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CORDIS Results Pack on

plant health

A thematic collection of innovative EU-funded research results

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Protecting plants to safeguard our future

Research and Innovation

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Editorial

Plant health is an overarching term for emerging risks including pests, diseases and weeds, integrated pest management and innovation in plant protection. It has the potential to contribute to the wider goal of ensuring the sustainability of primary production on an economic, ecological and social level. This CORDIS Results Pack showcases some of the cutting-edge projects at the forefront of research and innovation activities addressing plant health.

Healthy plants are no easy feat

Plants are the source of air we breathe and over 80 % of the food we consume. They play a critical role in achieving sustainable and competitive agriculture and forestry sectors and the protection of biodiversity and ecosystems. Therefore, keeping plants healthy is not only important, it is absolutely vital.

The achievement of healthy plants, however, is challenging for several reasons. For one, the trade and the movement of goods and people are facilitating the introduction, spread and establishment of plant pests and diseases. In fact, the Food and Agriculture Organization estimates that up to 40 % of food crops are lost due to plant pests and diseases annually. This impacts the food supply of millions of people and damages agriculture. Furthermore, climate change and intensification in agricultural and forest management practices can lead to the emergence of new pests and diseases, and existing ones are likely to become more severe. Adding to these challenges, people have turned to pesticides to secure yields in plant production. In doing so, there are mounting concerns over the effects of plant protection products on the environment, non-target organisms and human health.

Understanding these challenges, the European Parliament and the Council adopted Regulation (EU) 2016/2031 on protective measures against plant pests in October 2016. The new rules entered into force on 13 December of the same year, and aim to modernise the plant health regime, enhance more effective measures for the protection of the Union's territory and its plants, ensure safe trade, and mitigate the impacts of climate change on the health of crops and forests. The United Nations has also declared 2020 as the International Year of Plant Health with the aim of raising global awareness on the importance of protecting plant health.

Research and innovation facing threats head-on

A significant amount of research and innovation activities have been undertaken to address the challenges to plant health. Many of these are funded under different areas of Horizon 2020, including Marie Skłodowska-Curie Actions, the European Research Council (ERC) and the SME Instrument.

This pack focuses on 10 Horizon 2020 projects devoted to tackling the threats to plant health. The ASTERIX project has developed field robots that integrate machine vision and precision nozzle technology to discriminate weeds from plants and spray drops of bioherbicide only on the weeds, reducing the usage by more than 90 %. Another project, BIOFERTICELLULASER, employed plant growth-promoting bacteria as fertiliser to improve crop yield. Meanwhile, the DESSA project designed a decision support tool that provides accurate, farm-specific information to farmers on plant protection actions.

The EMPHASIS project addresses native and alien pest threats for a range of both natural ecosystems and farming systems. EUCLID has developed sustainable pest management methods for European and Chinese agriculture, while FOUNDATION is studying the molecular dialogue of Fusarium oxysporumto find new control strategies.

Then we have MET-PEST. This project has developed novel methodologies for the selective determination of fungicides in food, and in nEUROSTRESSPEP entirely new classes of biopesticides have been developed and tested. NEURICE has developed novel rice varieties with improved salt tolerance, and finally the POnTE project has optimised surveillance and prevention programmes for the management of future emerging agricultural diseases.

Asterix the farmer-robot conquers weeds with biopesticide without spraying interleaved crops

As global population growth and climate change are placing burdens on the world's food supply, more sustainable and eco-friendly ways to put food on the table are needed. An EU-funded robot with an eye for weeds and biopesticide as a weapon promises to augment crop yield for the masses.

More than 350 000 t of pesticides were sold in the EU alone in 2017. Aside from the potential health effects on the people who farm and consume products exposed to pesticides, the widespread use of pesticides is having serious effects on natural pollinators critical to our food supply and is more generally among the key causes of global insect decline and extinction threat.

Precision agriculture can increase the effectiveness of inputs to enhance farm profitability, natural resource management, and environmental and human well-being. The EU-funded Asterix project has embodied these benefits in an autonomous robot by the same name that applies eco-friendly biopesticides only to the weed leaves.

Bigger is better and hits just the spot

Conventional herbicides are applied by blanket spraying a mist to the whole field. In practice, it is very difficult to make the toxic effects 100 % selective for the weeds, resulting in some harm to the crop as well. Further, wind can carry the tiny droplets over significant distances where they can settle on water resources, adjacent vegetation, farm workers, and neighbouring homes and people.

"We have moved the selective properties from the herbicide to our spraying technique. A patented, vision-based, ultra-high-precision nozzle system is integrated with machine learning algorithms trained to differentiate between crops and their weeds."

As project coordinator Anders Brevik explains: "We have moved the selective properties from the herbicide to our spraying technique. A patented, vision-based, ultra-high-precision nozzle system is integrated with machine learning algorithms trained to differentiate between crops and their weeds." Asterix sprays relatively large individual droplets of bioherbicide only on the weed leaves. The larger drops minimise drift to non-targets.

