UNIVERSITY of York

Utilising Jasmonates for Plant Protection

BOA Technical Conference

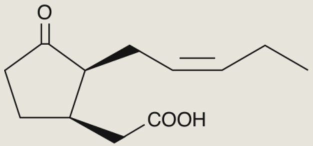
5th February 2025

CNAP
Centre for Novel Agricultural Products

UKRI
Biotechnology and Biological Sciences Research Council

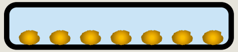
Utilising jasmonates for plant protection

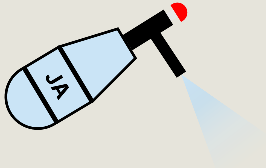
1. Overview of induced resistance (IR) and jasmonates.



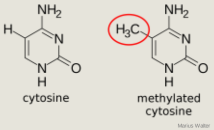
2. Two case studies on jasmonate induced resistance (JA-IR).

3. General patterns associated with jasmonate treatment.

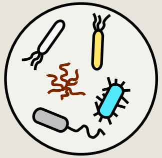




4. Where is the research going next?



Epigenetics



Microbiomes

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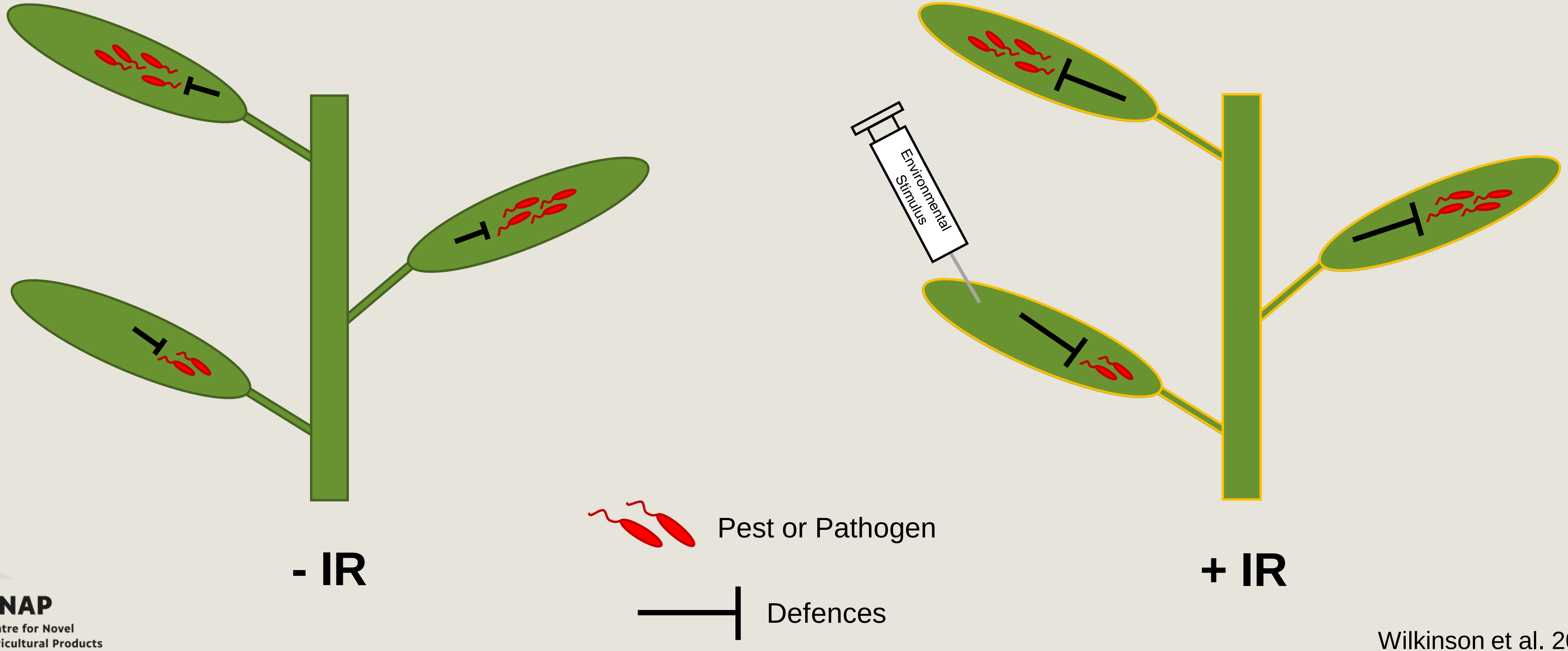
Induced resistance (IR)

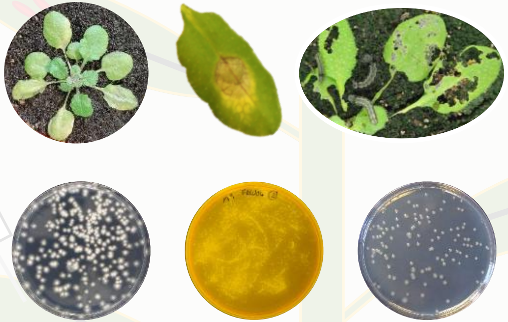


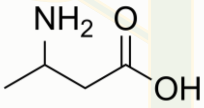
Wilkinson et al. 2019

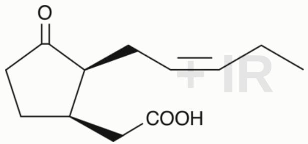
Induced resistance (IR)

Examples of resistance inducing stimuli:

- Pest or pathogen attack
- Plant beneficial microbes (e.g. *Pseudomonas simiae* WCS417)
- Chemicals
  - Non-protein amino acids (e.g. beta-aminobutyric acid)
  - Phytohormones (e.g. Jasmonic acid)







Wilkinson et al. 2019

Jasmonates

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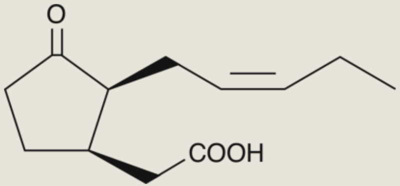
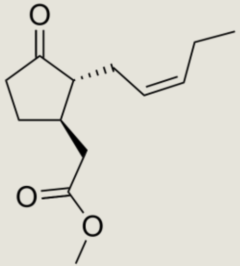
- Jasmonic acid (JA) - plant hormone.



