Unlocking the Potential of Essential Oils: Illuminating Epigenetic Effects on Plant Defence Mechanisms

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doi.org/10.33548/SCIENTIA1125

EARTH & ENVIRONMENTAL SCIENCES

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Essential oils (EO) are potent in enhancing plant stress responses and mitigating seed-borne diseases, particularly in high-value crops such as tomatoes. While their direct impacts are recognised, the indirect influences on plant growth, metabolism, and immune responses against phytopathogens remain uncertain. Dr Marta Berrocal-Lobo, an esteemed Associate Professor and researcher at the Polytechnic University of Madrid, in collaboration with the Group of Biopesticides led by Dr Azucena Gonzalez-Coloma, is unravelling the transcriptomic and metabolic responses of tomato seeds treated with an antifungal EO against the pathogen *Fusarium oxysporum* sp. Their findings pave the way for harnessing EO in sustainable agriculture.

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Towards Sustainable Plant Protection

Amidst a global imperative to curtail reliance on hazardous pesticides, there is a pressing need for eco-friendly biopesticides. These solutions safeguard agricultural landscapes and vital ecosystems like aquatic habitats and forests. As the world embraces environmentally conscious practices, the quest for natural biopesticides gains momentum, aligning seamlessly with the evolving directives of the European Commission.

Artemisia absinthium is a medicinal herb renowned for its therapeutic properties. The derivative, *Artemisia absinthium* oil (AEO), exhibits notable antifungal prowess, particularly against notorious phytopathogens like *Fusarium* species and *Botrytis cinerea*. Yet, amidst its efficacy lies a realm yet unexplored: the subtle molecular transformations it may induce during plant germination.

Dr Marta Berrocal-Lobo, leading a dedicated team at the R&I Centre for the Conservation of Biodiversity and Sustainable Development at the Polytechnic University of Madrid, is undertaking a pioneering investigation to unravel the intricacies of short- and long-term plant protection and susceptibility stemming from seeds primed with AEO.

Employing the tomato-*Fusarium oxysporum* sp. *lycopersici* (Fol) interaction as their model system, they delve into the metabolic and epigenetic transcriptional shifts underpinning disease control and Fol tolerance. This groundbreaking research promises to bolster our understanding of plant defence mechanisms and chart a path towards greener, more resilient agricultural practices.

Artemisia absinthium Oil: Protecting Seed Properties

In collaboration with the esteemed BIOPEST group of the ICA-CSIC, a domesticated variant of *Artemisia absinthium* (var. Candial) takes centre stage. Through meticulous *in vitro* testing, the potency of AEO has demonstrated remarkable efficacy in thwarting fungal spore formation.

AEO-coated seeds emerge as guardians of seed integrity, particularly evident in the absence of fungal presence. Notably, AEO-treated seeds exhibit heightened basal production of callose and reactive oxygen species (ROS), fortifying their defences even in pathogen-free environments. This fortified resilience translates into tangible benefits during germination, as AEO-treated seeds showcase enhanced vigour and growth, setting the stage for robust plant development even amidst fungal challenges.

The Resilience of Tomato Plants

Fungal presence poses a formidable threat to the vitality of tomato plants, hindering germination and impeding early shoot and root growth. Compounding the challenge, fungal infection disrupts the plant's ability to mount crucial immune responses, notably the production of ROS and callose deposition during germination.

Enter AEO: a transformative shield against fungal onslaught. By coating seeds with AEO, researchers observe a remarkable reversal of short-term growth impediments and the initiation of a sustained defence mechanism. Even after 12 days, AEO-treated seeds exhibit elevated levels of ROS and callose, indicative of fortified immunity against fungal intrusion.

Dr Berrocal-Lobo and her esteemed colleagues at CSIC's Biopest group have looked further into the metabolic and transcriptional landscape of AEO-coated seedlings. Their findings point to a cascade of molecular changes orchestrated by AEO, culminating in enhanced plant resilience. Notably, AEO treatment triggers the production of vital metabolites such as vanillic acid, coumarin, lycopene, and oleamide, renowned for their roles in plant defence and antimicrobial responses. Moreover, transcriptional analyses reveal a concerted upregulation of carotenoid and fatty acid metabolic pathways, signalling a profound adaptation to fungal presence.