Focus on farmers, benefits for all

The result of almost 10 years of development and testing largely in the fields of European farmers, Asterix can work round the clock, weeding most vegetables and herbs at a rate of approximately 1 ha per hour. It reduces the amount of pesticide used by up to 95 % and its 50 l of herbicide are equivalent to the 1 000 l in a conventional sprayer. Weighing about 10 % less than a tractor and sprayer, Asterix can also drive in the field shortly after rain to increase productivity.

Importantly, Asterix significantly augments yield. "We know from experience that herbicide use slows down crop development. We thought we might increase yield by about 5 %, but early data in parsley root suggest that we get approximately 45 % higher yield with Asterix," adds Brevik. He summarises: "Our technology will offer the public food with organic qualities with greater efficiency and lower cost than organic food production. It enables farmers to produce food that is good for consumers, the environment and the climate at an economically viable price."

Sowing the seeds of change

The team is ramping up to pilot with a few dedicated farmers in Germany and Norway to finalise technology validation. After that, Asterix is preparing a commercialisation plan that will increase sales in those two countries before moving into the rest of Europe. Asterix is on a mission to conquer new land and do its part to save the planet in the process.

PROJECT
Weeding robot for precision farming reducing herbicide usage by 95%

COORDINATED BY
Adigo AS in Norway

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/829983

PROJECT WEBSITE
www.asterixproject.tech/

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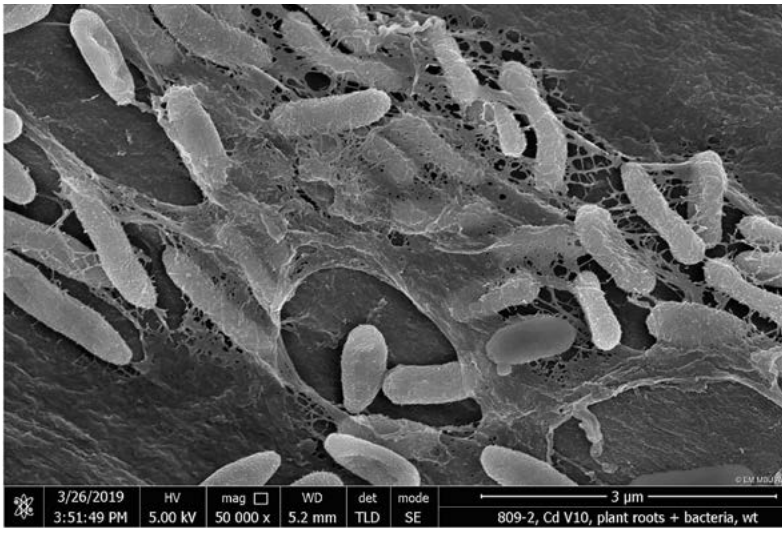
Bacteria as crop biofertilisers

Increasing food production with minimal resources while protecting the environment poses a significant challenge for humanity. A Marie Skłodowska-Curie initiative employed plant growth-promoting (PGP) bacteria as fertiliser to improve crop yield.

In agriculture, PGP bacteria constitute a promising and environmentally friendly approach to increasing crop yield. However, despite their great potential in lab conditions, implementation in natural soils has failed to produce the expected results probably due to an inability to adapt to new conditions or due to competition with soil native bacterial populations.



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A transcriptome approach to biofertiliser development

To address this issue, the EU-funded BIOFERTICELLULASER project invested in increasing knowledge of the molecular interactions between plants and PGP bacteria. "Our goal was to understand the factors that drive bacterial plant growth promotion and stress-resistance induction," explains project coordinator Pedro F. Mateos.

Researchers employed the rapeseed plant Brassica napus that is extensively utilised as a source of food for humans, for feed for animals and as a bioenergetic plant. They selected PGP bacterial strains capable of surviving as endophytes inside the roots, escaping the impact of adverse external environmental conditions and increasing their chance of survival when applied to the fields. In particular, they tested their in vitro mechanisms to promote plant growth such as sodium and potassium solubilisation and production of siderophores and phytohormones.

"Our goal was to understand the factors that drive bacterial plant growth promotion and stress-resistance induction."

Scientists selected the best bacterial endophytes and analysed their genome sequence. They annotated their genomes and explored the bacterial genetic machinery that potentially interacts with the plant to promote its development. Following evaluation in the field, they selected one PGP bacterial strain that offered significant plant growth improvement under stress conditions as well as protection against one of the most important rapeseed fungal pathogens, Leptosphaeria maculans.

This particular PGP bacterial strain underwent transcriptomic analysis when inoculated over the rapeseed plant roots. This led to the identification of a gene implicated in the synthesis of a bacterial metabolite that improves plant growth and resistance to biotic and abiotic stresses. To further elucidate its function, scientists deleted the gene and assessed the effect on normal and saline stress conditions, greenhouse assays and pathogen resistance.

