D7.4 Digital and space-based technologies combined with Agro-ecological and Organic practices – Batch 1

APEMETA

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PU	Public	x
PP	Restricted to other programme participants (including the EC services)	
RE	Restricted to a group specified by the consortium (including the EC services)	
CO	Confidential, only for the members of the consortium (including the EC)	

DISCLAIMER

PestNu ● Grant Agreement: 101037128 ● Innovation Action ● 2021 – 2024 | Duration: 36 months

Topic: LC-GD-6-1-2020: Testing and demonstrating systemic innovations in support of the Farm-to-Fork Strategy

List of Abbreviations & Definitions

Abbreviation	Definition
AI	Artificial intelligence
AOP	Agro-ecological and Organic Practices
CDTA	Centro de Demostración y Transferencia Agraria
CERTH	Centre for Research and Technology Hellas
D	Deliverable
DoA	Description of the Action
DSS	Decision Support System
DST	Digital and Space based Technologies
EC	European Commission
ECHA	European Chemicals Agency
EGTOP	Expert group for technical advice on organic production
EIP-AGRI	European Innovation Partnership for Agricultural productivity and Sustainability
EIT	European Institute of Innovation & Technology
EO	Earth Observation
ESA	European Space Agency
EU	European Union
F2F	Farm to fork
FWG	Food Working Group
GDSO	Green Deal Support Office
INM	Integrated Nutrient Management
IoT	Internet of things
IPM	Integrated Pest Management
JPR	Joint policy recommendations
M	Month
N	Nitrogen
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organisation
P	Phosphorous
PA	Practice Abstracts
PBR	Photobioreactors
PF	Pesticides and Fertilizers

PLC	Power Line Communication
REACH	Registration, Evaluation, Authorisation, and restriction of Chemicals
SEVT	Federation of Hellenic Food industries
T	Task
UNHCR	UN Refugee Agency
UV-LED	Ultraviolet light emitting diode
WP	Work Package

Executive Summary

This deliverable builds upon the work done on PestNu's Task 7.2, which aims to coordinate synergies with policy makers and operational groups.

As foreseen in the project DoA it contains a number of 10 practice abstracts (PA), which provide the main information on the systemic innovations on Digital and Space based Technologies (DST) and Agro-ecological and Organic Practices (AOP) covered by PestNu Project, which have been already submitted to the EIP-AGRI as a form of coordinating with this operational group.

In this deliverable the PAs are presented in the form of factsheets, building upon the text that was submitted - short and with direct and understandable language - and enhancing it with some additional elements such as photos, keywords and useful contacts, for pursuing the common goal of providing practitioners, namely farmers with useful information on the opportunities and benefits arising from the adoption of these innovations or practices.

Moreover, the document updates on the work done by the PestNu consortium regarding other T7.2 goals, between M12 and M18, following the approach and methodology presented in the deliverable D7.3 (M12). Explicitly, it adds on EU instruments found relevant for PestNu and includes the main policy related outcomes gathered in roundtable discussions during PestNu national workshops held in Austria, Italy, Cyprus and Greece (thus adding to those reported earlier from Portugal, Spain, United Kingdom and Sweden). Additionally, main policy related highlights from other synergies that took place, namely from clustering with other projects, are reported.

This deliverable will be formally updated at M36 and complemented by a new set of 20 practice abstracts, which will also be delivered through the EIP-AGRI platforms for feeding knowledge all along the Farm to Fork (F2F) chain of value.

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1. Introduction

1.1. PestNu project overview

PestNu is a European funded Horizon 2020 Green Deal three-year project (Oct 21-Sep 24) which aims at reducing the dependence on hazardous pesticides and the loss of nutrients from fertilisers combining novel digital and space-based technologies (for insect detection, product application, crop monitoring and decision making) with agro-ecological and organic practices (biofertilizers & biopesticides from circular agrowastes&waters treatment, nutritional programs) deploying, upscaling, field-testing and demonstrating them (TRL5->7) in novel circular economy food production systems like aquaponics, closed/semi-closed hydroponic greenhouses, and in open-field vegetable cultivation, under different conditions, soils and crops (tomato, cucumber, pepper, lettuce).

The maturity of the proposed technologies is now at a stage where demonstration and a clear perception of its added value and benefit of adoption by farmers and practitioners are of utmost importance and thus, practice abstracts fill a key role in knowledge exchange and dissemination both during the project and in its after life.

1.2. Purpose and scope of this deliverable

This deliverable is an output of PestNu's Task 7.2 which aims to coordinate synergies with policy makers and operational groups.

It presents 10 practice abstracts (PA) that were prepared in order to provide the main information on the systemic innovations on Digital and Space based Technologies (DST) and Agro-ecological and Organic Practices (AOP) covered by PestNu Project. These have already been submitted to the EIP-AGRI (European Innovation Partnership for Agricultural productivity and Sustainability) as a form of coordinating with this operational group, using the foreseen template (Common Format).

Building upon the elements that were submitted, enhancement with some additional elements was performed so that this deliverable could also serve the purpose of acting as a tool for communication and dissemination of the innovations and knowledge generated in PestNu

Moreover, the document also reports the remaining of the work done by the PestNu consortium in the field of coordination with policy makers and operational groups between M12 and M18, namely the main policy related outcomes arising from roundtable discussions that took place during PestNu national workshops held in Austria, Italy, Cyprus and Greece. These add to the results already reported for the other countries involved in the PestNu consortium, like Portugal, Spain, United Kingdom and Sweden, in the deliverable D7.3 published in 30 September 2022 (M12). Additionally, it adds some EU instruments found relevant for PestNu and includes results from other synergies that took place, namely from clustering with other projects.

This deliverable will be formally updated at M36 and complemented by a new set of 20 practice abstracts to be delivered through the EIP-AGRI platforms for feeding knowledge all along the Farm 2 fork chain of value.

1.3. Methodology

Following PestNu's first year, the consortium was challenged to elaborate and produce the first batch of 10 practice abstracts.

Kick off took place at the consortium meeting at M12 with a suggestion for PA distribution building upon the work done on Work Packages, WP2 and WP3, devoted to the Deployment and upscaling of Digital & Space based Technologies (DST) and to the Deployment and scaling up of Agro-ecological and Organic Practices (AOP), respectively.

Next, monthly meetings along with some 1:1 contacts allowed for the necessary interaction between the task leader and the partners in charge of building the practices. During this time close collaboration between partners and several reviews for improvement took place, in order to comply with the criteria set by the Common Format for EIP-AGRI. Furthermore, authors were asked to provide some additional elements such as photos, keywords and useful contacts so that, for the purpose of this deliverable, factsheets could be produced building upon the text submitted thereby creating a new set of tools able to be used for communication and dissemination purposes.

In addition to all 10 practice abstracts being in English, all of them will be translated into the different European languages of PestNu partner countries, including Greek, Italian, Portuguese, Spanish and Swedish and uploaded in the digital platform under the section Downloads.

Concerning the remaining of the coordination with policy makers and operational groups, different types of synergies were, as already foreseen in the DoA, for exploring/establishing relevant interactions for achieving the goals set for T7.2, namely via

- Collaboration and involvement with EC services and events (ex: e-meetings of the Food Working Group, participation in the Action Plan promoted by the Green Deal Support Office (GD-SO), attendance of an EU CAP Network Seminar)
- Direct meetings (ex: with EGTOP)
- PestNu national workshops (Austria, Italy, Cyprus, Greece)
- Clustering events with sister projects (ex: Clustering events on biopesticides and IPM)

1.4. Document structure

Following this introduction, Section 2 presents the first batch of 10 factsheets built from the practice abstracts for practitioners delivered to the EIP-AGRI whereas Section 3 reports the main recommendations for Policy and Research emerging from PestNu activities in these last 6 months and finally, Section 4 summarizes the main conclusions and displays some recommendations.

2. Digital and space-based technologies combined with Agro-ecological and Organic practices – Practice Abstracts for practitioners (batch 1)

According to the EIP-AGRI, practice abstracts are short summaries (1000-1500 characters) able to serve end users in their daily practice by describing the main information/recommendations emerging from the knowledge generated in projects. These are to be as interesting as possible for advisors/farmers/end-users, by using direct and easily understandable language and highlighting elements that are particularly relevant for them.

They provide, as far as possible:

• A brief description of the context

• The main results/outcomes of the practice (expected or final);

• The main characteristics that may justify the interest/choice of the practice.

