each of the Theme 1 priorities above, enter a scale of 1 (low) to 10 (high) based on the questions stated at the start of Section 1:

Theme 2: Nematode Lifecycle & Population Dynamics

The objective of this theme is to deepen the understanding of nematode lifecycles and population dynamics to identify clear intervention points for more effective management. By developing data-driven forecasting tools, the goal is to support proactive nematode control and improve decision-making, ultimately reducing the need for reactive treatments.

Industry/grower Priorities:
2.1 Study the full lifecycle of key nematode species under different environmental and agronomic conditions.
2.2 Identify environmental stressors that trigger nematode outbreaks.
2.3 Develop predictive models for nematode population dynamics based on climate and soil conditions.
2.4 Characterise population dynamics with economic thresholds for risk-based decision support.

Taking into consideration each of the Theme 2 priorities above, enter a scale of 1 (low) to 10 (high) based on the questions stated at the start of Section 1.

Theme 3: Development of Biological & Non-Chemical Control Solutions

This theme focuses on the development and validation of biological and non-chemical solutions for nematode control. It seeks to deliver effective, crop-specific biocontrol products as sustainable alternatives to traditional chemical treatments, while also advancing regulatory approval pathways to support the adoption of these environmentally friendly innovations.

Industry/grower Priorities:
3.1 Investigate biocontrol agents (e.g., nematophagous fungi, bacteria, predatory nematodes).
3.2 Explore plant-based nematicides and natural metabolites as alternatives to synthetic chemicals.
3.3 Assess the effectiveness of soil microbiome manipulation in reducing nematode populations.
3.4 Develop biostimulants that enhance plant resistance against nematodes.

Taking into consideration each of the Theme 3 priorities above, enter a scale of 1 (low) to 10 (high) based on the questions stated at the start of Section 1

Theme 4: Integrated Pest Management (IPM)

This theme aims to enhance integrated pest management (IPM) approaches by combining multiple control strategies into cohesive models. It emphasises the development of sustainable and cost-effective practices that are practical for growers, while minimising the environmental footprint of nematode management**.**

Industry/grower Priorities:
4.1 Optimise crop rotation strategies for different nematode species.
4.2 Investigate soil amendments (e.g., biochar, compost, cover crops) for nematode suppression.
4.3 Evaluate intercropping and companion planting methods that deter nematode infestations.

4.4 Improve irrigation and nutrient management practices to enhance plant tolerance to nematodes.

Taking into consideration each of the Theme 4 priorities above, enter a scale of 1 (low) to 10 (high) based on the questions stated at the start of Section 1

Theme 5: Precision Agriculture & Digital Solutions

This theme focuses on advancing precision nematode management by leveraging real-time data analysis and digital technologies. It aims to deliver scalable, efficient monitoring systems and promote the widespread adoption of digital decision-support tools among growers for more proactive and informed nematode control.

Industry/grower Priorities:
5.1 Develop AI-driven decision-support tools for nematode risk assessment.
5.2 Integrate nematode data into digital farm management platforms.
5.3 Explore automated soil sampling and testing methods using robotics.

Taking into consideration each of the Theme 5 priorities above, enter a scale of 1 (low) to 10 (high) based on the questions stated at the start of Section 1

Theme 6: Regulatory & Policy Support for New Solutions

This theme seeks to strengthen the regulatory and policy environment supporting sustainable nematode management. It prioritises accelerating the approval of innovative control products, building robust policy frameworks, and securing increased investment in nematology research and extension to drive long-term industry impact.

Industry/grower Priorities:
6.1 Conduct trials to generate efficacy data for new biological and chemical products.
6.2 Work with regulatory agencies to streamline approval processes for new nematicides.
6.3 Assess the economic impact of nematode infestations to justify R&D investments.

Taking into consideration each of the Theme 6 priorities above, enter a scale of 1 (low) to 10 (high) based on the questions stated at the start of Section 1

Theme 7: Education & Adoption Support

This theme focuses on maximising the value and reach of previous investments by accelerating the delivery of impactful outcomes to growers. It also aims to generate ongoing insights that inform both effective nematode management practices and strategic decisions for future investment.