The impact of PGP bacteria as biofertilisers

Chemical fertilisers used heavily in agriculture impose a significant environmental cost as they contaminate water and soils, consume lots of natural resources and emit nitrogen oxide gases with a greenhouse effect 300 times higher than CO_2. There is an overall consensus towards ecologically friendly fertilisers that can improve crop production and help reduce the use of dangerous chemical fertilisers.

BIOFERTICELLULASER selected PGP bacterial strains as biofertilisers based on their ability to enter the plant where they have fewer competitors and are protected from abiotic stresses. Ongoing work towards the identification of other bacterial genes implicated in the interaction with the plant will help elucidate the mechanisms for tolerating adverse conditions. This will aid not only the design of novel and better biofertilisers, but also the selection of plant cultivars with a better capability to tolerate stress conditions.

In view of the future, Mateos is confident that "the great potential of the bacterial strain we have isolated is worth exploiting further." Researchers are currently exploring the possibilities of a material transfer agreement with biofertiliser companies or a patent application by securing additional funding.

PROJECT

Role of bacterial cellulases in the transition from free living to root endophytes in rapeseed crops and in the design of efficient biofertilizers

COORDINATED BY

University of Salamanca in Spain

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/750795

Decision support tool reduces pesticides, boosts crop performance and yields economic gains

A crop protection approach called integrated pest management (IPM) is complex, and farmers require decision support systems to assist them in making the best choices about plant protection measures. An EU initiative has designed a decision support tool that provides accurate, farm-specific information to farmers on plant protection actions to be performed based on farm conditions.

The continuously growing need for agricultural production is paradoxically combined with limited soil and natural resource availability and unfavourable climatic conditions. Crop farmers struggle against this reality. On the one hand, they are being driven to shift towards greater sustainability, especially by reducing the use of pesticides, fertilisers and water. On the other, global markets demand an increase in production. The EU-funded DESSA project "provides real-time and accurate information to support farmers' decisions concerning the correct timing in pesticide use in order to reduce the number of applications without compromising crop quality and yield," says coordinator Giuseppe Mazzoli, CEO of coordinating company 3CiME.

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A 2009 EU directive on achieving the sustainable use of pesticides incorporates IPM. This farming system has been compulsory in the EU since 2014. IPM is regarded as key to the sustainable intensification of crop production and pesticide risk reduction. In IPM, all plant protection measures are considered jointly with the necessary actions that prevent pest population growth. However, implementing this holistic approach to sustainable agriculture can be difficult to manage.

Web-based decision support system for optimised crop protection measures

Project partners developed a decision support system that's based on the Internet of things and consists of sensors installed on a farm that measure key parameters such as pest/spore presence, humidity and moisture. These parameters are inputted into a cloud-based software built during the project that incorporates plant models. The software is comprised of algorithms that process the data. The exact measures

that must be taken based on each farm's circumstances are sent to farmers in real time via smart devices. "The system improves farmers' decision-making in crop protection, reducing crop production costs and boosting crop sustainability and production quality," explains Mazzoli.

The decision support system is user-friendly and addresses the agricultural sector's reluctance to incorporate digital solutions because it has been developed in close cooperation with farmers and cooperatives. It is also fully aligned with the EU directive since it engages farmers in practices with limited risk on human health and the environment, and gives priority to low pesticide input.

"The DESSA decision support tool is the first system to integrate sensors in fields with cloud-based analytic software that uses advanced crop-specific plant models for a wide range of fruits and vegetables."

Boosting crop yield and quality while reducing resource consumption

In a 1-ha tomato field in Italy, the DESSA team installed and successfully validated the prototype. Results showed a crop yield increase of 15 %, a pesticide reduction of 30 % and an overall reduction in production costs by 16 %.

In the 6 months following DESSA's completion in mid-2019, the consortium has been extensively spreading technology knowledge to farmers. Smart farming, and especially precision crop farming that was a focus of the project, has wide-ranging applications. The precision crop farming market is expected to grow at a compound annual growth rate of 12 % between 2018 and 2026. Its value surpassed EUR 4 billion in 2018, and is expected to reach EUR 7 billion by 2026.

"The DESSA decision support tool is the first system to integrate sensors in fields with cloud-based analytic software that uses advanced crop-specific plant models for a wide range of fruits and vegetables," concludes Mazzoli. "Farmers will need less time to monitor diseases in the field, use pesticides in a more sustainable way and watch their profits increase."

PROJECT
DEcision Support system for Smart Agriculture

COORDINATED BY
3CiME Technology S.r.l. in Italy

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/854408

PROJECT WEBSITE
3cime.com/en-us/Homepage/

Protecting European crops and biodiversity against new diseases and pests

Plant diseases caused by pests and invasive and alien pathogens are increasing with climate change and international trade. Now EU-funded scientists are looking for innovative ways to protect crops and forests.