- JA regulates plant responses to stress (e.g. herbivory).

- JA and its derivatives, such as the methyl ester of JA (MeJA), are collectively termed Jasmonates.



Jasminium grandiflorum

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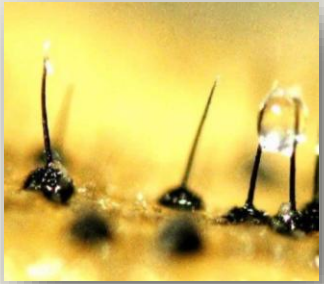
Case Study 1 – MeJA protects Norway spruce against the European spruce bark beetle

The problem – *Ips typographus*

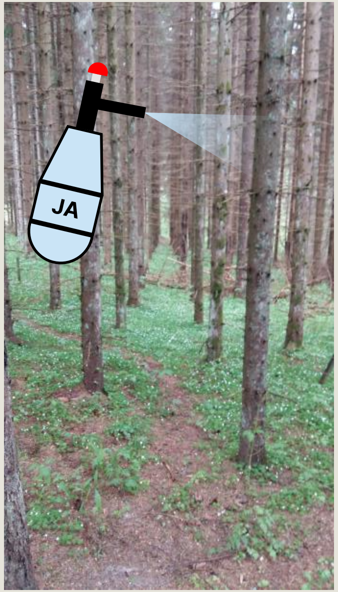


Blue stain fungi
(e.g. *Grosmannia penicillata*)

European spruce bark beetle
(*Ips typographus*)

Photos: Paal Krokene

MeJA spray treatment



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MeJA provides dual protection

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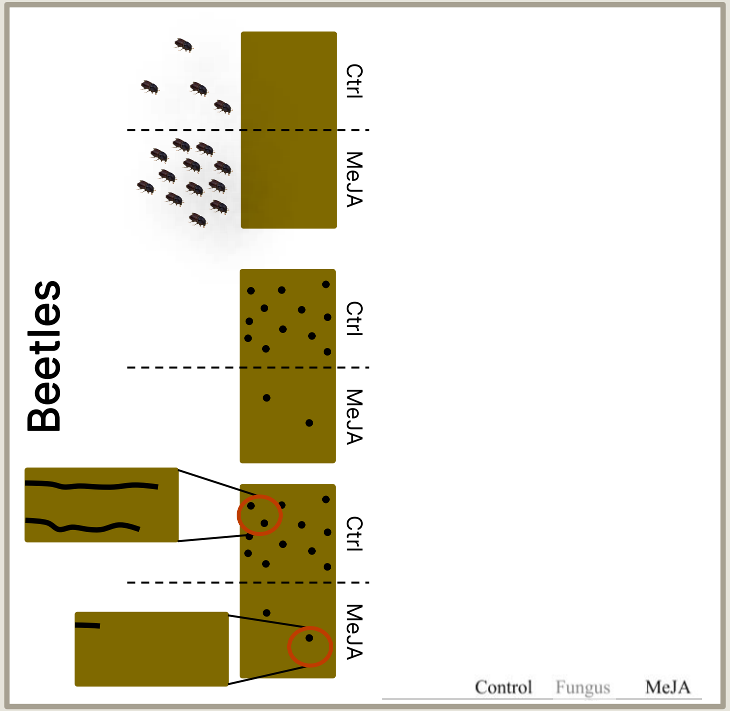