Industry/grower Priorities:
7.1 Undertake technical review of R&D in progress and identify existing initiative that need additional resources for impact, in-line with this strategy.
7.2 Review and scale effective management methods to others.
7.3 Develop and facilitate a 'community of practice' as resource to manage and use the broad knowledge and variability of the nematode challenges.

Taking into consideration each of the Theme 7 priorities above, enter a scale of 1 (low) to 10 (high) based on the questions stated at the start of Section 1**Section 2: Prioritisation of Industry Needs**

- Please rank the following **seven themes** in order of how you believe they should be prioritised in service of industry/grower needs.
  (Top = highest priority; Bottom = Lowest Priority)

Drag items from the left-hand list into the right-hand list to order them.

• Advanced Diagnostics & Early Detection • Nematode Lifecycle & Population Dynamics • Development of Biological & Non-Chemical Control Solutions • Integrated Pest Management (IPM) • Precision Agriculture & Digital Solutions • Regulatory & Policy Support for New Solutions • Education & Adoption Support	

Optional: Provide a brief rationale for your ranking of theme prioritisation:

- If a program of work relating to Nematode Management Practices was awarded $1M for further development towards extension or adoption of industry/grower priorities, how would you split the allocation of those funds (as a % proportion of the $1M) across the **seven themes** identified as Industry Needs? *****

Advanced Diagnostics & Early Detection	
Nematode Lifecycle & Population Dynamics	
Development of Biological & Non-Chemical Control Solutions	
Integrated Pest Management (IPM)	
Precision Agriculture & Digital Solutions	
Regulatory & Policy Support for New Solutions	
Education & Adoption Support	
	0 out of 100% Total

Optional: Provide a brief rationale for why you split the allocation of funds in this way:

Section 3: Open Feedback

Overall Suggestions:

- Are there any additional priorities or angles we should consider that are not listed above?

Barriers & Opportunities:

- What do you see as the biggest challenges and opportunities within the current industry/grower priorities across the seven themes presented?

Final Comments:

- Please share any additional thoughts or suggestions you might have to guide the strategy for nematode management as prioritised for your (industry/grower) needs.

SUBMIT

Thank you for your time, your feedback is appreciated.

Appendix E: Root cause analysis of the nematodes in Australian horticulture

Technological and Management Options

- **Challenges:**
  - Limited availability of nematode-specific management tools tailored to vegetable crops.
  - Reliance on chemical nematicides, which may be expensive, face regulatory restrictions or lose effectiveness over time.
  - Lack of integration of alternative solutions such as biological controls or resistant crop varieties.
- **Assumed Causes:**
  - Gaps in research and development for cost-effective and practical tools.
  - Barriers to commercialisation of innovative solutions (e.g., high costs, lack of field trials).
  - Insufficient communication of available technologies to growers.
- **Questions to Validate:**
  - What tools or methods do you currently use for nematode management?
  - Are there specific tools or technologies you feel are missing or inaccessible?
  - What would make adopting new technologies easier for your farm?

Cost Burden to Growers

- **Challenges:**
  - Economic losses due to reduced yields and crop quality from nematode infestations.
  - High direct costs for chemical treatments and indirect costs such as reduced soil fertility.
  - Difficulty in quantifying nematode-related losses, making cost-benefit decisions harder.
- **Assumed Causes:**
  - Limited access to cost-effective, scalable management solutions.
  - Insufficient economic incentives (e.g., subsidies) to encourage sustainable practices - long-term pest management strategies, such as Integrated Pest Management (IPM), biological controls, or resistant crop varieties.
  - Lack of granular data on the financial impact of nematodes by crop type or region.
- **Questions to Validate:**
  - How do nematodes impact your farm financially (e.g., yield loss, treatment costs)?
  - What cost barriers prevent you from implementing better management practices?
  - Would financial incentives or support encourage you to adopt sustainable strategies?

Diagnostics and Detection Mechanisms

- **Challenges:**
  - Diagnostic tools are often expensive or unavailable, especially in remote regions.
  - Detection often occurs reactively (after significant damage) rather than proactively.
  - Limited knowledge or capacity among growers to interpret diagnostic results.
- **Assumed Causes:**
  - High cost of advanced diagnostic technologies and limited local distribution.
  - Lack of awareness or training for growers on using diagnostic tools effectively.
  - Gaps in extension services to support diagnostics and interpretation.
- **Questions to Validate:**
  - How do you currently detect and confirm nematode problems on your farm?
  - Are diagnostic tools accessible and easy to use for you?
  - What would help you identify nematode issues earlier and more effectively?