Alien pathogens and pests cause havoc with crops and forests, affecting food security and livelihoods as well as biodiversity and ecosystem services. The EU-funded EMPHASIS project was set up as a broad-based approach for detecting and preventing the threat of invasive alien pests and local pathogens.

"Global trade together with climate change is really affecting the movement of pests, fungi, bacteria and insects which are continually arriving in Europe with plant material and with seeds," says project coordinator Maria Lodovica Gullino, director of the Centre of Competence for Innovation in the Agro-Environmental Field (AGROINNOVA), University of Turin, Italy.

"It is important to have good risk-analysis tools and models to understand the crops most at risk in Europe and the pathogens that can affect them."

"It is important to have good risk-analysis tools and models to understand the crops most at risk in Europe and the pathogens that can affect them," Gullino says. Epidemiological models were set up and existing models expanded to predict the arrival of new pathogens, especially alien species which may not be easy to detect in advance. Timely prevention and protection tools, which can reduce the use of pesticides in line with EU environment rules, were also developed.

Diagnostic tools

Molecular-level diagnostic tools based on the loop-mediated isothermal amplification (LAMP) method were developed to detect specific pathogens based on DNA amplification. "The molecular-based system is very easy to handle – it allows very quick extraction of DNA that can be done in the field, producing the results in just a few minutes," Gullino says, adding: "This diagnostic method has been developed for many pathogens with tests now available commercially and these are being used by technicians directly in the field."

This greatly reduces the delays encountered while waiting for results of laboratory cultures. "If you have instruments for quick detection, particularly molecular tools, then it becomes a method of prevention because you very quickly detect the pathogen and can reduce the number of direct interventions later on," she notes.

"Under the project, the LAMP-based system was extended in field trials to different pathogens that affect vegetables, cereals and forestry products," Gullino says. They include stem rust in wheat, downy mildew in basil, stem canker in oilseed rape and several others.

Sentinel plants

"We were also using sentinel plants – special plants put in the field that are affected very quickly so they can be used for very quick detection of the arrival of many pathogens." It is a

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simple system using plants or plots, varieties with resistance or susceptibility and treated or untreated crops, as an early warning system. It is also useful in timing first sprays, thus cutting down on pesticide overuse.

Other non-target-specific surveillance approaches included analysis of trapped fungal spores and insects. Metabarcoding using high-throughput DNA-sequencing technology for identification was developed to monitor spore trap samples for fungal pathogens and for monitoring sticky traps to detect spikes in numbers of invasive insects.

Other prevention methods included treating seeds, using specialised composts to improve plant health and resistance to disease, soils with microorganisms that reduce the growth of soil-borne diseases and integrated pest management systems.

Farmers associations were involved, with experiments conducted at the farm level. "This helps prevention, and also promotion of awareness, and it is a way of helping the new technologies and new management methods developed to be used by more farmers," Gullino says.

PROJECT
Effective Management of Pests and Harmful Alien Species - Integrated Solutions

COORDINATED BY
University of Turin in Italy

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/634179

PROJECT WEBSITE
emphasisproject.eu/

Technologies and tools to reduce agricultural pests in Europe and China

More sustainable pest management methods are needed to reduce the negative effects of pesticides on the environment as a whole. An EU initiative has developed sustainable production approaches for use in European and Chinese agriculture.

The EU-funded EUCLID project has introduced more sustainable pest management methods for Europe and China. Overall, the aim was to reduce the negative effects of pesticides, lower economic losses in agriculture, and provide scientific support to EU and China policies. "Agriculture is facing many challenges that we wanted to tackle by studying alternatives to pesticides for pest control in agriculture," says project coordinator Nicolas Desneux. Tomatoes, leafy vegetables and grapes were the main crops used in the research because of their economic importance in Europe and China.

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Pesticide alternatives for pest control

EUCLID partners developed and tested the potential of new or understudied integrated pest management (IPM) technologies. "The strength of the IPM technologies is that they target key pests and pathogens of worldwide commercialised crops," explains Desneux. "The use of EUCLID technologies allows a significant reduction in pesticide residues in the harvested fruits and vegetables."

Among these technologies, EUCLID project members investigated micro- and macro-biocontrol agents (BCAs) for the control of various pests. Macro-BCAs successfully fight the tomato leaf miner – the cause of large crop losses in tomato production. They also examined new technologies like the sterile insect technique to tackle cabbage moths and the RNA interference (RNAi) method, harmless to pollinators and natural enemies, against different pests.

"By delivering new innovations to reduce pest pressure on key crops, EUCLID has brought promising solutions to agriculture."

One especially promising IPM technology, a calcium-based biostimulant sprayed on tomato crops and grapes, is efficient against powdery mildew. The product is commercially available in Italy, but still needs to be registered across Europe. "Since it's a biostimulant, the registration process should be fast, making it even more attractive for other countries," says Desneux.