• The main added value/benefit of the practice

The practices will be made available and accessible on the EIP-AGRI website, as well as in the PestNu website as factsheets on PestNu downloads page, and will be used in upcoming project activities such as workshops and exhibitions, webinars and trainings.

2.1. AI Robotic Trap for real-time whitefly and black aphid monitoring

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

AI Robotic Trap for real-time whitefly and black aphid monitoring

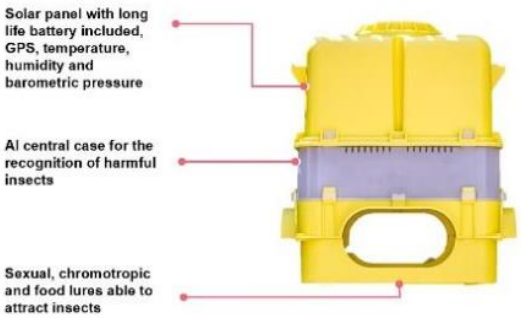
agriculture; smartfarming; AI; modular; trap; pests; alert; aphid; whiteflies

Italy

The EU-funded PestNu project will deliver Artificial Intelligence (AI) robotic traps for real-time pest monitoring in open-fields and greenhouses. The trap uses AI-based image processing algorithms (developed by CERTH) for the identification of whiteflies and black aphids, along with self-adaptive forecasting and prediction models that are capable of predicting pest attacks (developed by AGROROBOTICA). The trap, exploiting a 5G antenna and a GPS module, can rapidly send an alarm in the case of an insect attack providing the optimised plan for crop protection to the Decision Support System under cybersecurity. Finally, the trap is optimally designed (by AGROROBOTICA) to attack easily the targeted insects using 3D printing (developed by CERTH).

Pest infestations cause an average of 35% pre-harvesting losses and insects account for roughly 50% of these losses by reducing productivity and affecting crop yields. Furthermore, pests can also pose health risks to both farmworkers and consumers when pesticides are used to control them. By accurately identifying and monitoring pests with the PestNu AI Robotic Trap, farmers can adopt more targeted and effective pest management strategies that reduce the use of harmful chemicals and enhance the safety of agricultural practices.

solar-powered robotic AI trap



PestNu AI Robotic Trap main components

Practice abstract n.1

Valerio Goglia (Agrorobotica), Nikolaos Giakoumoglou (CERTH)

Valerio Goglia (valerio.goglia@agrorobotica.it)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 101037128.

2.2. Development of low-cost portable analysers for nutrient monitoring in aquaculture and aquaponics systems

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

Development of low-cost portable analysers for nutrient monitoring in aquaculture and aquaponics systems

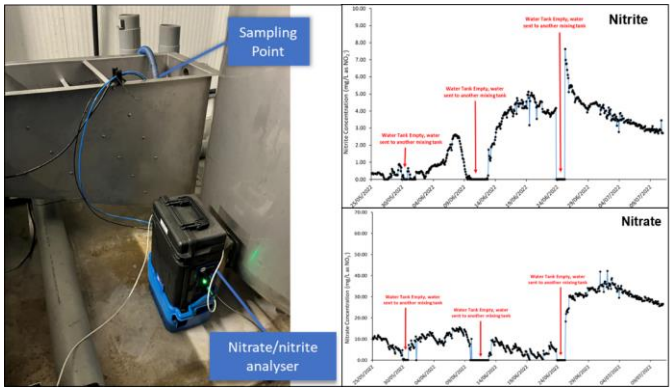
ion chromatography, 3D-printing, Nutrients, Water analysis

Ireland

Effective nutrient monitoring in aquaponics and aquaculture systems is crucial to achieve a profitable production and for complying with environmental discharge regulations. Analysis of nutrients such as nitrate, nitrite, ammonium and phosphate are usually carried out with high-cost analytical instrumentation in external labs that take a few days to report back results so no immediate decision-making is possible for fertiliser dosing and waste discharge. In recent years, a range of various online nutrient monitors have shown promise but remain expensive, deliver poor accuracy and are frequently impacted by the interferences found within the complex sample matrix of aquaculture and aquaponics.

Portable and low-cost nitrate/nitrite, ammonium and phosphate analysers developed by T.E. Laboratories during the PestNu project have achieved high accuracy of results based on ion chromatography and UV-LED detection. The development of these analysers was facilitated by 3D-printing technologies for the manufacture of components specifically tailored to the user and market needs developed in collaboration with CERTH. 3D-printing has revolutionised the industry because of the nearly complete flexibility it allows when developing prototypes, while also maintaining a considerably low price point compared to benchtop analysers.

The analytical systems developed during PestNu will be deployed and tested in real conditions on aquaponics and aquaculture systems from project partners in Greece and Spain.



Nitrate/nitrite portable analyser deployed at Tilamur aquaponics facility (Murcia, Spain) showing variations in nitrate/nitrite concentration over seven weeks.

Practice abstract n.2

Valeria Arenas-Montaño (Tellab), Meritxell Grau Butinyac (Tellab), Simon Bluett (Tellab), Ria Pechlivani (CERTH), Eoin Murray (Tellab)

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 101037128.

2.3. Precision Agricultural Robot for Agriculture 4.0

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

Precision Agricultural Robot for Agriculture 4.0

agrobot, precision agriculture, agriculture 4.0, robotics

Greece

The EU-funded PestNu project will deliver a precision agricultural robot that can operate in both greenhouses and open fields. The agrobot co-developed by CERTH-IKH will be able to navigate autonomously, avoid obstacles, fit in the tight rows in greenhouses, move on the heating pipes and lift its robotic arm 6 meters high. Its mission is to detect pests and diseases using AI algorithms (such as black aphids, whiteflies (developed by CERTH), botrytis' early detection (co-developed by CERTH-IKH) and spray the affected areas with high precision.

The agrobot addresses the rising needs of Agriculture 4.0, integrating innovations such as precision farming, IoT, big data analysis with AI and robotics in order to achieve greater production efficiency. The agrobots are autonomous machines that are able to carry out different agricultural tasks on the farm – from land preparation to harvesting – without direct human intervention. They are able to operate unsupervised in unstructured environments and can perform numerous activities such as autonomous precision seeding, mowing and pruning, picking and harvesting, monitoring and analysis and, last but not least, spraying and weeding. The PestNu agrobot focuses on the latter, while being modular and adaptable to be able to undertake other activities in the near future.

PestNu's agrobot will boost safety in agriculture, by distancing the farmers from the hazardous chemicals, will ensure reliability and repeatability in its accurate, high-quality work and promote sustainability by reducing the amount of wasted inputs and usage of water.

PestNu's autonomously navigated precision agricultural robot for greenhouses and the open field

Nikos Frangakis (iKnowHow SA), Nikolaos Giakoumoglou (CERTH)

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 101037128.

Practice abstract n.3

2.4. A device to automatically follow growth and status of microalgae during cultivation

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

A device to automatically follow growth and status of microalgae during cultivation

monitoring; growth; microalgae; optimization; AI

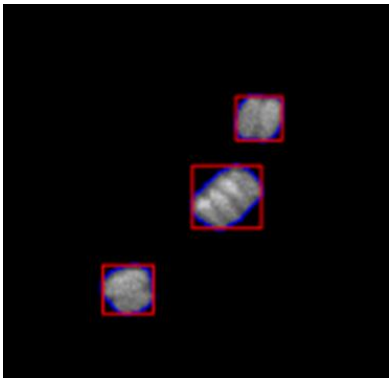
Sweden

The cultivation of microalgae for different purposes is increasing worldwide. Common to all types of cultivation is the importance of finding the best growing conditions to optimize production and quality of the harvested product.

In the PestNu project, we are developing a device that can monitor the growth of microalgae in real-time, as well as automatically evaluate the shape and size of the individual algae. The information can be used to optimize conditions and provide early warning of potential problems affecting the algae culture. Such problems might be caused by nutrient deficiencies, toxic substances, cross contamination by other microalgae, and even "infections" of the culture by grazing organisms that simply eat the microalgae.

The detection device itself takes small samples at pre-set times and passes them through a flow cell where a camera takes micro-pictures of the culture. The images are thereafter analysed to characterize the algae in terms of number, size, shape, as well as growth rate.

The camera system is designed to see the weak red fluorescence coming from the green chlorophyll inside microalgae when they are illuminated, making the algae shine in the dark depending on the load of chlorophyll. The collected images are automatically analysed by AI-based software, and information is transferred via a web-based interface to any computer or smartphone.