Regulatory and State Challenges

- **Challenges:**
  - Quarantine and movement restrictions due to nematodes can limit market access for affected growers.
  - Regulatory requirements (e.g., mandatory testing, certifications) add costs and complexity.
  - Variability in state-level policies may confuse or burden growers.
- **Assumed Causes:**
  - Regulations focused more on containment than prevention or management.

- Limited grower representation in shaping policies.
- Disparities in regulatory approaches across different states or regions.

- **Questions to Validate:**
  - How do state or national regulations impact your ability to manage nematodes?
  - Are there specific regulatory challenges that you find burdensome?
  - How could regulations better support your efforts to manage nematodes sustainably?

Barriers to Adoption of IPM Strategies

- **Challenges:**
  - Growers perceive integrated pest management (IPM) as complex and resource-intensive.
  - Limited trust in alternative solutions like biological controls or crop rotations.
  - A lack of demonstrations or success stories tailored to local conditions.
- **Assumed Causes:**
  - Insufficient outreach and training on IPM principles.
  - Economic pressure for short-term yield optimisation over long-term strategies.
  - Fear of inconsistent or unpredictable results from IPM practices.
- **Questions to Validate:**
  - What prevents you from adopting IPM strategies for nematode management?
  - How could IPM practices be made more practical or affordable for you?
  - What examples of successful IPM practices would build your confidence in adopting them?

Climate and Environmental Factors

- **Challenges:**
  - Climate variability exacerbates nematode problems by creating favourable conditions for outbreaks.
  - Drought or excessive rainfall affects soil health and may compound nematode issues.
  - Climate-driven shifts in growing seasons may increase nematode prevalence.
- **Assumed Causes:**
  - Lack of localised research on climate-nematode interactions.
  - Limited region-specific recommendations to adapt management practices to climate conditions.
  - Overreliance on practices that do not account for environmental variability.
- **Questions to Validate:**
  - How has climate variability or extreme weather affected nematode problems on your farm?
  - What environmental factors most influence your pest management practices?
  - What support or information would help you adapt to changing climatic conditions?

Soil Health and Farming Practices

- **Challenges:**
  - Soil degradation, compaction, and reduced organic matter exacerbate nematode problems.
  - Monoculture farming depletes soil resilience, making it more prone to nematode infestations.
  - Overuse of chemical inputs negatively impacts soil biology and structure.
- **Assumed Causes:**
  - Economic pressure to maximise short-term productivity over long-term soil health.
  - Lack of accessible education or support on sustainable soil practices.
  - Insufficient adoption of practices like cover cropping or organic amendments.
- **Questions to Validate:**
  - What challenges do you face in maintaining healthy soil while managing nematodes?
  - How do your farming practices impact nematode prevalence?
  - What tools or advice would help you improve soil health and reduce nematode risks?

Collaboration and Knowledge Sharing

- **Challenges:**
  - Limited platforms for growers to share experiences or learn from peers.
  - Weak communication between growers, researchers, and policymakers.

- Research findings often fail to translate into actionable solutions for growers.

- **Assumed Causes:**
  - Fragmented stakeholder networks with inconsistent engagement opportunities.
  - Research priorities are sometimes misaligned with grower needs.
  - Lack of centralised systems to disseminate knowledge effectively.
- **Questions to Validate:**
  - How do you currently access information or support for nematode management?
  - What could improve collaboration between growers, researchers, and other stakeholders?
  - How can research findings be made more actionable for your farm?