Supporting IPM knowledge and decision-making

Several papers, guidelines and web-based tools produced during EUCLID support sustainable pest management. Some key outputs include economic competitiveness, environmental sustainability, consumer preferences and policy

needs indicators, guidelines on using compost for controlling plant diseases and IPM benefits for end users. IPM packages contain solutions and strategies to encourage IPM adoption by farmers handling grapes, leafy vegetables and tomatoes. Decision support tools for reducing pesticide amounts in grapes and using pesticides optimally have been created. The IPM package assessment tool evaluates the potential of each developed technology on their environmental, social and economic performance.

Extensive knowledge transfer and dissemination activities like exchanges between farmers and farming advisors in field trials in seven countries and interviews with consumers and policymakers have helped to raise awareness and accelerate IPM adoption in agriculture. Over 35 open-access articles have been published, and more than 60 talks have been given at international conferences.

The inclusion of China and technology transfer to this country might also promote rapid IPM adoption between continents. In addition, pesticide-free technologies should have a significant positive impact on the environment, and particularly on the health of farmers and consumers.

"By delivering new innovations to reduce pest pressure on key crops, EUCLID has brought promising solutions to agriculture," concludes Desneux. "This will ultimately reduce the dependence of European and Chinese farmers on chemical pesticides."

PROJECT
EU-CHINA Lever for IPM Demonstration

COORDINATED BY
French National Institute for Agricultural Research in France

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/633999

PROJECT WEBSITE
euclidipm.org/

Parasitic fungus causing wilt and plant death targets different crops to wreak havoc

Fusarium oxysporum (Fo) is a formidable parasite; attracted to chemicals from plant roots, it invades its host causing massive collapse and death. By studying its molecular dialogue with different plants, EU researchers with the FOUNDATION project are looking for new control strategies.

There are more than 120 types of Fo species, each of which is adapted to a specific crop. No wonder then this soilborne parasite causes gigantic economic losses in field and greenhouse plants worldwide. "A recently emerged strain of this fungus, Tropical Race 4 (TR4), currently threatens to eradicate global banana production," emphasises Antonio Di Pietro, project coordinator and professor of genetics at the University of Cordoba.

Parasite 'talks' to host plant molecules

The researchers studied the interaction of Fo in three different plant species: tomato, banana and the model plant, Arabidopsis. "This enables us to identify the conserved mechanisms underlying biotrophic infection stages of Fo wilt disease during interaction with a broad host range," outlines Di Pietro.

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Some time ago, the research team discovered a chemotropic sensing mechanism by which this fungus locates plants in the soil, and grows towards chemoattractants released by the roots. The invader then grows silently with no symptoms in the plant cortex, after which it colonises the vascular tissue, often leading to plant death.

A second type of molecular cross-talk occurs in the biotrophic phase of root infection when the fungus grows between the cells of the root cortex, the apoplast. Di Pietro explains: "By using discovery proteomics, we are looking for key signalling molecules from both parties that likely shape the biotrophic molecular dialogue."

Evasion of the plant immune system is key to successful infection

FOUNDATION is providing the first glimpses into the biotrophic infection stage of Fo. For example, it is currently unclear how it evades recognition by the plant's immune system. Results so far indicate that Fo secretes a different set of previously unknown

effector proteins that may be crucial for the establishment of biotrophy.

Amey Redkar, the Marie Skłodowska-Curie fellow, is studying these early secreted effectors in the different fungal strains infecting tomato, banana and Arabidopsis. "Understanding the plant processes that are modulated by the pathogen for compatibility establishment will allow us to develop sustainable resistance," points out Di Pietro.

"Understanding the plant processes that are modulated by the pathogen for compatibility establishment will allow us to develop sustainable resistance."

Applications for resistance to infection in other crops

Evidence under the FOUNDATION belt so far obtained suggests that, similar to other fungus-plant interactions, resistance against Fo is based on molecular recognition of fungal molecules by specific host plant receptors. This then kick-starts the plant immune response.

However, pathogens can change the structure of these molecules or target the plant's defence system with effectors that suppress the immune response. Detailed knowledge of the 'arms race' between Fo and its hosts will reveal new resistance strategies, or even transfer resistance genes between different crops.

Problems getting enough fungus to work with

Obtaining sufficient fungal biomass for the analysis of biotrophic fungal signals has been a constant challenge. Applying the project's multi-model host strategy for the tomato-Fo interaction served as the main system for the analysis. "Transferrable to the banana-Fo pathosystem, this also provided us the opportunity to validate our results on different plant hosts," adds Redkar.

Application of fungicides to the soil is now banned in most agricultural settings, so improving plant resistance is the most efficient way to control vascular wilt disease. Di Pietro sums up: "FOUNDATION will provide key insights into vascular wilt molecular biology and open up new avenues for resistance crop breeding."