Example of an image used in automatic data processing for determination of the proportion of *Desmodesmus* microalgae growing in the preferred quadruple form indicating healthy growth.

Practice abstract n.4

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2.5. The importance of Earth Observation Tools: The AgroRadar

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

The importance of Earth Observation Tools: The AgroRadar

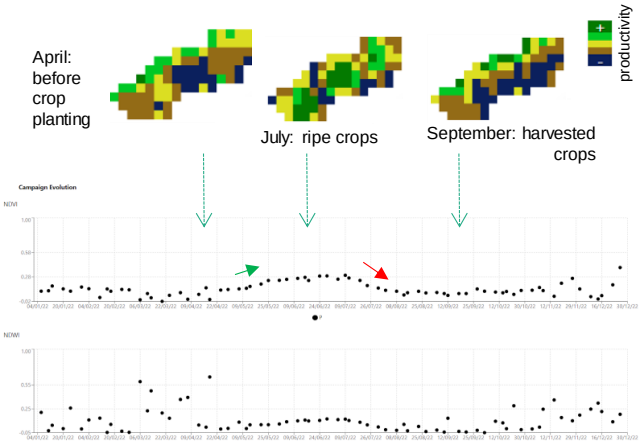
precision agriculture, remote sensing, blockchain, crop anomalies

Portugal

PestNu project follows the Farm to Fork and Green Deal strategies for a new and better balance of nature, food systems and biodiversity, by field-testing and demonstrating space-based digital technologies and agro-ecological practices to reduce the pesticides and fertilisers use. Earth Observation (EO) tools arise as a good technological and cheap approach to map plant nutrients and pests using satellite images from the Copernicus program data/services from European Space Agency (ESA).

Farmers can have their crops monitored and inspected in space and time. They can access information on plant productivity and water stress, vegetation structure, regional canopy temperature (extremely important to delineate pests and diseases management risk zones) through the SmartAG application, the user-friendly interface of AgroInsider's AgroRadar platform (deployed in PestNu), which automatically downloads and processes EO (ESA Sentinel 1, 2) and Meteosat 2nd Generation (Land Surface Temperature) data using artificial intelligence algorithms that provide big data and deep learning abilities on agro data.

Through the SmartAG app, the farmer can also register georeferenced evidence - samples' coordinates, photos, videos and sound recordings from the field can be automatically uploaded to the database, thus improving traceability procedures of food production systems targeting the Sustainable Development Goals marketplaces. Moreover, PestNu foresees additional protection of the evidence registered through AgroRadar by blockchain technologies (deployed by CERTH). In this way, PestNu is creating a transparent process from food production to the end consumer throughout the value chain.



6 Monthly analysis of crop (tomatoes and peppers) productivity in 2022

Temporal analysis of tomato and pepper production in 2022 at CDTA (Spain) with visible productivity increase up to July when they were ripe (maximum productivity and NDVI - Normalized Difference Vegetation Index - value)

Practice abstract n.5

Patrícia Lourenço (AgroInsider), José Rafael Marques da Silva (AgroInsider), Georgios Gogos (CERTH), Ria Pechlivani (CERTH)

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2.6. Plant enabler production using hydroponic wastewater

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

Plant enabler production using hydroponic wastewater

microalgae; biofertiliser; circular economy; green economy; no-waste

Italy + Greece

PestNu wastewater treatment is a microalgae-based, containerized, modular, scalable, and self-controlled plant capable of treating manure sludge in Photobioreactors (PBR) with low operational and installation costs.

The system treats wastewater to reduce the quantity of Nitrogen (N) and Phosphorous (P) contained, thanks to the microalgae that are fed with N, P and CO_2. As a result of the process, the water is partially depurated and it can be used for irrigation purposes, with concentrations of N & P compliant with EU regulations. In addition, the produced microalgae biomass can be harvested and used to produce high-value bio-products, such as plant biostimulants. The process is automated and continuously controlled by a central system (PLC) from which the sensors, the pumps and the lighting system are connected. The data recorded (pH, flow rates, temperature) through the sensors permits the system to be automatically adjusted and optimised. The main innovation is the installation of an additional tank, inserted after the biomass collection to convert the biomass into a biofertilizer. It is expected the system will produce a microalgae-based biofertilizer capacity of 10 Kg per five days. The main short-term effects of the plant are:

- Creation of a circular economy model compatible with the Agri-farm wastewater purification process.
- Production of algal biomass purification process Cost / Benefit analysis, allowing operators and managers to analyse the potential of PestNu technology.
- The agricultural sector has raised awareness of environmental impacts, transferring the concept of waste = resource.

The Container Plant

Tanks

Biofertiliser reactor

PLC
Power Line Communication

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Practice abstract n.6

2.7. Decision Support Systems for Agriculture

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

Decision Support Systems for Agriculture

Decision Support System; DSS; innovation in agriculture; farming data analysis

Greece

PestNu is a comprehensive project that helps farmers improve crop quality and prevent potential issues through a variety of tools and products. These tools gather and process data in a database, which can then be accessed through PestNu's Decision Support System (DSS).

PestNu's DSS, developed by CERTH & SIDROCO, is a user-centric cloud-based Farm Management System that provides circular economy strategies and best practices for efficient decision-making in agriculture. Farmers can use DSS to get detailed information about their crops, including suggested actions and strategies to improve yield and prevent threats. Additionally, DSS produces an analytical report on demand, containing historical data gathered from cultivation. By processing data with algorithms, DSS can provide farmers with recommendations that are based on the latest information and best practices in the industry.

The benefits of DSS usage are:

- Process large amount of data and extract useful information
- Comparison of current with previous conditions in the field
- Beneficial and comprehensible analysis of the crop
- Punctual and immediate notification when issues or threats are detected
- Reduction of required time for physical presence at the production field

The objectives of DSS are to:

- Reduce the usage of fertilizers and pesticides
- Avoid preventable issues and threats occurred at the production field
- Improve the working conditions of farming
- Increase the income and reduce the production costs of the farmers
- Motivate people to involve with farming

Practice abstract n.7

Ioannis Hadjigeorgiou (SIDROCO), Theocharis Saoulidis (SIDROCO), Georgios Gkogkos (CERTH), Nikolaos Giakoumoglou (CERTH), Ria Pechlivani (CERTH)

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 101037128.

2.8. The usage of biostimulants on open-field vegetable crops

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

The usage of biostimulants on open-field vegetable crops

biostimulant; hydroponic; stress; yield

Spain

PestNu targets agro-ecological and organic practices (AOP) in a systemic approach to reduce pesticide and fertiliser use and nutrient loss. For this reason, the effect of biostimulants on plant growth and yield has been assessed in an open-field farm in Murcia, where different formulations have been tested on lettuce, tomato and pepper crops. In addition, the PestNu project will demonstrate the use of biopesticides focused on fungal diseases under organic farming conditions, combining these products with the aforementioned biostimulant and a biofertiliser developed within PestNu.

The biostimulants under testing are produced using a biotechnological process converting microalgae biomass grown with drainage solutions from hydroponic greenhouses into a sustainable and effective product.

The use of AOPs such as biostimulants can help growers achieve higher yields by providing them with a product that acts as a booster to the fertiliser already applied to their crops. Biostimulants have a high concentration of free amino acids from the high protein content of the microalgae biomass, which are biostimulants at certain stages of plant growth (as well as phytohormones, trace elements, vitamins, etc.) and can improve their stress tolerance.

In a field test (CDTA, Murcia) with lettuce plants, the combination of biostimulant + fertiliser led to a similar yield to a conventional test and slightly increased it compared to a test done with the fertiliser itself (about 7%). These lettuce presented a lighter and more ideal average weight (450-650 g), than the conventional ones, which were heavier and far from the commercial calibres. This is a step forward considering some of the project's goals (30% more production than a conventional test).

PestNu field trials with lettuce plants in CDTA, Murcia, Spain

Practice abstract n.8

Joaquín Castejón (CDTA), Pedro Mínguez (CDTA), María Álvarez (Neoalgae), Sofia Faliagka (UTH), Pablo Quirós (FERTINAGRO)

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2.9. Establishment of a nutritional program for organic farming

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

The usage of biostimulants on open-field vegetable crops

biostimulant; hydroponic; stress; yield

Spain

Among its goals of demonstrating agroecological practices, PestNu focuses on the implementation of organic fertilisation plans by Fertinagro, using organic fertilisers and biostimulants, for better use of soil nutrients.