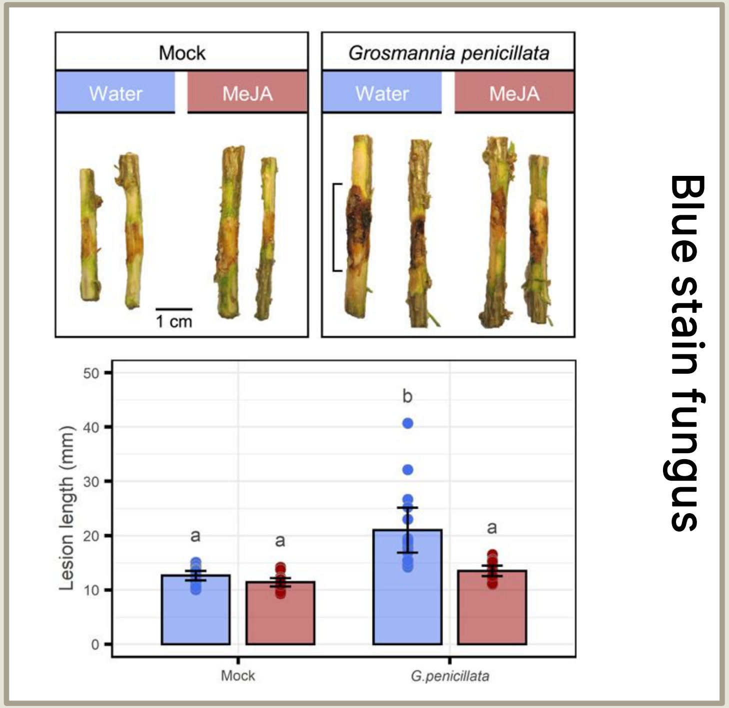

Left: Mageroy et al. 2020 Right: Wilkinson et al. 2022

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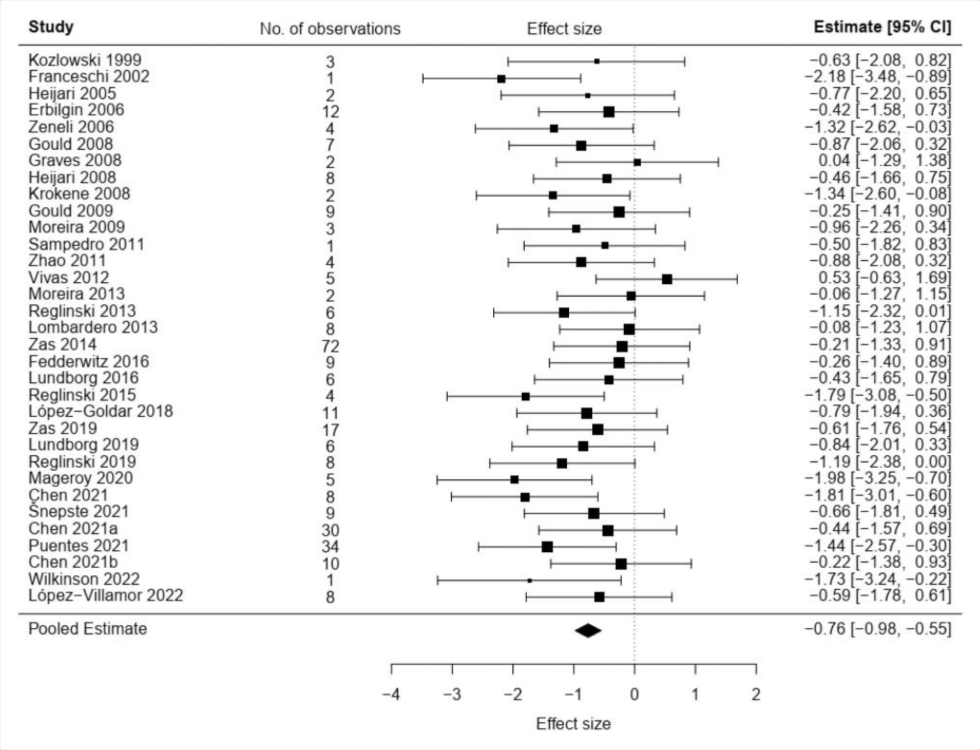
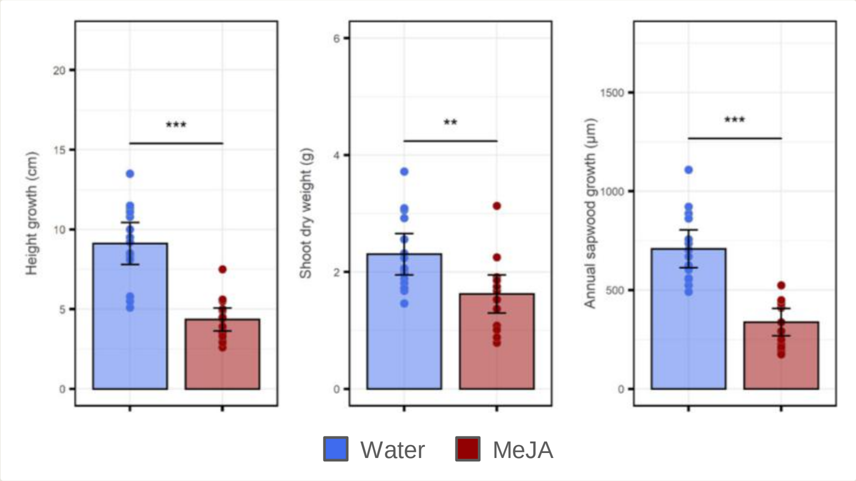
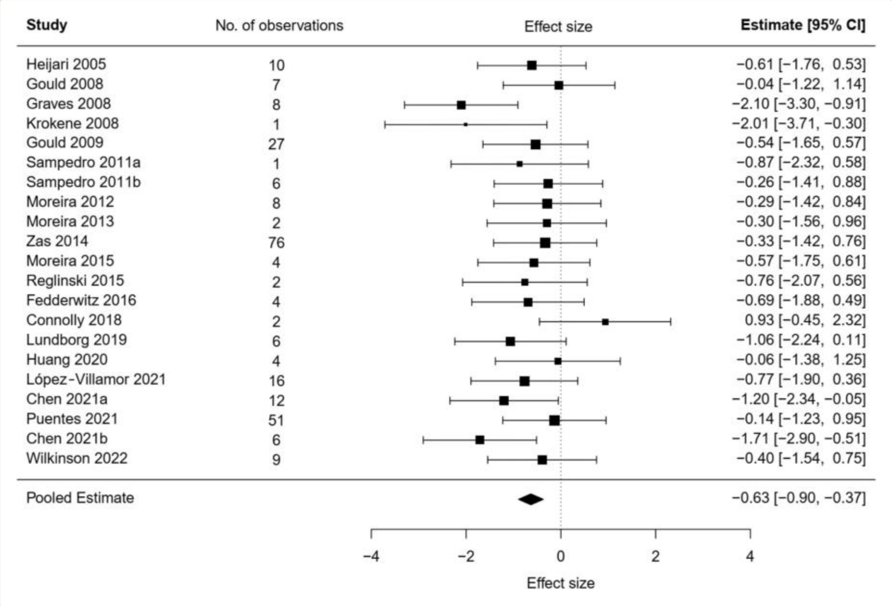
MeJA provides consistent protection in *Pinus* and *Picea*



Huynh et al. 2024

MeJA represses growth in *Pinus* and *Picea*





Left: Wilkinson et al. 2022 Right: Huynh et al. 2024

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Case Study 2 – Jasmonate seed treatment provides long-lasting protection of tomato against pests and pathogens