PROJECT
Fusarium oxysporum mediated underpinning of cell type-specific modulation in multiple host interaction

COORDINATED BY
University of Cordoba in Spain

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/750669

Novel fungicide analytical methodology improves food safety

Agriculture employs various chemicals such as pesticides and fungicides to enhance productivity, significantly impacting food quality and human health. A European initiative developed novel methodologies for the selective determination of fungicides in food.

Dithiocarbamates (DTCs) are one of the most commonly used fungicides effective against a broad spectrum of fungi and plant diseases. Additionally, DTCs are often used in combination with modern systemic fungicides to broaden their activity spectrum and enhance plants' resistance to various pathogens. This leads to elevated DTCs levels in food samples collected from the EU. Despite the environmental and food chain impact of DTCs, the current analytical approaches for determining their presence suffer from serious drawbacks.

Novel methodology for DTC determination

With the support of the Marie Skłodowska-Curie programme, the MET-PEST project developed and validated novel methodology for the accurate and selective determination of DTCs in food. The current European reference method for DTCs measurement is a single residue method and relies on non-selective and indirect quantification of the sum of DTCs species. To determine their concentration in fruits or vegetables, the existing method converts all DTCs fungicides into carbon disulfide, making it impossible to identify the original DTCs to which humans have been exposed.

"In MET-PEST, we combined different analytical methodologies to provide complete information on the exposure to individual DTC fungicides," explains the research fellow Alin Constantin Dirtu. Depending on the scope of the analysis, researchers developed methods that analysed DTC content based on class, residue content or degradation product.

The multi-approach strategy involved methodologies such as high-performance liquid chromatography (HPLC) combined with elemental/inorganic mass spectrometry (MS) – currently employed for trace metals speciation – and molecular/organic MS – currently employed for the organic contaminants. The approach based on the combination of HPLC with inorganic MS, was employed for the first time to determine the main degradation products of DTCs ethylene-thiourea and propylene-thiourea, currently not regulated in food in the EU. According to project coordinator Petru Jitaru: "Such a method can help improve food control and redesign the safety measures associated with DTC regulation."

"In MET-PEST, we combined different analytical methodologies to provide complete information on the exposure to individual DTC fungicides."

Scientists compared the analytical potential and efficiency of these methods in real-life food samples from EU countries as well as in samples imported from external markets. In addition, they investigated the impact of different cooking modes on DTCs degradation pathways. DTCs proved rather unstable upon contact with the acidity of fruits and vegetables during cutting and mixing, as well as upon storage and cooking. However, the MET-PEST methods could determine the DTCs fungicide through its degradation products.

Long-term impact

Collectively, MET-PEST has contributed towards improved analytical methodologies for DTCs determination, better

understanding of their stability and ultimately their impact on health. The selective DTC determination method developed during the project has the potential to replace the current reference method and precisely determine the toxicological profiles of the different DTCs species. Moreover, it can be employed to determine DTCs molecules currently forbidden in EU countries in fruits and vegetables imported from outside the EU market, further improving food safety control.

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Future plans include the development of an inorganic chemical technique for measuring sulfur-based contaminants in foods. Compared to the conventional HPLC-MS approach, this method will use isotope dilution for quantification with a more accurate outcome. Jitaru is confident that "the MET-PEST methods of selective DTCs determination will lead to a paradigm shift in foodstuff control measures, positively impacting consumer health."

PROJECT

Multi-approach determination of metal based pesticides in food

COORDINATED BY

The French Agency for Food, Environmental and Occupational Health & Safety (ANSES) in France

FUNDED UNDER

H2020

CORDIS FACTSHEET

cordis.europa.eu/project/id/753053

Peptide-based highly selective eco-friendly pest control

A multidisciplinary team of EU researchers has developed and tested entirely new classes of biopesticides based on insects' peptide hormones. They will reduce the risk of pesticide use in human health and are not harmful to the environment or beneficial insects, thereby providing sustainable crop protection.

High levels of agricultural productivity must be maintained to ensure that the growing human population is fed. Currently, around 20-40 % of world productivity is lost to insect attack according to the UN's Food and Agriculture Organisation. This is expected to worsen with climate change.

Insecticides are used to control pests and ensure food security. The answer, however, is not to simply eliminate all insects, as they play a vital role in the pollination of crops. Insecticide resistance is also a problem that has been detected for every major insecticide. Moreover, several mainstay insecticides are being limited or withdrawn due to tightening of legislation. Thus, 'greener', more selective insecticides are required that pests are not resistant to.

The nEUROSTRESSPEP project addressed this challenge by developing new small protein 'mimetics', similar in function to insect peptide hormones, which will interfere with the insects' survival ability. "These may be developed as new classes of environmentally-friendly insect control agents targeted to specific groups of insects, whilst protecting beneficial insects; and which do not engender insect resistance," says project coordinator Shireen Davies.