Nutritional programs priorities:

- Edaphic regeneration
- Rhizosphere nutrition
- Metabolic potentiation of the plant

NUTRITIONAL PROGRAM FERTINAGRO

PRODUCT (Kg/Ha)	IN	Ground	Rooting and plant development				Plant development						HARVEST	
		Time 0	W42	W43	W44	W45	W46	W45	W46	W47	W48	W49	W50	RECOLEC.
Efisoil Renovation					5			2,5						
Aminovit Vigorion Azon						2					2			
Efisoil Aminoshoot ECO				12,5						12,5				
Biogel Ferrum														
Microquel Amin Copper			5											
Efisoil Superbia AzoN					2				2					
Superblackpot												4		

Ecological nutritional program carried out by Fertinagro for CDTA in PestNu

The aim is to support supporting higher-quality organic crops with yields equal to or higher than conventional fertilisation, improving soil quality. Although it may be more expensive than traditional fertilization, soil regeneration and care lead to a more balanced production. It is also an effective and sustainable tool in hydroponics and aquaponics systems.

In PestNu, a nutritional program is being applied to tomato, cucumber and lettuce crops in open field, aquaponics and hydroponics. Open field trials conducted in Spain (CDTA) with tomato and lettuce plants resulted in similar yields compared to their conventional counterparts. Fertinagro's biofertiliser helped increase commercial yield (within ideal weight). However, root toxicity was recorded in a trial performed in an aquaponic system (Tilamur, Spain) after mixing two biostimulants. New trials are underway using the biostimulants separately.

Promising results were obtained in aquaponic and hydroponic trials (University of Thessaly, Greece) when foliar spraying two liquid biostimulants on lettuce and tomato crops. In the case of lettuce, both products increased yield compared to plants standardly fertilised. Both biostimulants resulted in higher leaf Ca^{2+} content in lettuce tissue. Similar results were also found in tomato crops. Tomato yield, calcium, and nitrogen uptake were significantly enhanced.

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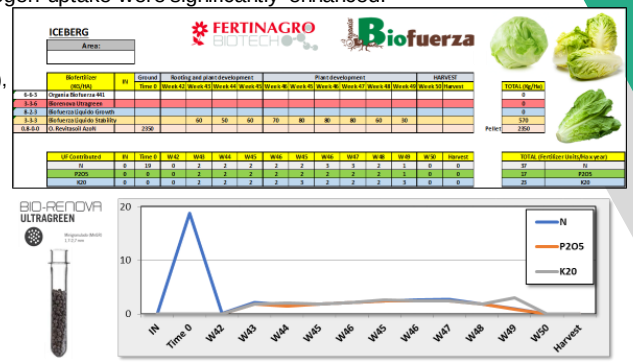


Example of a nutritional program used in PestNu: (Week 42: 9-15 October)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 101037128.

Practice abstract n.9

2.10. Manufacture and use of an ecological biopesticide against fungal diseases in vegetables

PestNu

"Field-testing and demonstration of Digital and Space based technologies with Agro-ecological and Organic practices in systemic innovation"

Manufacture and use of an ecological biopesticide against fungal diseases in vegetables

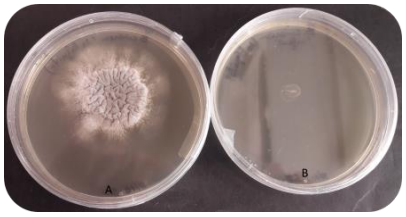
Sustainability; fungal disease; biofungicide; broad spectrum; circular economy

Spain

The PestNu project targets agroecological and organic practices to reduce pesticide use, following EU strategies and increasingly restrictive regulations regarding the use of conventional products.Fertinagro designed a biofungicide with fungistatic capacity against the foliar phytopathogenic fungus Botrytis cinerea providing also a biostimulant effect. Moreover, this product is effective against mildew infections. The biopesticide was designed based on a circular economy approach, using by-products such as agricultural and food waste as raw materials. It is composed of:

- Potassium carbonate
- Surfactant
- Humectant
- Vegetable extracts
- Water

PestNu & Fertinagro's biopesticide



A: *Botrytis cinerea* growing on Saboraud agar (5 days after inoculation); B: *Botrytis cinerea* has not been able to grow on Saboraud + PestNu biofungicide agar. (5 days after inoculation)

Its final market price would be approximately 15€ / 500cc.

Within PestNu field trials, two tests were carried out (CDTA, Murcia, Spain), one in June 2022 using a pepper crop, and one from December to January 2023 using lettuce plants. However, no fungal infections appeared in the first trial. The fungicide-treated lettuce plants showed traces of chemicals on the leaves, while the PestNu plants (biopesticide) were free of contaminants.

Regarding the fungal attack in the first lettuce crop, 20% of the lettuce analysed presented severe damage by fungi (mildew) when using a conventional pesticide, while only 5% of lettuce suffered from severe damage when using PestNu biopesticide. In the second lettuce crop, after a conventional fungicide treatment, 13.5% of analysed lettuce was severely damaged, compared to 19% damage found for PestNu-treated plants, while the % of partially damaged lettuce was very similar in both treatments. Taking into account that we are comparing the effect of the biofungicide PestNu with chemical pesticides, the results are promising.

Lettuce crop in CDTA

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 101037128.

Practice abstract n.10

3. Coordination with policy makers and operational groups

3.1. Overview of relevant related EU instruments (continuation)

The aim of this Section is to continue reporting EU instruments found relevant for PestNu activities in continuation of what was done on D7.3 (Section 3) of the PestNu Project.

3.1.1. REACH regulation

Brief overview

Created by the EU, REACH regulates the Registration, Evaluation, Authorisation, and restriction of **Chemicals**. The goal of REACH is to limit the potential risks chemical substances impose on both human health and the environment. REACH is enforced by the European Chemicals Agency (ECHA). The ECHA manages the technical, administrative, and scientific aspects of REACH.

The REACH Regulation was adopted in 2006 to better protect human health and the environment from the risks of chemicals, while promoting the competitiveness of the EU chemical industry. This is one of the main instruments that sets standards for chemicals. As part of the Green Deal and its European Chemicals Strategy for Sustainability, in 2022 the EU announced a revision aiming to adapt the legislation to put the European chemical industry on the path to sustainability and achieve the ambition of a toxic free environment, while ensuring that innovation and competitiveness of our chemical industries are stimulated. However, the Commission's Work Programme 2023 has now announced the postponement of the publication of the revision to the fourth quarter of 2023. With its upcoming EU-presidency in the first half of 2024, Belgium has expressed multiple times its willingness to see the revision come as soon as possible, ideally in the second quarter of 2023, in order to be able to work for a revision before the end of this EU legislature.

Relevant or crossing points for PestNu

- Rules governing the registration, evaluation, authorisation and restriction of chemicals in the EU
- Procedures for collecting and assessing information on the properties and hazards of substances

Relevant actions & initiatives for PestNu to build upon

- Track commission adoption, planned for second or fourth quarter of 2023 and assess impacts (positive and negative) for PestNu
- Evaluate possible adaptations needed in WP5 (Demonstration & evaluation of the systemic innovations in operational environments) tasks requiring impact assessment

More information

REACH

Understanding REACH

EU's chemicals strategy for sustainability towards a toxic-free environment

EU must deliver REACH revision before end of current legislature

3.1.2. Waste Framework Directive

Brief overview

The Waste Framework Directive sets the basic concepts and definitions related to **waste management**, including definitions of waste, recycling and recovery. Among others it explains when waste ceases to be waste and becomes a secondary raw material, and how to distinguish between waste and by-products, thus setting an important legal background for enforcing circular economy.

The foundation of EU waste management is the five-step "waste hierarchy" (Figure 1), established in the Waste Framework Directive. It establishes an order of preference for managing and disposing of waste.

The Commission is currently working on a targeted revision of the Waste Framework Directive and has conducted a preliminary analysis in the context of assessing impacts, including stakeholder consultations. Based also on this, the Commission has defined the scope of the policy initiative for the targeted amendment of the Waste Framework Directive in 2023. Among others, the initiative will assess the feasibility of setting food waste reduction targets to implement the Union's commitments under the UN Sustainable Development Goals and the F2F Strategy and limit the food supply chain's impact on the environment and climate.

Figure 1 Waste hierarchy set by the European Waste Framework Directive.

Relevant or crossing points for PestNu

The Commission is preparing a set of end-of-waste criteria for priority waste streams.

Individual components (biodegradable waste) used for the manufacture of the finished product are not yet affected by the end-of-waste status, i.e. they continue to constitute waste.