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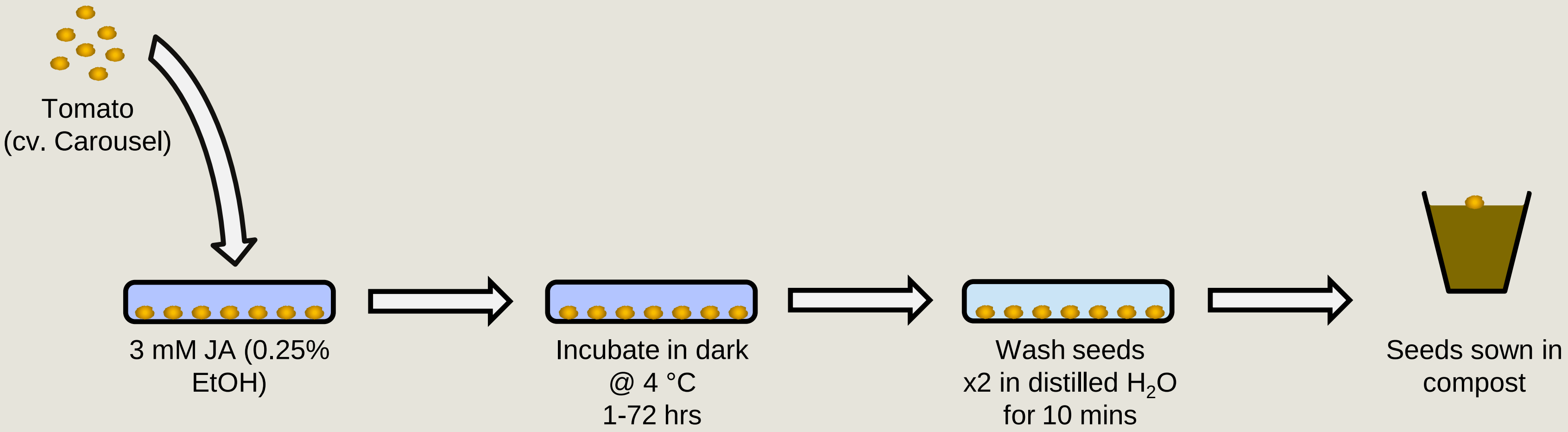
Jasmonate seed treatment



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Worrall et al. 2012

JA seed treatment protects against pests and pathogens

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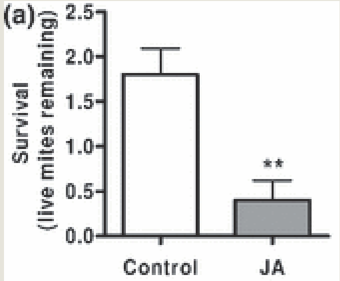
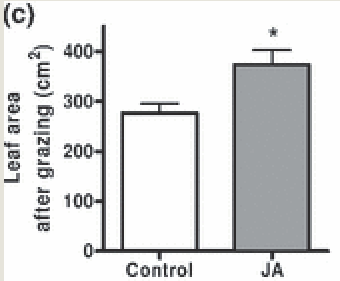
Red spider mite
(*Tetranychus urticae*)

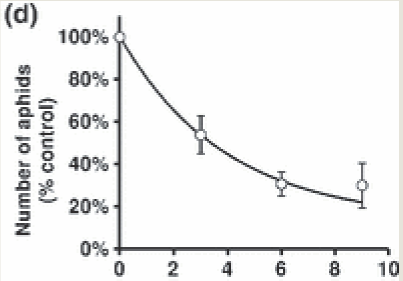


Credit: Jacopo Werther

Tobacco hornworm
(*Manduca sexta*)

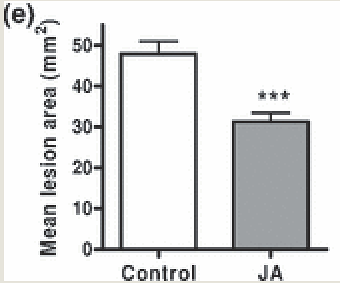


Green peach aphid
(*Myzus persicae*)



Credit: Scott Bauer

Grey mould
(*Botrytis cinerea*)



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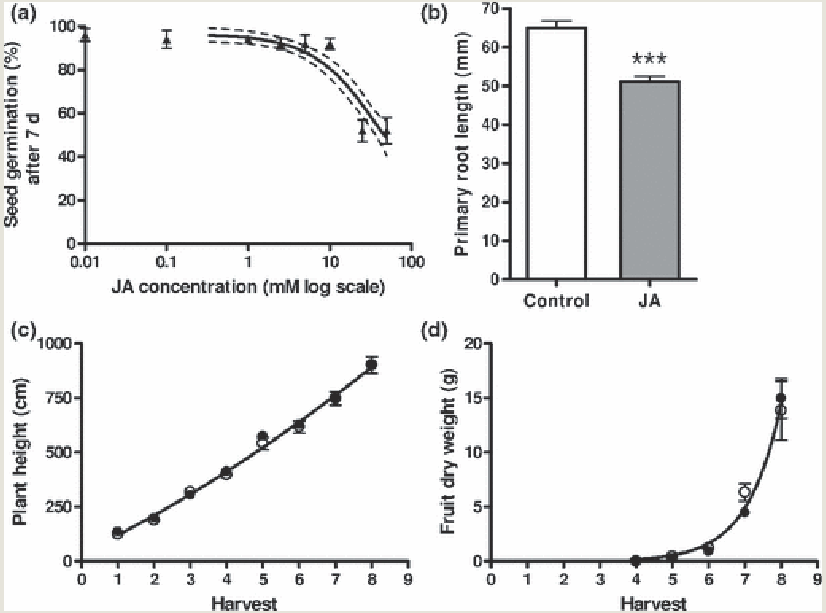
Worrall et al. 2012

JA seed treatment does not have a long-term impact on growth and development of tomato (cv. Carousel)



(a) Germination.