In essence, Dr Berrocal-Lobo's pioneering work underscores the enduring impact of AEO on plant tolerance, offering a beacon of hope for sustainable agriculture in the face of fungal adversity.

Reviving Plant Defences: Reactive Oxygen Species

ROS wield a double-edged sword in plant defence, capable of inducing cell death through apoptosis, a vital mechanism against pathogens. In the face of fungal invasion, the observed decline in ROS production within infected cells is expected. However, a remarkable resurgence of ROS is witnessed in AEO-coated seedlings, attributed to the induced synthesis of lycopene – a potent red carotenoid pigment celebrated for its antimicrobial prowess.

Unravelling Epigenetic Landscapes: Insights from AEO Seed Priming

Concurrently with metabolic shifts, the transcriptional landscape unveils intriguing revelations. Notably, the upregulation of two methyltransferases, pivotal players in the methionine cycle, alongside NRPD2 – an integral component of the DNA methylation pathway reliant on RNA – after 12 days of seed priming signals a profound epigenetic overhaul. Dr Berrocal-Lobo underscores the significance of deciphering these epigenetic signatures, poised to unveil the elusive targets of AEO treatment and the observed enhancement in plant protection. This groundbreaking research paves the path for harnessing 'directed epigenetic changes' via seed priming, offering a novel avenue to fortify plant resilience against diseases.

Forging Sustainable Solutions: Environmental Implications of AEO Seed Priming

Dr Berrocal-Lobo and her team champion the pivotal role of seed priming with essential oils in catalyzing transformative epigenetic shifts in crops, bolstering their resilience against formidable phytopathogens. The priming of tomato seeds with AEO not only instigates tolerance to *Fusarium oxysporum* sp. but also orchestrates a symphony of epigenetic modifications and methylation pathways, fortifying plant defences. These innovative strides hold promise for advancing eco-friendly biopesticides and cultivating plants resilient to environmental stressors, heralding a greener, more sustainable future for agriculture.

> The presence of fungus negatively impacts germination and the early shoot and root growth of infected tomato plants. Moreover, fungal infection impairs plant responses in the production of ROS and callose deposition during germination.

MEET THE RESEARCHER

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Dr Marta Berrocal-Lobo is an Associate Professor specialising in Biochemistry and Plant Biotechnology at the Forestry Engineering College of the Universidad Politécnica de Madrid (UPM). With a PhD in Plant Biotechnology from the Agronomic Sciences Engineering School in Madrid in 2002, Dr Berrocal-Lobo has cultivated a distinguished research career spanning multiple continents and prestigious institutions.

She honed her expertise during a two-year tenure at the Carnegie Institution of Washington, where she contributed to the Plant Science Department at Stanford University in California, USA. This was followed by a two-year research appointment at the National Center of Biotechnology in Madrid, Spain. Dr. Berrocal-Lobo further enriched her academic portfolio with five years of groundbreaking research at the Center of Biotechnology and Plant Genomics. Dr Berrocal-Lobo's impactful contributions to the field are underscored by her extensive publication record, which includes over 25 scientific articles, numerous review articles and book chapters, and the licensing of one patent. Her commitment to scholarly mentorship is evident in her supervision of over 17 Master's and PhD theses, nurturing the next generation of scientific talent.

Currently serving as the group leader at the R&I Centre for the Conservation of Biodiversity and Sustainable Development, Dr Berrocal-Lobo leads a dynamic research team exploring epigenetic and molecular plant immunity responses to phytopathogens. Their research endeavours aim to identify new priming bioproducts and biopesticides tailored to enhance plant tolerance across forest and non-forest species, particularly against high-impact phytopathogens. This vital work aligns seamlessly with the sustainability policies of the European Union, positioning Dr Berrocal-Lobo as a leading figure in the quest for environmentally sound agricultural and forest practices.

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FUNDING

PID2019-106222RB-C31/SRA (State Research Agency, Spain 10.13039/501100011033) European Hub on New Challenges in the Field of Essential Oils (EOHUB)

Erasmus+ 600873-epp-1-2018-1-es-eppka2. European hub on new challenges in the field of essential oils (eohub) (European Economic Community European Funds Erasmus+)

FURTHER READING

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