The end-of-waste status of a product offers advantages to the enterprise that wants to market such product. In many MS, new products made from biodegradable waste continue to be regarded as waste even if they have been properly placed on the market under national law. Such products continue to be

subject to waste legislation until they are recovered according to their purpose. If, on the other hand, an enterprise decides to CE mark such products and market them as fertilisers, the finished product is not subject to waste legislation. This means that such a product is no longer subject to various obligations arising from waste law, such as the verification procedure, the use of the A-signs and restrictions on use.

The change is directly related to the European Commission's “end-of-waste criteria” for recycled materials. The European Commission's "Circular Economy Package” also aims to re-classify as products (i.e. as non-waste) such materials that have undergone a recycling process and fulfil certain general conditions applicable throughout the EU, thus simplifying and harmonising the legal framework for operators in the recycling sector.

The end-of-waste status will create an incentive for enterprises to invest in the development of new bioproducts made from recycled materials. This is because, in addition to the fact that these products no longer fall under waste legislation, an innovative enterprise can also advertise the environmental friendliness of its products to an environmentally aware user.

Relevant actions & initiatives for PestNu to build upon

- Track commission adoption, planned for second quarter 2023 and assess impacts for biopesticides development

More information

Waste Framework Directive

Changes to harmonize EU fertilizer legislation: The new Regulation (EU) No. 2019/1009

3.1.3. European Citizens' Food Waste Panel

Brief overview

Citizens' panels are becoming a regular feature of democratic life in the EU, bringing together randomly-selected citizens from all 27 member states to discuss – at European level – key, upcoming proposals that affect us all. European citizens’ panels see participants working together in small groups (each of around 12 people) and all together (in plenaries). A facilitation team provides support. Based on the discussions, citizens make recommendations for the European Commission to consider when defining policies and initiatives.

Between mid-December 2022 and the end of April 2023, three panels consisting of around 150 participants will have the opportunity to develop concrete recommendations on some of the key initiatives of the 2023 Commission Work Programme. The first set of citizens' panels will address the issues **of food waste**, virtual worlds and learning mobility.

Relevant or crossing points for PestNu

The Food Waste Citizens’ Panel sessions took place between December 2022 and February 2023 and 23 recommendations were presented to the European Commission around three lines of action aiming to: strengthen the cooperation in the food value chain; encourage food business initiatives; support the change of consumer behaviour

Relevant actions & initiatives for PestNu to build upon

- Monitor Citizen's panels' future actions and results in order to assess points in common with the PestNu strategies, namely those involving reaching out to consumers (ex. MASOUTIS)

More information

European citizens' panels

3.1.4. European Year of Skills Initiative

Brief overview

The European Year of Skills puts skills centre-stage. Helping people get the right skills for quality jobs and helping companies, in particular small and medium enterprises, address skills shortages in the EU is what this Year is all about.

Relevant or crossing points for PestNu

Among others, they foster the showcasing of skills development opportunities and activities across Europe, the easier recognition of qualifications across borders, they bring organisations and people together to share their experiences and insights, and set out how EU initiatives and funding possibilities can help.

Relevant actions & initiatives for PestNu to build upon

- Design and register PestNu trainings as skilling events on the platform

More information

European Year of Skills

3.2. Recommendations for Policy and Research under PestNu workshops

The aim of this Section is to provide an update onthe outcomes of the roundtables that took place during national PestNu's workshops held between September 2022 and March 2023, in continuation of what was done on D7.3 (Section 5.4.1) of the PestNu Project.

As then stated, the first set of the national PestNu's workshops angled for taking the most out of the gathering of relevant stakeholders for promoting collaboration, building of bridges and breaking of silos between actors of the food chain and primary sectors. All workshops' agendas sought to actively promote debate, including roundtables focused on the discussion and identification of barriers of existing guidelines, opportunities to build upon and also what incentives would encourage adoption of innovations and solutions by EU farmers towards Integrated Pest Management (IPM) and Integrated Nutrient Management (INM).

3.2.1. Austria

Brief description

The Austrian cluster workshop was held as a hybrid meeting on 25th of October 2022 in Vienna. The theme of the workshop was pesticide reduction with DST and AOP with PestNu partners presenting technologies and products, as well as local speakers presenting relevant trends in Austria, the barriers and opportunities of precision farming in the Austrian context. The event was organised by the PestNu project partner Global 2000. Participants were reached out to and invited based on their expertise and involvement in the field of DST and AOP. These participants included members of the PestNu advisory board, industry stakeholders, research institutions, policy experts, farmers representatives and NGOs. A total of 29 people attended the event.

Goals

The aim of the workshop was to bring together Austrian stakeholders, discuss some wider issues around new technologies in agriculture and elaborate solutions which could be translated into policy recommendations. The workshop built on further issues which have already come up in previous workshops in this thematic area.

Approach

Firstly, the PestNu project was introduced and some of the technologies being developed were presented by the project partners in order to provide a clear understanding of the innovations, as well as the whole project scope, goals and approach. Experiences and perspectives from external speakers and national stakeholders who work and research within this same field of agricultural innovation were included. These presentations were followed by a roundtable discussion held with the aim to discuss potentialities for pesticide and fertiliser reduction with the help of digital technologies in Austria.

Key Findings

Agricultural transformation

- Defining a common vision – participants shared their vision for sustainable agriculture and what role the reduction of pesticides plays in a deeper transformation. Main conclusions identified the need for holistic solutions requiring fundamental system change. While technologies offer opportunities in the right direction, they are not the only solution.
- Getting to the root of the problem - Climate change, drought, erosion, monoculture linkage to current problems regarding pests needs to be addressed such as their more frequent occurrence, poor soil fertility etc. A shift towards organic farming emerged as a key to healthy ecosystems and pesticide reduction.
- Strengthening regional and circular economy and raising awareness on the value of food - are important points to focus on from a policy perspective.
- Agroecology and diversity (cultures, ways of doing business, operating structures) - are needed for food systems to be able to absorb volatile crises.
- Networking and exchange - Doing politics and getting people talking to each other. Participants shared that sometimes they don't know what's happening around the corner, highlighting that

it is important to show: What's going on elsewhere? What great solutions are available? Discussion focused on how we could all cooperate in finding a common solution and conclusions highlighted that farmers' interests, science, politics – there should be basics of agreement on this and built upon that.

Usability and adoptability of digital technologies

- Technologies must work in practice - Farmers need to be certain that new technologies actually work before investing in them. Technologies must be extensively tested in practice and consultations with developers must take place. Feedback should be given once robots have been in operation for a while. Farmers have made the experience that things sound great in theory and should work theoretically, but in practice sometimes they don't work.

- Advisors and training/ education play an important role in spreading new technologies to farmers – a shareable example is that training in the field of digitalisation in agriculture exists in Austria for students between 15 and 19 years. There is also a Bachelor's degree program: agricultural biology and link to technical digitization.

- The monetary costs are one of the main barriers - robotics is currently not affordable for average farms in Austria. It must pay off on the farm to buy a subsidized product - often only farmers with 1000s of hectares purchase precision agriculture equipment. How do we acquire and share digital technologies? In Austria the "Maschinenring" exists which facilitates common use of digital technologies.

- Inclusion of small-scale farmers is important – Care should be taken to ensure that these farmers are not "structurally excluded" as there are already many areas that do not apply to them. Knowledge transfer must not go only in one direction saying "the farmers must know how this works..." but also engage in asking what is actually needed by the (small-scale) farmers.

- Technology life cycle and resource use - It is crucial that digital solutions actually contribute to a use of fewer resources: production of digital technologies must need less energy and resources etc. Long before the technologies come to the farm, energy and resource expenditure should be considered. The topic of saving energy has to be especially considered when we look at robotics. A doubt emerged on whether different robots for different cultures will be needed and what are indeed its impacts in terms of resource and energy use.

- Diverse landscapes are valuable – Austria's agricultural landscape is very diverse and mostly does not have standard conditions for robotics. For encouraging mosaic agriculture, there is the potential to adapt robotics to it. It is indeed conceivable that automatic control can support diversity.

Pesticide and fertiliser reduction targets

- Participants discussed the dependency on synthetic pesticides and fertilisers concluding that market regulation could be the most effective tool to reduce dependency without creating new other dependencies.

- Awareness on the value of food is needed – Conclusions point out that food waste can't be ignored when talking about the reduction of resources, such as synthetic pesticides. Sometimes there is more food waste in organic farming, because some things cannot be treated without chemical means. So far there are missing alternatives that really work.