(b) Root growth.

(c) Plant height at harvest.

(d) Fruit dry weight.

b-d 3 mM JA concentration as used for resistance tests.

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Worrall et al. 2012

General patterns associated with jasmonate treatment

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Jasmonate treatment - Advantages

- Induces resistance to pests.
- Increases resistance to pathogens.
- Enhance recruitment of pest predators (indirect defence).

Haas et al (2018)

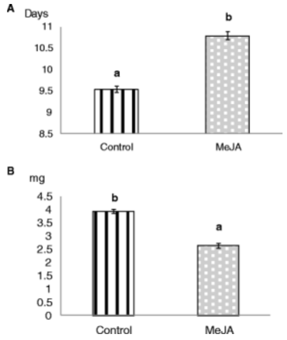
Table 1 Mean (± SD) biological parameters of *Plutella xylostella* on *Brassica oleracea* plants developed from seeds coated with chitosan (2%), jasmonic acid (3 mM), or various controls (distilled water, ethanol, acetic acid) under laboratory conditions

Treatment	Mean relative growth rate	Larval period duration (days)	Pupal period duration (days)	Pre-imaginal mortality (proportion)	Adult emergence (proportion)	Oviposition (no. eggs laid)	Egg viability (proportion)	Oviposition preference
Water	61.56 ± 10.826a	10.96 ± 0.999	6.13 ± 0.515a	0.43 ± 0.129bc	0.80 ± 0.122	44.55 ± 0.510a	0.85 ± 0.035b	6.28 ± 1.893bc
Ethanol	54.41 ± 10.418a	10.84 ± 0.567	6.22 ± 0.356a	0.31 ± 0.119c	0.80 ± 0.113	28.92 ± 3.244b	0.89 ± 0.034b	8.01 ± 2.144b
Acetic acid	58.36 ± 13.972a	10.96 ± 0.868	6.40 ± 0.629a	0.45 ± 0.129b	0.73 ± 0.130	45.98 ± 4.106a	0.91 ± 0.250a	8.99 ± 2.294b
Chitosan	56.91 ± 10.376a	10.58 ± 0.679	6.55 ± 0.301a	0.57 ± 0.129b	0.64 ± 0.151	31.01 ± 3.51b	0.85 ± 0.040b	4.85 ± 1.667c
Jasmonic acid	44.42 ± 9.03b	6.86 ± 0.483	3.53 ± 0.249b	0.84 ± 0.095a	0.60 ± 0.244			10.99 ± 2.514a

Means within a column followed by different letters are significantly different (based on Bayesian contrasts: P<0.05).

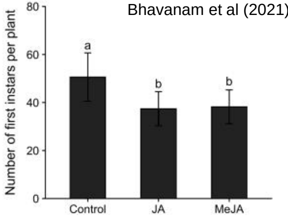
Cabbage and Diamondback moth (*Plutella xylostella*)

Strapasson et al (2014)



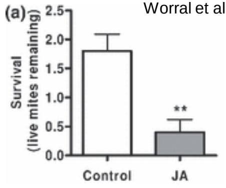
Tomato (cv. Cereja) and leaf miner (*Tuta absoluta*)

Bhavanam et al (2021)



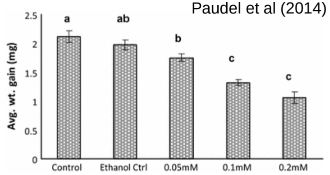
Rice and water weevil (*Lissorhoptrus oryzophilus*)

Worral et al (2012)



Tomato (cv. Micro-Tom) and Red spider mite (*Tetranychus urticae*)

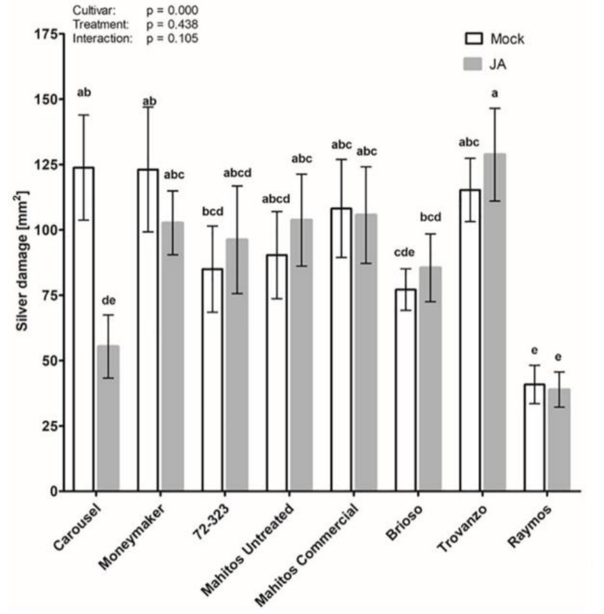
Paudel et al (2014)



Tomato (cv. Micro-Tom) and corn earworm (*Helicoverpa zea*)

Jasmonate treatment - Disadvantages

- Cultivar specific benefits.
- Reduced germination.
- Repressed growth.
- Reduced yield.



Western flower thrips (*Frankliniella occidentalis*)

Mouden et al. 2020

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Jasmonate treatment by seed soaking or spraying often provides **strong protection against pests and diseases**. However, these benefits can be cultivar/species specific and be associated with costs under certain conditions.

