**Task 2.2.5: Non-chemical methods of pest control (M6-M30; task leader:** UNITO; **partners involved**: UNINA, UNIBO, UNITO, CREA, UNIBAS)

Here we will focus on the development of alternative control strategies largely based on a wealth of physical methods of pest suppression and/or able to disrupt reproduction and alter the behaviour. This will include the technical devices based on physical cues (i.e., light, sound, microwaves, heat, pressure, etc.), or on selective trapping systems. The efficacy of the proposed methods will be assessed along with the impact that they may have on non-target organisms, to ensure the ecological sustainability of the proposed pest control method.

***Methods***: starting from already established background knowledge on the role that specific physical cues have on pests and pathogens, research work will be designed to develop application methods that are both ecological and economically sustainable, considering both greenhouse and field environment.

***Initial TRL***: 4

***Final TRL***: 6

**Deliverables**

**D2.2.1** Protocols for assessing plant resistance/tolerance to pests and disease agents (M18)

**D2.2.2** Report on mechanisms regulating plant multitrophic interactions (M24)

**D2.2.3** Report on cutting-edge technologies for selection, production and distribution of biocontrol agents (M36)

**D2.2.4** Report on developed biopesticides and biostimulants (M36)

**D2.2.5** Report on non-chemical innovative tools and strategies for pest control (M36)

**Milestones**

**M2.2.1** List of selected model crops (at least 3), pests and pathogens (one or two for each selected crop) to be used for plant bioassays and multitrophic interaction studies (M6)

**M2.2.2** Selection of at least 2 promising technologies/tools from each of the three applied tasks (i.e. T2.2.3-5) as candidates for developing products with a high TRL (7-8) (M18).

**Interactions with other Spokes**

Plant genetic materials made available by Spoke 1 (*WP1.3 - Developing advanced genotypes with improved resilience*) will be screened for resistance/tolerance to pests and pathogens; the role of plant microbiota in the modulation of plant growth and defense, and the underlying mechanisms of action, will be studied in collaboration with Spoke 1(*WP1.1 - Plant, animal and microbial genetic resources: mining for resilience* and *WP1.2 - Dissecting morpho-physiological and molecular mechanisms of adaptation*), focusing the attention on pests, pathogens and their natural antagonists; the effect of biopesticides and biostimulants obtained from different sources and types of biomasses by Spoke 8 (*WP8.1 - Producing new products to upgrade waste value, WP8.3 - Nutrient and organic matter recovery from wastes to reduce the use of agrochemicals and closing waste cycle*) will be assessed, or the protocols defined will be shared in a coordinated research effort.

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|---|---|---|---|
| **Work package number** | 2.3 | **Lead beneficiary** | UNINA |
| **Work package title** | Smart technologies towards a sustainable "zero pollution" in agriculture | | |
| **Start month** | 1 | **End month** | 36 |

**Objectives**

- To develop accurate environmental monitoring protocols, predictive models for crops, pests and fertilizers management
- To promote precision agriculture for a timely and targeted environmental delivery of agrochemicals
- To use deterministic models and artificial intelligence (AI) to drive the definition of sustainable Integrated Pest Management (IPM) plans and fertilization strategies
- To develop a geoSpatial CyberInfrastructure for a Decision Support System (DSS) to reduce the use of agrochemicals and environmental pollution

**Description of work**

**Task 2.3.1** *Monitoring technologies at different spatial scales* **(M1-M36**; **task leader**: UNIPD; **partners involved**: UNINA, UNIBO, UNIPD, UNITO, CREA, UNIBAS, e-GEOS**)**
Here a panel of monitoring technologies, tailored towards different spatial scales, will be produced. The task will include the following activities:
- metanalysis of scientific literature evaluating crop health monitoring technologies with reference to varying spatial scales and to a range of stakeholder's requirements (e.g. farmers, Public Authorities);
- selection of a panel of best proximal and remote sensing approaches along with plant phenotyping techniques with reference to their cost-benefit ratio;
- performing crops health monitoring by proximal sensing, remote sensing and plant phenotyping in experimental farms and over a range of pedoclimates in selected landscapes;
- analytical and Integrated Evaluation of the performance of all the applied monitoring technologies with respect to the different spatial scales and different stakeholder requirements.
***Methods***: metanalysis. Test of proximal sensing including EMI, Electrical Resistivity, Gamma Ray Spectrometry. Test of cost benefit ratio between satellite images from Copernicus, NASA, RapidEye. Geoeye,Worldview Test of drones and other low cost platforms for plant phenotyping in experimental farms.
***Initial TRL*:** 3-4
***Final TRL*:** 4-7