Five main points emerged as “must-dos”

- Increase the efficiency of industrial/ conventional practices and reduce the use of environmentally destructive inputs.
- Substitute industrial inputs and practices with alternative practices.
- Reorient ("redesign") the agro-ecosystem with new pillars for ecological processes.
- Establish a more direct link between food producers and consumers
- Build a new global food system based on equality, participation, democracy and justice. This goes beyond sustainability and helps to restore the life-supporting systems, on which we all depend on.

3.2.2. Italy

Brief description

The Italian cluster workshop was held on 19th of October 2022 in Fondi, in Lazio region, Italy. The theme of the workshop was “The PestNu project and the Farm to Fork (F2F) strategy in the Italian agri-tech landscape” thus allowing for Italian PestNu partners to present their technologies and products, and also discuss and interact with relevant stakeholders, thereby raising awareness on pesticides and digital tools and the probable impact of new EU regulation, while building up from the knowledge and opinion sharing from actors all along the Farm 2 Fork value chain. The event had an audience of 18 people in the room and another 16 online, including researchers, advisors, tech developers, farmers, teachers, and public authorities.

Goals

Besides the dissemination of the PestNu project and its innovations, namely those under deployment by partners Agrorobotica, STAM and Agroinsider, this workshop aimed to discuss barriers and opportunities regarding policy and regulatory, technological and also economic aspects that affect Italian agricultural context, with regard to Digitalisation, bringing together different perspectives and putting up to discussion the most relevant hot topics.

Approach

The agenda was designed to reflect the goals of the workshop, with panels devoted to the presentation of the PestNu innovations, complemented by talks on the importance of technological development in Italy and related barriers, and also on national agricultural policies, fertilizers/pesticides and the innovations foreseen in the national context in the light of the most recent national and EU regulation as well as investors vision for enabling technologies in the food and precision agriculture sectors. The workshop also included a roundtable discussion on "What opportunities, barriers and incentives could help improve farmers' adoption of digital innovations towards more sustainable food production systems?"

Key Findings

- Despite the undeniable enhancement that digital technologies and precision agriculture represent to agronomic practices that have always been used, there are several factors hindering their

adoption by farmers. It was highlighted the limited access some of them have to these technologies, problems related to communication between the various technologies. For instance, there is currently no facilitated access to telematic services such as to reduce this gap.

- Also, sometimes there is a non-correspondence between these technologies and the real needs of the farmers/companies using them, or inadequate responses to farmers/companies' requests for innovation. It is still possible to make a distinction between those that adapt to currently adopted practices and those that, on the other hand, cause a change in such practices. Sometimes only the basic functions are under use, thus not exploiting the full potential of the innovations. On the other hand, if the technological innovation completely involves the process, bringing a real reorganization at company level, an expansion of skills, or even a change in the business model, the adoption of these technologies does not only translate into the purchase of some tools but in a real acquisition from scratch of tools and methodologies can generate a real cultural revolution in the way of managing the farm/company.

- Farms represent real ecosystems which are nowadays asked to contribute to environmental and social sustainability as well as to the protection and improvement of natural resources such as water, air, soil and therefore to increase the level of safety and well-being of the community. This is not a trivial commitment and support is needed so that there is adequacy of the innovation to the context that will host this process in order to avoid reducing it all to economic terms. Moreover, it must be a concern the whole F2F value chain to find proper approaches.

- The current and consolidated version of the Regulation 2115/2021 is seen to be bringing a considerable increase of bureaucratic process. Additionally, and for Italy in particular, it will envisage a reduction of around 62% (in quantity) of pesticides and fertilizers (PF), and that may put the entire Italian production chain in difficulty, above all for high-income crops such as horticulture. Moreover, it seems that recently there has been a slowdown of the demand for organic products; and also as organic cultivation yield is lower operators are forced to intervene more frequently and use greater quantities of PF.

- There is concern arising from the fact that at least 32% of the agriculture production units in Italy, with peaks of up to 80% in the Veneto, that fall under sensitive areas and Natura 2000 areas where there is an absolute prohibition of using PF set by the new regulation.

- Although ultimate goals of safeguarding man and the environment and attention to climate change must be guaranteed and precision agriculture is the way to achieve productions recognized by the market, farms, while complying with mandatory regulations, must be able to continue their business while maintaining the typical competitiveness of a market economy.

- A critical issue that concerns micro realities or individual sector operators is to understand which ones can benefit from using digital technologies, and the doubt comes precisely from the cultural "Modus Operandi" that individual farmers put in place as for them, the very low margins of the sector do not allow for reaching a satisfactory quality of service / price ratio for digital tools, and this asks for new approaches. This aspect can be addressed in a decisive way by trying to find a solution for small farmers, for example, operating through consortia that have a daily relationship with many of them, supplying these machines to each of them supported by a consultant who will monitor alert and the status of multiple devices through a unified DSS, in this way it will be possible to achieve fundamental objectives: 1) some machines would have a lower cost, with purchases in large quantities by the consortia (accessibility); 2) field consultancy in the "Setting-up" phase would allow defining the technical details of the field and crops in order to make the most of the devices

(Consultation) and 3) the cost of the consultant could be spread over a greater number of agricultural operators thus obtaining a negligible cost per unit

- It could also be possible to evaluate monthly instalment payments with an "all-inclusive" service. However, the problem does not arise in the case of medium-large agricultural enterprises that have greater resources (both human and economic), know-how to adopt DSS systems integrated with the devices. Thus, results can hardly be achieved without concrete actions, differentiated according to the size of the companies.
- Considering current fertiliser's costs, having a self-sustainable bio-stimulants production could help farm's economic balance. From a regulatory point of view, the two products/outcomes of the PestNu plant: the purified water and the bio stimulants shall be standardized and respect specific quality and origin standards before the consumption in the farm, and possibly outside the farm, if the bio-stimulants are sold on the market. However, the path towards the standardization and certification is complex, even though there is certainty that if certified products are available to farmers, they will consider investing innovations such as the wastewater plant proposed by PestNu.
- Among the factors that could certainly facilitate the funding of innovative companies, with particular regard to the Agritech sector, it was highlighted the existence key metrics for the reference sector and of the tools for measuring and representing company performance. Those could contribute for a clear, complete and verifiable flow of information representing a basis for reducing the risk in investment management relationships.

3.2.3. Cyprus

Brief description

The Cypriot cluster national workshop took place on the 14th of December 2022, in Nicosia, both physically at the facilities of the Cyprus Productivity Center and online. The title of the workshop was "Sustainable agriculture in Cyprus: Towards the application of the Green Deal". The main scope of the event, organized by STRATA, has been the presentation of the current situation of agriculture in Cyprus as well as to present trends of the sector, and bring together people from the farms, public authorities, academia, industry and associations. Totally 58 individuals participated in the event, 20 physically and 38 online.

Goals

The main goal of this workshop has been to bring together people from different parts of the sustainable agriculture value chain, and generally for the agriculture sector in Cyprus. This contact's intention was to reveal, via discussions, topic in agriculture in Cyprus which need to be changed, differentiated, or improved in order to successfully apply the Green Deal directions. To this end, at the first part of the workshop the presentations aimed mainly at the depiction of the current situation of the agriculture in Cyprus nowadays. Of course, above all, a very important goal of the workshop was also to present the PestNu project in depth, to all the participating stakeholders, in terms of dissemination.

Approach

The Workshop initiated with the presentation of the PestNu project, its scope, its expected impact and objectives. The technologies developed within the context of the project were also presented in detail. After that, two presentations regarding the current situation of agriculture and bio-agriculture in Cyprus

took place. The following presentations elaborated mainly on the topic: the Biopesticides, biostimulants, and biofertilizers: opportunities and perspectives for sustainable agriculture, and at the end of the first part of the workshop a case study of a successful aquaponics farm in Cyprus has been presented. These presentations were followed by a round table discussion which deepened mainly in the needs for change, in order the Green Deal to be applied, as well as in policy and regulation changes which are required.