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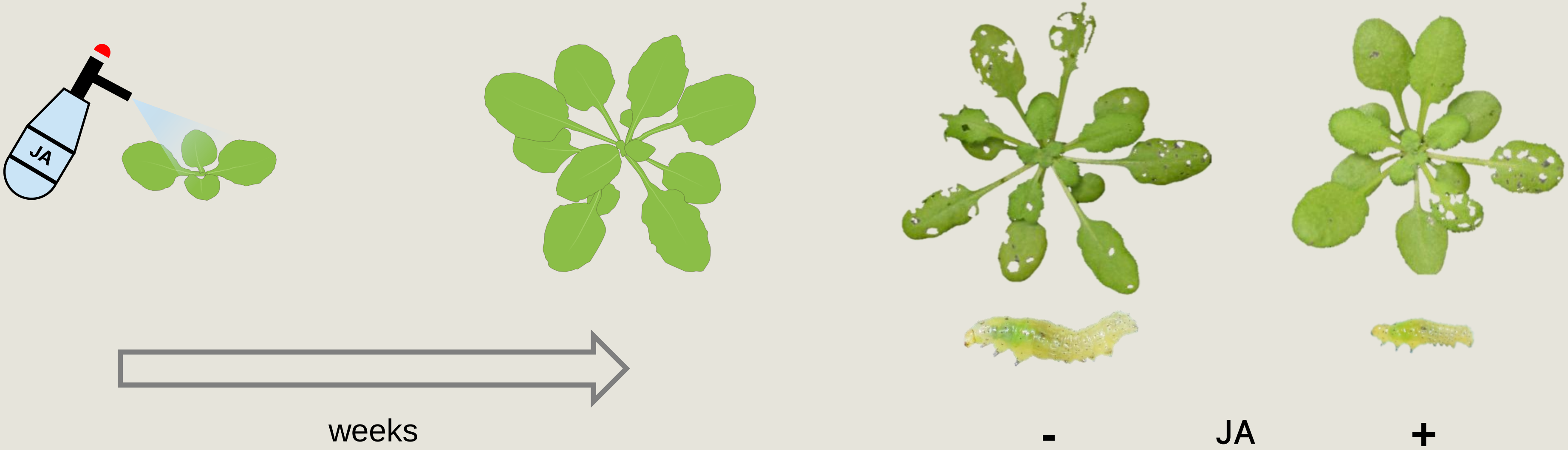
Where is the research going next? - Epigenetics

Deciphering the mechanisms of JA induced resistance



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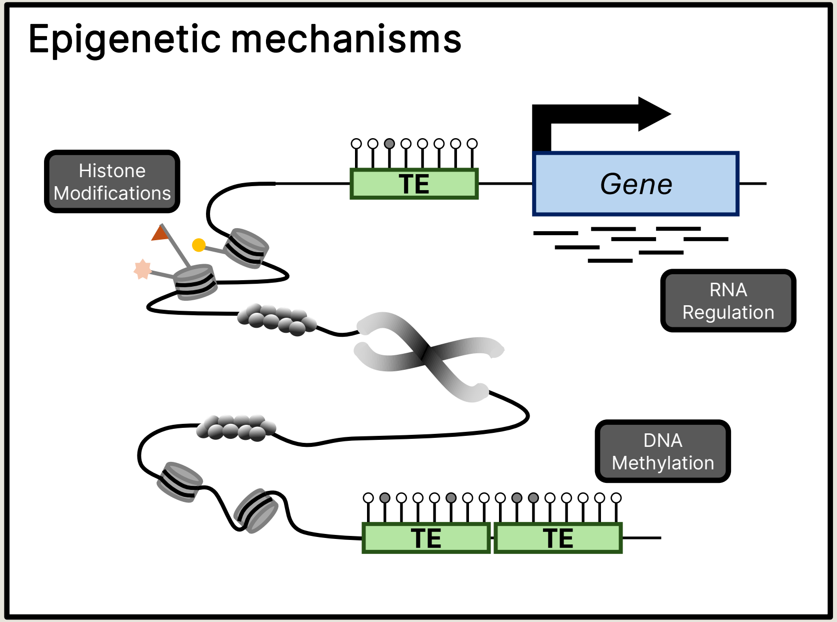
Wilkinson et al. 2023

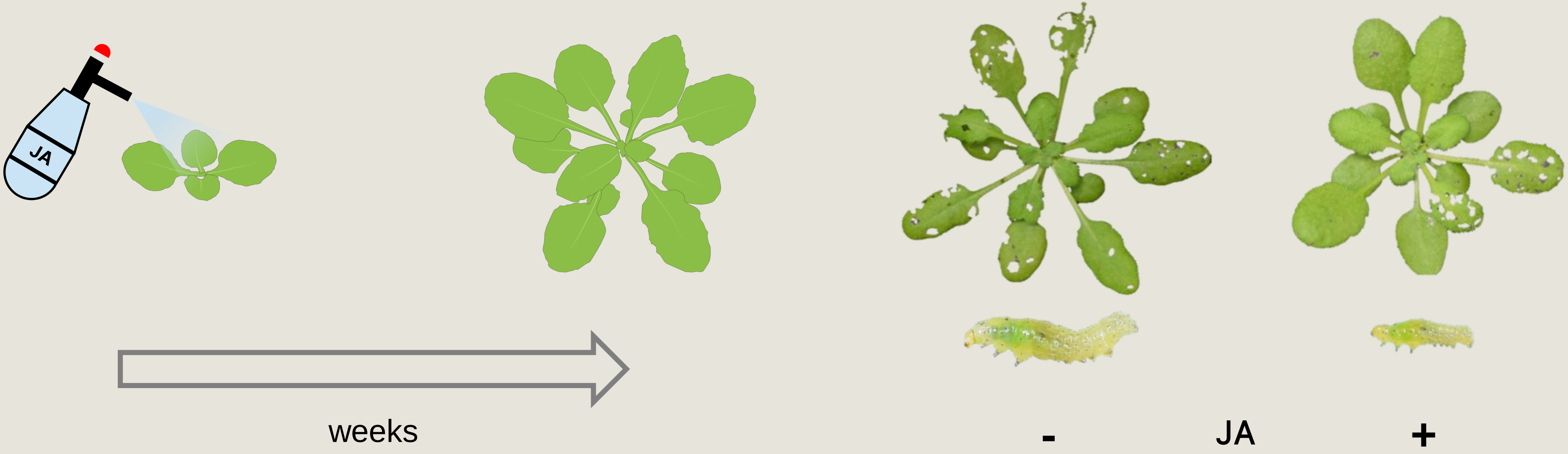
Epigenetics

Epigenetics is defined as the study of changes in gene function that are heritable within and across generations and that occur independently from changes in DNA sequence[1].