Appendix F: Workshop-Webinars Insights Analyses

Workshop-webinar 1: RESEARCHER Insights Analysis

Question	Response Analysis and Key Insights	Implications
1. Timing of Nematode Problems	• Early vs. Late Detection: Many responses indicate that nematode issues begin early, often during the reproductive or juvenile stages, but are only noticed later, frequently at harvest or after significant crop loss. • Influencing Factors: Continuous cropping, monocropping, and environmental stresses (e.g., warmer months, poor chemical practices) are consistently cited as conditions that either initiate or exacerbate nematode problems.	• There is widespread recognition that by the time symptoms become obvious (e.g., yield loss, visual root damage), it is often too late for effective intervention.
2. Economic Threshold for Action	• Variable Thresholds: Growers generally take action when yield loss becomes obvious or exceeds a certain economic threshold, with some responses mentioning a 20% loss or simply "obvious damage." • Crop-Specific Considerations: Decisions vary by crop sensitivity, the cosmetic tolerance of harvested produce, and the cost of management options.	• While economic thresholds guide interventions, the acceptable level of loss is highly variable and dependent on individual grower economics and crop value.
3. Diagnostic Tools and Methods	• Multiple Methods Employed: Common tools include visual assessments (root symptoms and damage), traditional morphological identification, bioassays, and molecular techniques such as species-specific PCR and DNA testing. • Integration is Key: Several responses advocate for combining morphological and molecular methods to improve diagnostic accuracy. • Limitation: A recurring concern is that relying solely on visual or traditional methods often means that by the time the problem is diagnosed, damage is already significant.	• Early and precise detection is critical, suggesting a need for routine and integrated diagnostic approaches.
4. Decision Timing for Management Interventions	• **Ideally Pre-Planting:** Many respondents stress that the decision to address nematode issues should occur pre-planting, based on prior history or early diagnostics, to prevent damage.	• There is a clear gap between ideal proactive management and the reactive measures that are commonly practiced, highlighting an opportunity for earlier intervention.

Question	Response Analysis and Key Insights	Implications
	• **Reactive vs. Proactive:** Despite this, responses indicate that decisions are often made only after visual symptoms or significant yield impacts are observed.	
5. Challenges in Identifying Nematode Presence and Impact	• **Sampling and Diagnostic Limitations:** Challenges include obtaining representative soil/root samples, the complexity of mixed nematode communities, and the difficulty in linking nematode numbers to actual yield loss. • **Grower Awareness and Willingness:** Some responses point out that growers may be reluctant to provide samples or recognise the problem early.	• Enhancing sampling methods, lowering the cost and turnaround time of diagnostics, and improving grower education could address these challenges.
6. Resources and Tools for Management	• Current Practices: A variety of management tools are mentioned, including fumigation, chemical nematicides, crop rotations, resistant cultivars, biological controls, and integrated management strategies. • Diverse Approaches: The effectiveness of these methods depends on factors such as soil type, nematode species, and crop sensitivity.	• An integrated approach that combines chemical, cultural, and biological practices is favoured, although many feel that some current methods (like fumigation) are unsustainable or only offer short-term relief.
7. Effectiveness and Improvements in Treatment Options	• Variable Efficacy: Treatment outcomes range from effective in certain conditions (e.g., lighter soils) to ineffective in others (e.g., heavy soils, misapplied chemicals). • Need for Better Products and Methods: Respondents call for improved products (especially for specific crops like brassicas), better application methods, and a deeper understanding of nematode lifecycles.	• There is a strong demand for innovative, sustainable treatments that address the shortcomings of current chemical options and incorporate integrated pest management (IPM) principles.
8. Overarching Challenges and Future Directions	• Research and Knowledge Gaps: Major challenges include inadequate species identification, limited diagnostic capacity, insufficient extension services, and regulatory hurdles slowing the approval of new actives. • Need for Education and Monitoring: Many responses stress the importance of regular soil testing, improved grower training, and better in-field diagnostic tools (including rapid tests and AI-based approaches). • Ideal Outcomes: A highly satisfactory outcome would involve sustainable, proactive management practices that improve yield,	• To achieve these outcomes, the sector needs investment in research, better diagnostic and extension services, and policies that facilitate the adoption of modern, sustainable management practices.

Question	Response Analysis and Key Insights	Implications
	reduce reliance on chemicals, and leverage an integrated, ecological approach to nematode control.	
Overall Analysis	The responses illustrate a common narrative: nematode problems are typically under-detected until they cause significant damage, largely due to limitations in current diagnostic methods and reactive management practices. There is consensus on the need for: • Early Detection and Proactive Management: Emphasising pre-plant diagnostics and historical field data. • Integrated and Sustainable Approaches: Combining chemical, cultural, and biological controls tailored to specific crops and nematode species. • Improved Diagnostic Tools and Grower Education: To ensure more timely and effective interventions. • Policy and Research Support: To drive innovations in nematode management and overcome regulatory and economic barriers.	• Addressing these challenges could lead to more consistent, sustainable, and economically viable nematode management strategies in the vegetable sector.

