ERA CoBioTech

BioTech Research & Innovation Hack

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ERA CoBioTech Funded Projects at A Glance: SUSPHIRE

Sustainable Bioproduction of Pheromones for Insect Pest Control in Agriculture

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INNOVATION IS IN OUR GENES

SUSPHIRE

Sustainable Bioproduction of Pheromones for Insect Pest Control in Agriculture

Researchers with the EU-funded SUSPHIRE are contributing to the sustainability of pest control in agriculture through the establishment of fungal and plant bioproduction platforms for insect sex pheromones.

Insect pheromones, a sustainable solution to pest control in modern agriculture

Some of the most aggressive pests of agriculture are insect larvae. Semiochemicals are chemicals emitted by insects for communication. The most widely known of these are sex pheromones, produced by virgin females to attract mates of the same species. Dispensing insect sex pheromones in plant production environments is used to trigger mating disruption in the target species and prevent breeding, thereby providing a highly species-specific control method. This presents a sustainable alternative to conventional pesticides, the use of which are progressively being restricted due to concerns about their non-specificity and negative impacts on biodiversity. Insect sex pheromones are already used as a pest-control strategy; however, chemical synthesis is currently the only approach for manufacturing, and the use of toxic ingredients and the creation of toxic by-products is inevitable for some pathways. Further, the unusual chemical characteristics of many insect pheromones mean that chemical synthesis is not cost effective.

The SUSPHIRE project aims to demonstrate that biosynthesis can provide a sustainable, low-cost manufacturing platform for the commercial production of insect pheromones and reduce the cost of production of pheromones that are currently commercially non-viable. The long-term aim is production of a living bio-dispenser but the SUSPHIRE team also investigates several intermediate marketable products including pheromone-enriched biomass; bioproduced precursors that can be used to bypass unfavourable steps and reduce the cost of chemical synthesis; and enzymes to assist chemical synthesis of complex precursors. The introduction of these biotechnology approaches to pheromone production will expand the use of sex pheromones for sustainable pest control in agriculture, reducing its current environmental impact and providing sustainable manufacturing platforms.

Engineering plants and fungi as biofactories for insect pheromones

SUSPHIRE scientist focus in two types of pheromones: moth-type pheromones and mealybug-type pheromones. Moth pheromones have a relatively simple fatty acid-derived backbone. The genes involved in their biosynthesis are partially known, therefore scientist can directly transfer them with small modifications to plants and test which are the condition required for optimized bioproduction. The bioproduction of mealybug pheromones requires additional discovery steps. Mealybug pheromones are irregular monoterpenes, a very special type of molecules rare in the biosphere. Therefore, scientist need first to understand the biosynthesis steps prior to transfer them to plants and fungi.

Once the relevant genes are transferred to the biofactory organism, researchers need to measure parameters such as production levels, biomass, etc and evaluate the required improvements to make the strategy successful at an industrial scale.

Main results

During the project, SUSPHIRE scientist have successfully engineered several plant prototypes that produce moth-type pheromones as well as other prototypes producing irregular monoterpenes that could eventually serve as precursors of mealybug-type pheromones. With these prototypes, scientist have evaluated performance parameters, such us productivity, biomass or pheromone release rates that give them indications of the scalability and the potential for industrial use. Some of these results were extremely promising, serving as basis for future optimized versions of the plant pheromone producers. Social scientist in the consortium have also taken SUSPHIRE as a model project to propose mechanisms to ensure that scientists conduct their research in a responsible manner that takes into account the needs and values of European society.

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Consortium:

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National institute of Biology (NIB), (Slovenia)

Technische Universität Darmstadt (TUDA), (Germany)

Ecologia y Proteción Agrícola (EPA), (Spain)

Project duration:

1 April 2018 - 30 September 2021

Total budget: 1.6 €M

This project has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No [722361]

Future prospect

SUSPHIRE scientist have engineered for the first time a plant releasing to the environment significant amounts of an active insect pheromone. They have also created several intermediary prototypes that help to understand the additional bioengineering steps required for successful industrial upscaling. From this foundational step, many new opportunities will appear, including the design of new types of pheromones biofactories, able to defend crops from different pests in a specific and sustainable manner. Bottlenecks such as release rates and growth penalties have been identified, and some solutions have been proposed during the project, whereas others will require additional efforts in the future.
A main output in the project was the development of the first plant prototypes releasing active pheromone molecules to the environment. These are *Nicotiana benthamiana* plants producing a blend of moth pheromone volatiles. The scientific article describing this achievement was accepted for publication in BioDesign Research (a Science Partner Journal), and it is currently available also open access at the BioRXiv repository https://www.biorxiv.org/content/10.1101/2021.03.31.437903v1
The consortium also elaborated a comprehensive position paper entitled "Insect pest management in the age of synthetic biology" which is published open access in Plant Biotechnology Journal. DOI: 10.1111/pbi.13685
Several new Synthetic Biology tools for plant and fungi have been also developed during the project that will be pivotal in the engineering of new versions of pheromone biofactories. This includes the so-called FungalBraid cloning system (DOI: 10.1002/cpmb.116), and more recently, a copper-regulated genetic switch and som eother successful synthetic regulatory elements (https://www.biorxiv.org/content/10.1101/2021.09.07.459151v1.full.pdf)
Cai Y, Kallam K, Tidd H, Salzman A & Patron NJ (2020) Rational design of minimal synthetic promoters for plants. Nucleic Acids Research, gkaa682
Social scientist in the group have also elaborated assays using SUSPHRE as model project for Responsible Research and Innovation (The ties that bind – collective experimentation and participatory design as paradigms for responsible innovation. (erscheint in René von Schomberg und Jonathan Hankins (Hg.) Handbook of Responsible Innovation: A Global Resource, Edward Elgar, 2019) https://doi.org/10.4337/9781784718862
Several additional research outputs are now in the elaboration phase.

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Figure 1: The SUSPHIRE team meet at Technische Universität Darmstadt (TUDA), Germany.

Website: **http://susphire.info/susphireproject/**

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