[1]Parker et al. 2021

Mimicking JA induced resistance



Wilkinson et al. 2023

Precision breeding - Gene editing

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Science & Environment

Commercial development of gene-edited food now legal in England

23 March 2023

BBC NEWS

Researchers in Cambridge are developing gene-edited potatoes that don't bruise in order to reduce food waste

By Pallab Ghosh
Science correspondent

Gene-edited food can now be developed commercially in England following a change in the law.

"Gene edited organisms generally do not contain DNA from different species, they contain changes that could be made more slowly using traditional breeding methods."[1].

[1]Defra "Gene editing explainer" (2021)

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Epigenome editing

PNAS
PNAS PLUS

Targeted DNA demethylation of the *Arabidopsis* genome using the human TET1 catalytic domain

Javier G
Jenny M
[a]Departme
California,
[d]Genome
California,

Contribute

New Phytologist
Research

Mitotically heritable epigenetic modifications of *CmMYB6* control anthocyanin biosynthesis in chrysanthemum

Mingwei Tang
Xue Yin[1,2], Bo
Lingyu Zhang
Yang Zhang[1,

nature communications

Article

https://doi.org/10.1038/s41467-022-35675-7

Improving cassava bacterial blight resistance by editing the epigenome

Received: 6 July 2022

Accepted: 15 December 2022

Published online: 05 January 2023

Kira M. Veley[1], Kiona Elliott[1,2], Greg Jensen[1], Zhenhui Zhong[3], Suhua Feng[3,4], Marisa Yoder[1], Kerrigan B. Gilbert[1], Jeffrey C. Berry[1], Zuh-Jyh Daniel Lin[1], Basudev Ghoshal[3,7], Javier Gallego-Bartolomé[3,8], Joanna Norton[4], Sharon Motomura-Wages[4], James C. Carrington[1], Steven E. Jacobsen[3,5,6] & Rebecca S. Bart[1]

Deciphering induced resistance in tomato

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BBSRC Discovery Fellowships

Project title: *Deciphering plant stress memory: the exploration of how DNA methylation and the rhizosphere microbiome control stress memory in plants*

Funding period: 2024 - 2028

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Where is the research going next? - Microbiomes

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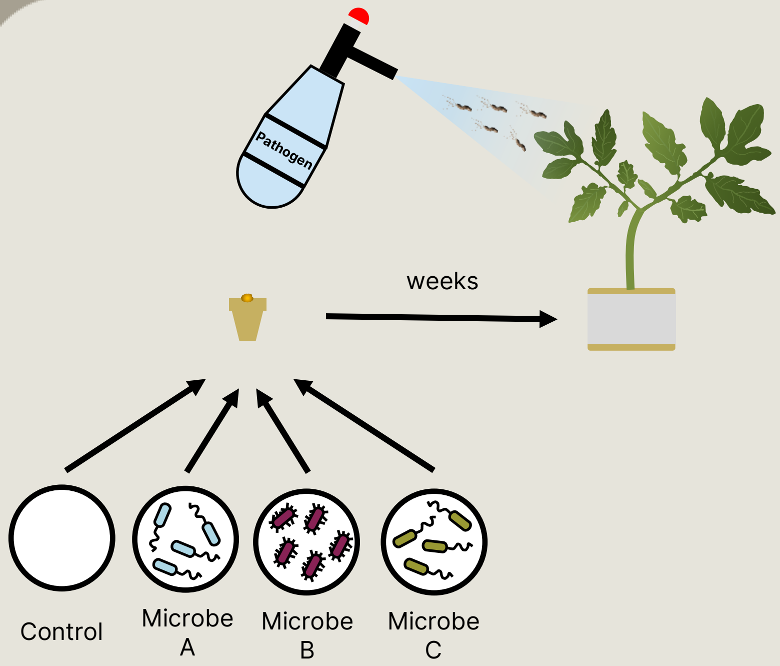
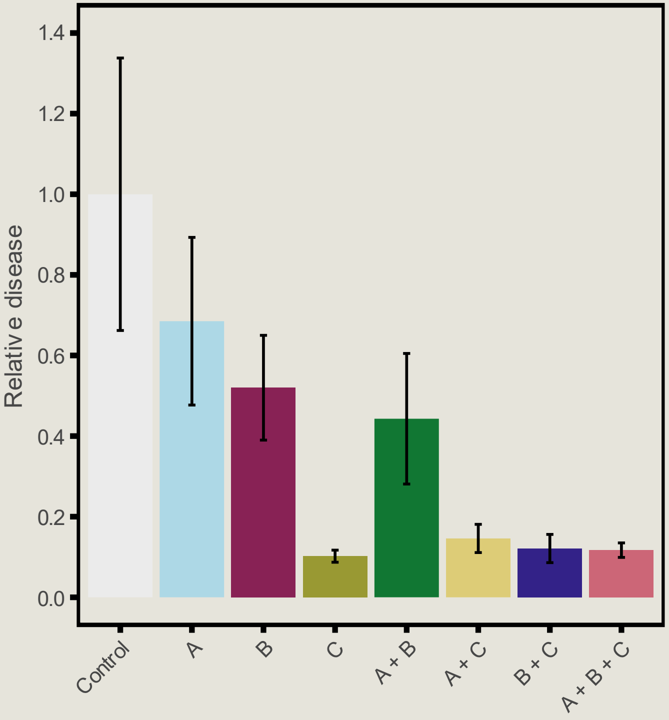
Plant beneficial microbes