Key Findings

- Small bio-farmers require an immediate set of a national strategy to support organic farming and which will include initiatives to the farmers to follow organic farming, investments and funding to young farmers in order to follow organic farming and finally extended educational programmes regarding new regulations. The current requirements and procedures for setting an organic farm are too complicated, and the costs in order to maintain them are extremely high. This is the main reason why organic agriculture in Cyprus only represents close to 5% of the total farming sector (and it should reach 25% by 2030).
- The ministry claimed that there is a well-organized structure of promotion and education regarding the application of the Green Deal. The farmers support the opinion that it needs to improve. Also, the agronomists supported the opinion that there should be an organization, responsible for the education and knowledge transfer to the agronomists and the farmers as well.
- After the closing of the “cooperative bank” the farmers face financing problems and they need the support of the government, in order for them to be able to adopt smart technologies in their farming. The farmers’ association claimed that big funds from the ministry of agriculture are not distributed to the farmers and stay unexploited. They believe that the requirements of receiving funding from the ministry organizations should be readjusted in order for more professionals to deserve them, so all the available funds will be channelled to the farms.
- There is a need for a new regulation in Cyprus regarding drones and targeted air spraying. The mass air spraying in Cyprus has been cancelled as the farm sizes are not big enough to support air spraying. Also, the crops are differentiated in a small area so air spraying is not an ideal option. There is a need for the development of a new regulation which will allow the use of drones, which will proceed with targeted air spraying.
- As a conclusion it should be highlighted that a common vision of all the wide spectrum of stakeholders regarding the application of the Green Deal and the reduction of pesticides and fertilizers use was perceived, however in Cyprus there are a few obstacles, mentioned above, which have to be overpassed and corrected in order to proceed with the effective transformation of the whole agriculture context towards sustainability.

3.2.4. Greece

Brief description

On 31st January 2023, SEVT organized a hybrid workshop entitled “New technologies and agro-ecological practices for the achievement of F2F strategy goals” within the framework of European project PestNu. The event took place in Athens with more than 100 participants, 35 participated physically and

74 on-line. The attendees who participated were mainly representatives from universities, food industries, agriculture associations and policy makers.

Goals

The aim of the workshop was to present the European project PestNu and also to discuss the promotion of the green transition within the framework of European policies, such as the Green Deal, the F2F Strategy and the Recovery and Resilience Fund, which contribute to the creation of a new model of development and innovation.

Approach

The opening of the event was carried out by SEVT and CERTH, followed by speakers coming from the Policy, the Academic and the Research sector, the primary production, food industry, and retail, some of whom also joined the discussion panel of the Round Table devoted to the theme “Sustainable practices in the primary production and new technologies: Perspectives & Incentives”.

Key Findings

- PestNu project aims to promote incentives which will encourage EU farmers to adopt the existing guidelines. It is of great importance to have contributions to train and certify agricultural advisors (by regional/national authorities), in order to consult farmers of small and medium-sized farms on how to use pesticides and machine vision methods. The establishment of a multifactorial and cross-sectoral approach will encourage the cooperation of different, but also complementary sectors (researchers, farmers, consultants, businesses, NGOs, etc.).

- There is a necessity of transitioning from Contract to Precision Agriculture, dealing with the problems of climate change and the modern challenges of the agri-food sector and thus a detailed description of the first (i.e., safety of propagating material, fertilization plan, rational irrigation, plant protection) and second level (transition from conventional to precision agriculture) of F2F was given. It was highlighted how will the second level of F2F strategy dynamically contribute to address the problems caused by climate change to agricultural crops. The agricultural production can be protected by implementing special management plans such as the use of plant wastes/residues (either as soil improvers or bio-stimulants) to optimize plant growth and contributing to the Circular Economy. Protection of the manufacturing sector against climate change can be accomplished through the study of the precision agriculture model and the use of early warning and risk assessment systems.

- The contribution of retail to the supply chain, by adopting the sustainable development, is important. The strategic goals and priorities of sustainable development in the retail industry were highlighted and analysed, including recycling, awareness, organic products, animal by-product management, reduction of food waste, saving energy, use of sustainable materials, and development of green stores.

- The agro-food sector is a key priority of the National Strategy for Smart Specialization 2021-2027 and substantially contributes to the determination of research priorities. By being a comprehensive smart economic transformation agenda, which aims to adopt a new and more sustainable development model for the manufacture of high added value products and services, the strategy provides expertise through the business discovery process and aims to identify business opportunities by exploiting research results and innovations and integrating them into

the value chains – thus being open to knowledge and innovations arising from EU projects like PestNu.

- The agricultural sector is dealing with many challenges (problematic lands, uneven distribution of water resources, extreme weather conditions) that affect the quantity and quality of product manufacture. A model of agricultural production needs to be developed through a holistic approach that focuses on technology, environmental protection, and sustainability. For a more diversified use of the farms, all modern technologies that are available (sensors, satellite data, robotic machines, or automation) in the production chain under the context of intelligent management should be effectively applied.
- Academic Institutions play an important role in the dissemination of innovative technologies and systems to the final stakeholders (Farmers, producers etc) and it would be important to consider the possibility of a National Strategy development in the context of the corresponding European F2F strategy.
- The loss of links to assure knowledge transfer to farmers can be overcome by fostering cooperation with companies and networks providing innovative technology, and training (e.g., certified agricultural advisers) aiming to the modernization and development of the country's agricultural sector.
- The Contract Agriculture, by which producers follow the corporate specifications and the company's basic rules and principles in cultivation, so has to be aligned with the F2F strategy.
- Structural changes are necessary to support and integrate smart technologies in agriculture as the implementation of innovative farming practices (Smart farming systems) and how much end-users' needs are covered, and the environment is benefited have to be considered.
- The Common Agricultural Policy 2023-2027 and its specific financial requirements are demanding for farmers' funding and that may hinder its potential for supporting transition of food production systems.

PESTLE Analysis by participants

Positive and negative factors influencing DST & AOP adoption for reduction of the dependence on fertilizers and pesticides and that of nutrient losses on soil:

Political	Financial support; involvement/support of great importance; familiarization with agro-sector difficulties;
Economic	Lower losses; higher costs; need for investments to the primary production
Social	Food Safety; Communication between researchers and farmers
Technical	Support to research; new cultivation technologies; training of farmers; innovative technologies facilitating production
Legal	Low availability of legislation; necessity of legislative development; support from policy
Environmental	Sustainability; Reduce CO2 emissions; reduction of environmental footprint

3.3. Other synergies established by PestNu & main findings

Setting the ground for joint policies recommendations

PestNu partners have put some effort for building upon the main findings of D7.3 namely within the participation in the Green Deal Support Office (GDSO) activities of the Food Working Group (FWG). In the last months PestNu has been in charge of promoting the Mapping of Common Drivers and Barriers which allowed for putting down some of these findings as barriers and opportunities and, along with sister projects, several efforts points and possible pathways for future work and actions have already been bulleted. Among others it is the building of joint policy recommendations (JPR) addressing:

- The difficulty and necessity of accelerating and get efficiency on reaching certain stakeholders like farmers or industry actors - and for that further engagement with, for instance, the promoters of initiatives like EU Farm Book or of the EU Code of Conduct on Responsible Food Business and marketing could be of interest
- Regulative barriers regarding the putting to action of circular economy approaches using waste as a resource for new bioproducts – and for that further mapping of specific areas and regulations and the way they impact the FWG projects results' exploitation (ex: waste usage by industry and the end of waste status; difficulties for new bioproducts from waste certification under the fertiliser's regulation for then achieving farmers' trust and foster innovations uptake) could be done in the short term, with JPR. Still on this field identification of the best target audience is of utmost importance as, among other stakeholders, policy makers are themselves difficult to be reached

Biopesticides promotion

Within other WP7 activities, namely under T7.1 clustering with other projects PestNu promoted an online event on Biopesticides & IPM on the 28th of February 2023 where, along with eight other projects it was possible to debate common drivers and barriers and possible joint actions. Among others, main concerns that emerged regard aspects (already highlighted previously on D7.3):

- The imperative need to reach farmers to overcome their scepticism regarding biopesticides, by sharing with them knowledge and current efforts being undertaken in a simple and accessible language and also by being available to discuss previous fails and their causes
- The need to engage with advisors, cooperatives, policy makers, retail, industry and other F2F actors to also involve them in the transition to biocontrol and reduction of synthetic pesticides use
- Regulative barriers regarding the time, cost and expertise involved with the registration of new biocontrol products, which completely hinder the mainstreaming of these solutions, and also contribute to the current polarised situation due to the lack of commercial alternatives to set out the transition

Aquaponics promotion

PestNu partners, namely Tilamur, kept pursuing the best pathways promote aquaponics. Among these, the efforts for reaching out directly to the EC group of advisors EGTOP were made. It was concluded that dossiers discussed by these experts are supposed to be kicked off by regional/national authorities and sent the European Commission at DG Agri. However, it was perceived that these regional actors are not aware of that nor feel the capability of doing so and thus, efforts are needed to promote the breaking of silos between policy makers and engage/promote regional actors.