Workshop-webinar 2: SUPPLY CHAIN Insights Analysis

Question	Response Analysis and Key Insights
1. Diagnosis & Identification	• Multiple methods are used, including visual assessments, soil testing, and DNA sampling. • Experts and diagnostic expertise are crucial but not always accessible. • Challenges include turnaround time, species identification, and understanding life cycles for better-targeted sampling.
2. Challenges in Identifying and Managing Nematodes	• Lack of expertise in diagnostics and management. • Limited chemical options and loss of older effective products. • High costs of treatments and difficulty in accessing post-planting control options. • Limited land availability restricts crop rotation, a key management strategy.
3. Management Strategies & Effectiveness	• Crop rotation, soil fumigation, and chemical treatments are widely used, but effectiveness varies. • Newer biological control options exist, but adoption is low due to limited research and regulatory challenges. • Integrated Pest Management (IPM) strategies combining chemistry, biological controls, and crop rotation are seen as the best approach.
4. Limitations of Current Treatments	• Treatments fail when misapplied, irrigation is insufficient or used in isolation instead of a holistic strategy. • High-cost treatments limit accessibility.

Question	Response Analysis and Key Insights
	• Lack of awareness or trust in biological solutions affects adoption.
5. What's Missing in Nematode Management?	• Industry-wide education and training on best practices. • More research on biological control options in local conditions. • Regulatory changes to facilitate newer, environmentally friendly solutions. • Stronger IPM adoption to reduce reliance on chemical treatments alone.
6. Desired Outcomes & Industry Improvements	• Comprehensive education programs tailored to each crop. • Development of IPM programs that combine all available control options. • Data-driven guidelines to help growers implement the most effective strategies. • Regulatory support for biological control agents to encourage innovation.
Overall Analysis	• Effective nematode management requires a multi-faceted approach that includes proper diagnostics, education, research, and integrated management strategies. The biggest barriers are cost, accessibility of expertise, and reliance on chemicals. Future efforts should focus on better grower education, regulatory improvements, and developing sustainable biological and cultural control options.

Workshop-webinar 3: GROWER Insights Analysis

Question	Response Analysis and Challenges	Implications
1. Timing and Detection of Nematode Problems		
When are problems experienced?	Varied Timelines: • Some respondents noted problems occur at the start of the season, while others indicated issues only become apparent at harvest or mid-harvest (e.g., in greenhouse environments). A common theme is that nematode damage (like galling) may be hidden until the crop is stressed or symptoms become visually evident.	• Early infestations may go unnoticed until stress factors (e.g., drought, salt issues) or developmental stages (e.g., galling during fruit set) reveal the problem. • The delayed visual manifestation means that by the time symptoms are clear, management may already be late.
2. Thresholds for Taking Action		

Question	Response Analysis and Challenges	Implications
When does the problem become significant enough for intervention?	Risk-Based and Historical Considerations: • Several responses mention that if there has been a previous issue in the same soil/block, growers might act pre-season to minimise potential risk. • Some indicate that soil testing is employed early, yet in many cases, by the time a problem is identified, it's already advanced.	• The decision to intervene is not solely based on the current visible level of damage; it often factors in historical occurrences and the risk of further spread. • The economic threshold, where even minor damage (especially in crops with cosmetic value like brassicas) matters, plays a role in decision-making
3. Diagnostic Tools and Methods		
What tools are effective for identifying a nematode issue?	Common Methods: • Visual Assessment: Inspection of roots for symptoms such as stunting, galling, or the presence of cysts. • Soil Testing: Using soil samples to detect nematode populations early, sometimes with further laboratory analysis. • Molecular Diagnostics: DNA tests that can differentiate between live and dead nematodes, offering species-level insights. Challenges Identified: • Visual symptoms are often too late, making reliance on them a reactive rather than proactive measure.	• A combined approach is favoured: integrating visual assessments with soil and molecular testing can lead to earlier and more accurate diagnosis. • The delay in symptom manifestation underlines the need for routine, pre-season soil testing, especially in fields with known issues.
4. Decision-Making for Management		
When is a decision to address nematodes made?	Based on Past Experience and Immediate Observation: • Decisions are frequently driven by historical field data (if nematodes were an issue previously) pre-emptive treatments may be applied.	• Proactive management is favoured, but practical constraints (such as a lack of registered products for certain crops) often lead to reactionary measures. • The gap between detection and decision-making can compromise treatment efficacy.