Jasmonates regulate root associated microbiome

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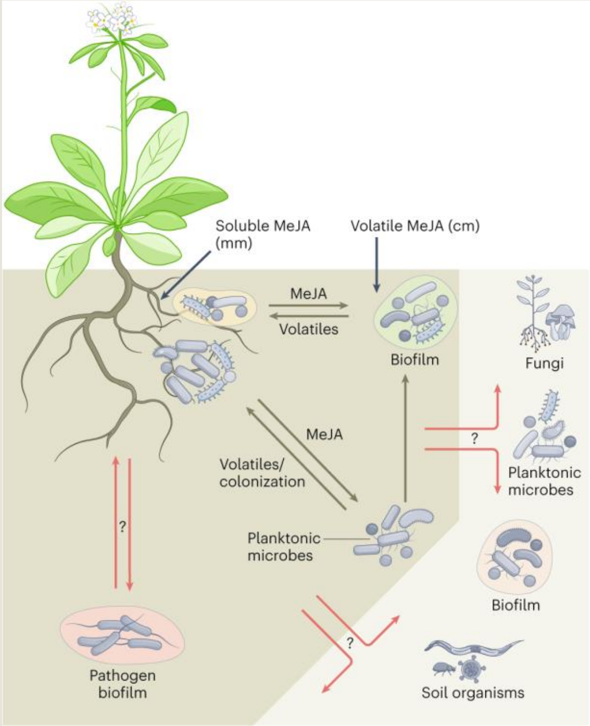

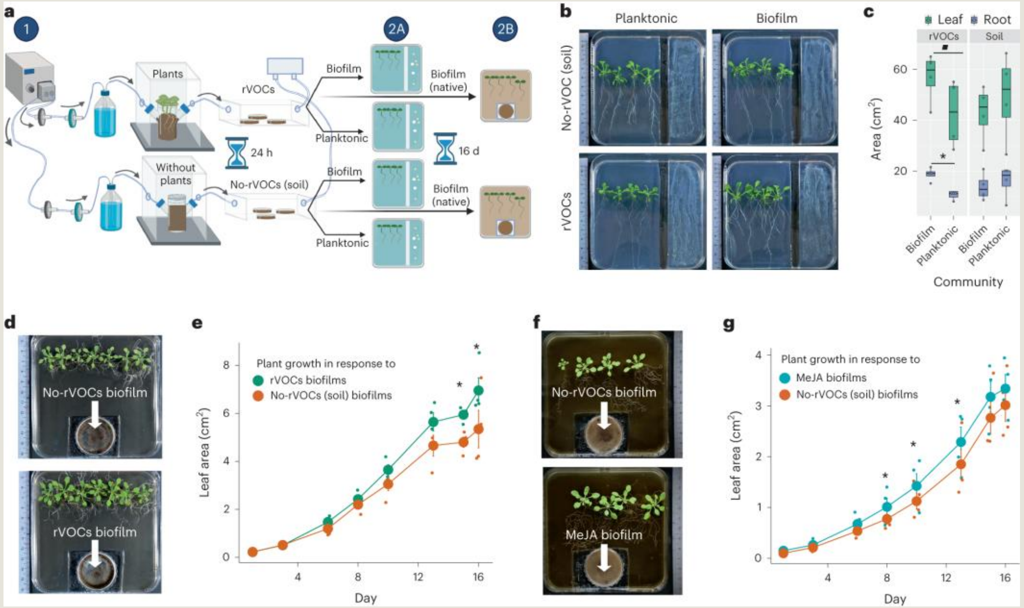

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Left: Raza and Jiang (2024) Right: Kulkarni et al. 2024

Combining crop protection strategies

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GenerationResearch

Ensuring food security for the future: Novel crop protection strategies

FUNDING: 9 weeks (full time, 37 hrs per week, £12.60/hr per hour, £700 consumables, £500 student accommodation bursary)

UKRI Biotechnology and Biological Sciences Research Council

White Rose Mechanistic Biology DTP

Universities of Leeds, Sheffield & York

LOCATION: YORK,, UK

SUPERVISOR(S): Dr. Sam Wilkinson, Dept. Biology, York

Application Form

Plant pests and diseases are a major threat to global food security. Our reliance on unsustainable chemical pesticides highlights the urgent need for alternative crop protection strategies. Hormones such as jasmonic acid (JA) play a key role in coordinating plant defence responses. Previous research found that soaking seeds in JA can enhance resistance in plants. A similar protective effect can also be elicited by exposing seeds to plant-beneficial microbes. This project aims to determine whether a dual treatment of soaking tomato seeds with JA and beneficial microbes offers greater protection than either treatment alone. Plants will be grown in a controlled environment chamber, with growth monitored over three weeks. Resistance to the pest *Mamestra brassicae* and the pathogen *Botrytis cinerea* will then be assessed. A student undertaking this project will learn to prepare seed treatments, cultivate tomato plants, monitor growth, rear insects, culture fungal pathogens, and evaluate pest and pathogen resistance. The student will be expected to take increasing ownership of the project after receiving initial guidance. Students will need to find their own accommodation and be expected to present their findings orally at a research day in York in September 2025

Crop: Tomato

Treatments:

- JA seed treatment.
- Synthetic community of plant-beneficial microbes.

Pests/pathogens:

- *Mamestra brassicae*
- *Botrytis cinerea*

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Acknowledgements

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NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

University of Sheffield

Dr Melissa Mageroy

Prof. Paal Krokene

Prof. Stephen Rolfe

Prof. Jurriaan Ton

The Research Council of Norway

UKRI Biotechnology and Biological Sciences Research Council

TRANSFORMING UK FOOD SYSTEMS
Strategic Priorities Fund

UNIVERSITY of York

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Biotechnology and Biological Sciences Research Council

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