In parallel, there were meetings and visits that allowed for the promotion of aquaponics next to Spanish Agency for International Development Cooperation (AECID) and UNHCR, the UN Refugee Agency, which has revealed a great interest in exploring these novel food production systems for refugee camps.

Some other relevant aspects were testimonies during participation in a EIT Food course on Sustainable Aquaculture, namely the fact that some countries' f*isheries act regulations are out of date, inhibiting access to new innovations. Additionally there isn't a set timeframe on how long it might take to set up, plan and invest on aquaculture industry with long time to get an aquaculture license (at least in Northern Ireland).*

Biofertilisers promotion

PestNu partners from APEMETA participated in the EU CAP Network Seminar on 'Smart circular farming to address high energy and fertiliser prices'. Among others, relevant points emerging from the discussions highlighted that:

- despite the existence of several DST, solutions dissemination requires support and initiatives that allow for farmers to have the perception of their existence, namely throughout advisors and by more demonstration (and subsequent continuous improvement) in different environments, crops, geographies, etc. On the other hand, it's urgent to work on how to change farmers and practitioners' mindset.
- Circular economy is a very relevant pathway to support the reduction of the dependency on synthetic fertilisers: the use of waste for the production of new biofertilisers and biostimulants needs further incentives and support and there are regulative barriers arising from the Waste Directive (and the putting to action of the end of waste status). Although the legal and regulatoy framework are being updated and consolidated (ex: new regulation on fertilisers, EU Mission on Soil) there is a gap in time and action concerning their perception and adoption that inhibit accelerating the shifting to less dependent and more resilient food systems

Organic farming promotion

PestNu partner Global 2000 engaged in a press conference on pesticide reduction entitled "Call for strong EU pesticide reduction in a new light" where they have presented the results of a new peer reviewed study (Burtscher-Schaden/Durstberger/Zaller, 2022) on the toxicological comparison of pesticide active substances approved for conventional and organic agriculture in Europe, highlighting the need for policies and strategies to reduce the use and risk of pesticides, and to strengthen organic farming in order to protect biodiversity and maintain food security.

4. Conclusions and Recommendations

4.1. The added value of PestNu practices

This document gathers 10 practice abstracts that have been produced in the first 18 months of the PestNu project all of which were uploaded to the EIP-AGRI platform in alignment with the tasks' initial goal. These PA have been presented **as factsheets that highlight the main added value to practitioners** implementing (or wishing to implement) the **technologies, products and practices** that PestNu focuses on.

On the field of **digital and precision agriculture** PestNu innovations comprise tools for farmers and farming systems managers such as AI robotic traps for real-time insect monitoring, autonomous self-navigating robots for pest (insect, fungi) monitoring and 3D spot spraying, AI satellite imaging for agricultural anomalies monitoring by AgroRadar using Copernicus services, and real-time IoT based nutrient analysers. Decision Support systems providing automated decisions processes for IPM and INM as well as Food Sustainability Index certificates.

Regarding **circular economy and agro-ecological practices** PestNu includes a foliar biopesticide product targeting fungal diseases with nutritional effects, formulated by circular bioeconomy operations from agro-food wastes; an automated circular economy system for treating the wastewater streams of hydroponic greenhouses and further production on-site of a microalgae- based biofertilizer as well as nutritional programs for organic farming. Additionally, as conventional and PestNu products are to be field-tested and demonstrated under systemic approach, some initial and promising results of trials already performed are displayed.

The PestNu project is committed to promoting a reduction in the use of chemical and hazardous pesticides and fertilizers, as well as minimizing nutrient loss. The project's second half is focused on the pre-pilot systemic combination of the interconnected set of innovations, for optimization, and next, to the field testing and demonstration of these DST & AOP systemic innovations in an aquaponic plant and open-field vegetable farms in Spain and evaluation of their performance in daily practice

Next Steps

- PestNu aims to provide further value to EIP-AGRI stakeholders by delivering an additional set of 20 practice abstracts on M36.

This deliverable is linked with PestNu Task 7.2, devoted to the coordination with policy makers and operational groups and thus contacts with the EIP-AGRI Service Point staff have been held to arrange collaboration towards feeding of the newsletter and webpage of EIP-AGRI/EU CAP Network, through submission of the short summaries and additional general elements about PestNu in the Common Format template. This procedure will be again applied on M36 of the PestNu project by updating this deliverable with a second batch of practice abstracts.

4.2. Recommendations for Policy and Research arising from PestNu activities

Towards keeping up with the promotion of relevant synergies within the scope of T7.2, the national PestNu's workshops held in AT, IT, CY and GR and reported in this deliverable kept angling for taking the most out of the gathering of relevant stakeholders for promoting collaboration, building of bridges and breaking of silos between actors of the food chain and primary sectors. Additionally, they tried to promote a collective action over F2F direct and indirect actors for assessing relevant opportunities and barriers found by these informal networks active/interested in the fields of pesticides & fertilizers, precision agriculture, organic farming, etc.

Main outcomes of roundtables discussions are in line with and reinforced those already reported earlier in D7.3 (M12) of the PestNu Project **namely**

- **the need for trust-building among farmers regarding new technologies** – suggestions brought here highlight that technologies must be tested intensively in practice and consultations with developers must take place. When robots have been running for a while, feedback should be possible by farmers as many have already experienced that despite tools should work theoretically, in practice sometimes they don't.
- **knowledge sharing and transfer to farmers and their advisers** again emerged as **a central point for coordination with policy makers and operational groups.** Inclusion of small-scale farmers is important and as **many farmers struggle with lack of scale, time and skills for being up to date regarding new and innovative tools, trained advisors are needed.** Suggestions brought here even highlight how can **some business models building upon** advisors as pivots able to accompany innovations market strategy due to their closeness to farmers, proneness for using DSS and potential for making the most of the devices/tools by being present in the setting-up phase allowing also some contribution for defining the technical details of the field and crops
- **networking has a key role for the success in reaching many of the upcoming policy goals,** and thus **effort should be put in its promotion -** there should be basics of agreement on this and built upon that.

Thus, it is recommended that future PestNu actions towards clustering, communication and dissemination build upon some effort points such as:

- find/develop/engage in two-way communication with farmers allowing for training and knowledge sharing and also have feedback on specificities and technicalities for maximizing innovations best fitting to farmers' needs;
- actively engage with the training of advisors as they represent the best and more effective way to reach small scale farmers;
- identify common ground through networking namely by attempting the production of joint policy recommendations with other projects

Regarding **policies and regulations currently on the ground** some **concerns** were raised:

- The Common Agricultural Policy 2023-2027 and its specific financial requirements are demanding for farmers' funding and that may hinder its potential for supporting transition of food production systems.
- The current and consolidated version of the Regulation 2115/2021 is seen to be bringing a considerable increase of bureaucratic process
- The pathway towards the standardization and certification of new bioproducts is complex – and despite current conventional fertiliser's costs some things cannot be treated without chemical means because so far there are missing alternatives that really work.
- Market regulation could be the most effective tool to reduce dependency without creating new other dependencies

Additionally, the **need for holistic approaches** and **systemic pathways to embed new tools in the market economy** emerged as main conclusions:

- On one hand **it must pay off to the farm** to buy a subsidized product/device and the very low margins of the sector, especially in the case of small farmers, do not allow for reaching a satisfactory quality of service / price ratio for digital tools. Besides the possibility of them finding new business models (eg. operating through consortia, supported by advisors) it could also be possible to evaluate monthly instalment payments with an "all-inclusive" service. However, the problem does not arise in the case of medium-large farms with more resources and know-how to adopt DSS. **Concrete actions are needed, differentiated according to the size of the companies**.
- However, experience shows that **when a technological innovation completely involves the process**, bringing a real reorganization at company level, an expansion of skills, or even a change in the business model, the adoption of these technologies does not only translate into the purchase of some tools but in **a real acquisition from scratch of tools and methodologies can generate a real cultural revolution in the way of managing the farm/company**. Thus, **efforts for finding new business models and changing also some of the traditional mindset of farmers are needed**, along with solutions development.
- Moreover, **strategies to reorient the agro-ecosystem with new pillars for ecological processes** and also, the s**trengthening of regional collaborations, circular economy and awareness on the value of food are important points to focus on from a policy perspective.**

PestNu

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