The consortium of 14 partners covered the full spectrum from research laboratory to field testing, involving ecologists, entomologists, biochemists, chemists, neuroscientists, physiologists, commercial companies and translational research expertise. In addition, the academic-industrial setting supported competitive European research and facilitated collaborative links between consortium participants and other stakeholders.

Insects' neuropeptides mimicked

Like humans, insects control their bodily processes with a number of peptides that circulate in their blood, although their peptides may be vastly different from ours. Many of these comprise short strings of amino acids called neuropeptides, however, not all insects use the same signals. nEUROSTRESSPEP therefore data mined the genomes of insects to identify neuropeptides which had features shared by agricultural pests but not by beneficial insects like honey bees. These formed the basis for designing new peptides that resemble the structure of these hormones.

"Researchers also designed, synthesized and tested more than 150 neuropeptide analogues for their ability to reduce insect survival, with assays to determine the most selective and bioactive analogues."

Project partners collated over 6 000 peptide sequences from across 97 % of insect species to identify order and species-specificity of neuropeptides and developed the new publicly available database for insect neuropeptide research (DINeR). They also used cutting-edge '-omics' technologies to comprehensively and accurately predict and identify all bioactive neuropeptides in pest, beneficial, and invasive alien insect species.

Furthermore, researchers performed a range of functional studies in 20 insect species including manipulation of neuropeptide gene expression

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for multiple neuropeptide families. This confirmed specific neuropeptides as excellent candidates for species-/order-specific insect biocontrol agents. "Researchers also designed, synthesized and tested more than 150 neuropeptide analogues for their ability to reduce insect survival, with assays to determine the most selective and bioactive analogues," explains Davies.

Multiple benefits for stakeholders

nEUROSTRESSPEP has provided a cost-effective and efficient way to control insect pests while protecting human health and more effectively preserving limited natural resources. This will help increase agricultural productivity and improve food quality, thereby safeguarding food security.

The project will communicate this innovative technology to the entire agri-food chain, comprising growers and producers, agrochemical companies, the scientific community, consumer groups, non-governmental organisations, regulatory bodies and the media. This will help to ensure maximum exploitation of the project's results and benefits.

PROJECT
Novel biocontrol agents for insect pests from neuroendocrinology

COORDINATED BY
University of Glasgow in the United Kingdom

FUNDED UNDER
H2020

CORDIS FACTSHEET
cordis.europa.eu/project/id/634361

PROJECT WEBSITE
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Introducing genetic variation in rice crops to protect against climate change and pest infestation

Rice is one of the most important cereal crops in the world. To address rice sensitivity to salinity and resist infestation by pests, European researchers developed novel rice varieties with improved salt tolerance through breeding.

The global temperature rise over the past 50 years has increased salinisation, especially in coastal areas, due to an increase in sea level and water scarcity. Salinity affects rice plant growth and reproduction, negatively affecting cereal productivity. At the same time, seawater treatment has emerged as the most effective strategy for combatting the apple snail species from the genus Pomacea, which eats the sown seed and the rice plantlets in paddy rice fields, inducing losses of tens of billions of euros a year.

Introducing genetic variation in rice crops

To overcome the negative impact of seawater treatment but also mitigate the effects of water salinisation due to climate change, scientists of the EU-funded NEURICE project developed commercial rice varieties. "Our goal was to obtain

rice lines tolerant to abiotic (salinity) and biotic (apple snail) stress," explains project coordinator Salvador Nogués Mestres. NEURICE brought together experts from diverse scientific fields such as biotechnology, plant physiology, farming and agriculture development, electrophysiology and cell signalling.

"Our goal was to obtain rice lines tolerant to salinity that can resist abiotic (salinity) and biotic (apple snail) stress."

Partners selected a salt-tolerance character called Saltol from a traditional Indian rice variety known to be one of the most salt-tolerant rice varieties in the world. They then back-crossed it for several rounds with different Spanish, French and Italian elite rice strains while selecting those descendants that kept the salt-tolerance genomic region, a strategy known as introgression.

The tolerance to salinity of these descendant plants was evaluated in hydroponic tests under controlled greenhouse conditions. At the same time, scientists investigated key mechanisms implicated in salinity tolerance control at the molecular, cellular and whole plant levels and sequenced hundreds of rice varieties to find out new salt tolerance-related genes.

"Introgressing a character in only 2 years is very challenging, and as far as we know we've developed the fastest backcross breeding protocol ever," emphasises Nogués. Scientists analysed over 70 DNA markers in each generation to select those individuals with the highest percentage of European variety genome. In addition, a break-through fast-breeding method including in vitro embryo-rescue technique forced immature rice embryos to germinate one month in advance and achieve three generations a year. This way they successfully introduced a chromosomal region by breeding in the fastest manner, yet avoiding transgenic technologies. Importantly, the new salt-tolerant rice varieties maintained the features required for the regional natural environment.