Question	Response Analysis and Challenges	Implications
	• In some cases, the decision is delayed until the issue is clearly identified, though this often means it is too advanced for effective intervention.	
5. Challenges in Identification and Impact Assessment		
What are the biggest challenges in identifying the presence and impact of nematodes?	Diagnostic Uncertainty: • Differentiating nematode species and correlating specific symptoms to nematode presence is challenging. • There is a risk that crops may already be severely affected before a definitive diagnosis is made. Environmental and Methodological Confounders: • Similar symptoms caused by other factors (e.g., poor water quality, salt stress) can mimic nematode damage. • The lack of rapid field test kits is noted as a significant hurdle.	• There is a clear need for more reliable, rapid diagnostic tools and greater expertise in nematology to aid in early detection and accurate diagnosis.
6. Management Tools and Resources		
Which resources or tools are used most for managing nematodes?	Current Practices Include: • Fumigation: Although used, it is noted to be non-targeted and, in some cases, being phased out. • Soil Testing and Research: Essential for monitoring and informing management decisions. • Resistant Cultivars: Where available, though options are limited, particularly for brassicas.	• The reliance on fumigation and soil testing indicates a dependence on chemical and diagnostic methods, while cultural controls or integrated pest management strategies appear underutilised. • The lack of effective products for certain crops (e.g., beet cyst management) points to a gap in the available tools.
7. Effectiveness of Current Treatments		
How effective are current treatment options?	Short-Term vs. Long-Term: • Chemical treatments, including fumigation, may reduce nematode numbers temporarily but are seen as environmentally harmful and often ineffective in the long run. • The effectiveness varies based on nematode species and the presence of ongoing stress factors, like poor water quality.	• There is a recognised need for new, sustainable treatment options and better understanding of nematode lifecycles to improve long-term management. • The current reliance on reactive chemical treatments may not be sustainable, particularly for crops with no registered control options.

Question	Response Analysis and Challenges	Implications
8. Areas for Improvement in Nematode Management		
What treatments are seen as ineffective and what improvements are suggested?	Treatment Limitations: • Ineffectiveness often stems from poor timing and incorrect application. • There is a call for the registration of new products, especially for brassica crops. Potential Improvements: • Greater research into nematode lifecycles to identify optimal intervention stages. • Adoption of cultural controls and preventative practices, supported by better extension services and education.	• A shift toward preventative measures and improved diagnostic tools could enhance management outcomes. • Industry-wide education and the development of new products are viewed as critical to overcoming current challenges.
9. Broader Management Challenges and Desired Outcomes		
Biggest challenges and what should be happening:	Challenges: • Limited expertise in nematology and insufficient extension services. • Funding constraints and a shortage of reliable identification tools. Desired Improvements: • More frequent educational short courses for growers. • Better water quality (e.g., free of sodium) and registration of new, effective control products.	• A comprehensive strategy that includes education, improved diagnostic methods, and new control products is needed. • Policy changes and enhanced research funding could drive significant improvements in nematode management.
Overall Analysis		
	The responses collectively underscore that nematode problems are multifaceted and highly context dependent. Effective management requires: • Early Detection: Through routine soil testing and proactive use of molecular diagnostics. • Informed Decision-Making: Based on historical data, economic thresholds, and real-time observations.	• This comprehensive approach would help mitigate the impact of nematodes and enhance the sustainability of crop production.

Question	Response Analysis and Challenges	Implications
	• Integrated Management: Combining chemical, cultural, and preventative measures. • Industry Education: To improve nematology expertise and ensure that growers have the tools and knowledge needed to manage infestations effectively.	