The future of salt-tolerant rice varieties

With Europe producing two thirds of its consumed rice in excess of 3 million t per year, maintaining rice crop health is paramount for agriculture and for food security. Researchers discovered new genes and alleles that can now be exploited to improve the adaptation of European rice varieties to the new conditions imposed by climate change, such as higher salinity, higher temperatures and less water availability.

According to Nogués: "The most significant achievement of the project was raising awareness among European farmers about the apple snail pest, and how to avoid its spreading to the main European rice production areas." Introduction of these novel salt-tolerant European rice varieties can lead to the eradication of the apple snail throughout Europe through seawater treatment. This will have a positive environmental and socioeconomic impact, avoiding less effective and highly contaminant chemical strategies.

Know-how obtained during NEURICE on how to produce these new salt-tolerant rice varieties, the discovery of new salt-tolerance genes and the new varieties themselves, will be fed into the European rice industry and rice farming sector. Coupled with improvement of management practices such as rational water use and implementation of remote salinity monitoring systems, it will significantly advance the agriculture of rice.

PROJECT
New commercial EUropean RICE (Oryza sativa) harbouring salt tolerance alleles to protect the rice sector against climate change and apple snail (Pomacea insularum) invasion

COORDINATED BY
University of Barcelona in Spain

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From genomics to satellite images: high-tech research tackles alien pests in Europe

Before the outbreak of olive quick decline syndrome in Puglia, the bacterium Xylella had never been detected in Europe. POnTE project researchers have optimised surveillance and prevention programmes to help manage future emerging agricultural diseases.

Stark statistics reflect the gravity of the effects of plant pathogens on agricultural yields. According to research stats from the EU-funded POnTE project, olive growers could suffer production losses up to EUR 7.5 billion over 50 years due to the Xylella bacterium.

Italy's olive trees: the first big research rescue mission

POnTE's coordinator and head of the operative unit of the National Research Council at Bari, Italy, Donato Boscia, describes the situation at the beginning of the project in 2015. "After the first detection of Xylella in 2013 and several scattered outbreaks in Italy, France, Spain and Portugal, POnTE contributed to raising awareness and surveillance for the disease by developing tools and protocols for efficient detection of the bacterium."

"Genomic studies fixed the approximate time and route of introduction of Xylella strains in Europe, all the information necessary for reducing the risk of further introductions," Boscia points out. Extensive transcriptome analyses and identification of possible differentially expressed genes shed light on host plant response and possible resistance pathways. The search for sources of evolved resistance to Xylella has revealed preliminary encouraging results and identification of resistant and or tolerant olive cultivars.

The meadow spittlebug is the main carrier or vector of this bacterium. POnTE identified the most relevant vectors in the EU and their preferred host plants in many crops, using the mark-recapture technique to track their potential natural spread. Data supported the design of targeted spittlebug surveys, field trials for the control of vector populations and development of important models for short-range spread.

Aerial pre-visual identification of Xylella-infected olive trees was achieved by using high-resolution hyperspectral and thermal imagery. Importantly, indicators for early and/or asymptomatic detection of Xylella infection were developed to achieve a method for automatic classification of disease severity over large areas.

Extending the research net to other crops and ecosystems under threat

Other pests, Candidatus Liberibacter solanacearum, CaLsol for short, that affects vegetable crops and Hymenoscyphus fraxineus, a fungus responsible of the ash-dieback disease in Europe's forests, received attention from POnTE researchers. Adopting the same multidisciplinary approach, they aimed to characterise the pests' biological aspects and propose strategies to control their spread in EU territory.

"After the first detection of Xylella in 2013 and several scattered outbreaks in Italy, France, Spain and Portugal, POnTE contributed to raising awareness and surveillance for the disease by developing tools and protocols for efficient detection of the bacterium."

Characterisation of the haplotypes of different CaLsol-infected samples from Europe and other Mediterranean countries enabled plotting of a map of their geographical distribution. Inherited together from a single parent, haplotypes are important indicators of ancestry and mutation that can be traced to follow pathogen spread and its evolution.

Automated traps have been developed that acquire and send images of the CaLsol vector, a jumping plant louse (the Psyllid family), to a remote server. Psyllid feeding behaviour was also studied using the electrical penetration graph technique and correlated with CaLsol disease transmission.

Agricultural impact and future research

Boscia sums up, focusing on the economic health of EU agriculture and livelihood of farmers in Europe: "POnTE data and dissemination will surely be of great help in the future management of these phytosanitary emergencies, and public awareness has also been increased as a result."

The research effort will not end with POnTE, as it is continuing with the complementary project XF-ACTORS. Improved surveillance and prevention programmes currently being developed will be sustainable and coexist with agricultural practices to manage alien pests, new and old, in Europe.

PROJECT
Pest Organisms Threatening Europe

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Zsófia TÓTH, Silvia FEKETOVÁ

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