**Task 2.3.2** *Modelling crops and environmental health* **(M1-M30**; **task leader**: IBF; **partners involved**: UNINA, e-GEOS, IBF**)**
This task will address crops health and environmental protection models. These models will address pest, weed prediction, and control models. They will include the following features: crop growth, plant-pathogen interactions, agrochemical leaching and climate change.
The task is divided in the following activities:
- metanalysis of scientific literature evaluating crop health models considering type of pest, spatial scales, and different user requirements;
- selection of the best crop health models considering the following features: type of pest, accuracy, reliability, quality of output, spatial scales, transferability, cost-benefit ratio, availability of open-source code, potentiality of web-based model implementation (e.g. on-the-fly modelling);
- model implementation and model testing for a selection of pests over a range of experimental farms and pedoclimate in different landscapes and for climate change scenarios.
***Methods***: metanalysis. Testing - including calibration and validation - of the selected crop health, Crop growth, pesticide and nitrate leaching models and sensitivity analysis. Testing are performed also by using existing datasets from experimental farms.
***Initial TRL*:** 4
***Final TRL*:** 6

**T2.3.3** – *Precision agriculture and smart technologies for application of agrochemicals* **(M1-M36**; **task leader:** Engineering; **partners involved**: UNIBO, UNIPD, UNITO, UNIBAS, UNICT, ENG, IBF**)**
This task will focus on the use of precision agriculture and smart technologies for reducing the agrochemicals use. The task will be organized in the following activities:
- metanalysis of scientific and technical literature addressing both (i) smart automation systems for precision spraying and (ii) multicriteria DSS app supporting crop health farming activities (including monitoring and plant disease identification) for specific pest;
- selection of the best smart automation systems and multicriteria DSS app for crop health (such as those available through IPM decision (https://www.ipmdecisions.net) on the base of their cost-benefit ratio and type of pest;
- implementation and field testing of the selected smart automation systems for precision spraying also considering their effectiveness, design, implementation cost and potential incentivation actions;
- implementation and field testing of a range of simplified multicriteria DSS app supporting farmers in (i) selecting the best suite of monitoring approach for their needs and (ii) identifying main plant pests and diseases.
***Methods***: metanalysis. Field testing in experimental farms.
***Initial TRL*:** 3-4
***Final TRL*:** 4-7

**T2.3.4** – *Development and validation of sustainable IPM plans* **(M1-M36**; **task leader:** CAI; **partners involved**: UNINA, UNIPD, UNITO, CREA, UNICT, CAI**)**
This task will will deliver a panel of integrated tools and strategies structured in plans for plant protection which are both ecologically and economically sustainable and accepted by the society. Optimal IPM plans for major crops in different pedoclimatic areas will be defined using modeling approaches, on the basis of characteristics of the landscape where the plans will be implemented. The strategies defined will be validated under relevant field conditions, in different pedoclimatic areas.
***Methods***: deterministic models based on a thorough landscape modelling for context specific prediction of the optimal integration of different tools will be adopted. This will allow to identify the most appropriate plans for a specific area, where field experiments for validation will be carried out.
***Initial TRL*:** 4
***Final TRL*:** 7

**T2.3.5** – *Development of a geoSpatial CyberInfrastructure (GCI) for a Decision Support System to reduce the use of agrochemicals and environmental pollution* **(M1-M36**; **task leader:** e-GEOS; **partners involved**: UNINA, UNIBO, UNICT, e-GEOS, ENG, IBF**)**
This task will be fed by all the above 2.3 tasks and will release a set of multidisciplinary S-DSS tools to reduce the use of agrochemicals.
- An analysis of all findings obtained from all 2.3 tasks relevant for the development and for tuning T2.3.5 activities.
- Building the IT infrastructure including datacube, and a pool of well-focused HPC services (e.g., GPU, COMPs)
- Building the dataset (pests' distribution and biology, proxies of pesticide use, historical and current climate, climate change, soil, land use, landscape, hydrogeology) to be used by the GCI
- Implementing and/or developing of web-based modelling aiming to (i) crop health modelling (for selected pests) and (ii) reducing environmental pollution. The models will be fed by the dataset and have to be implemented over the GCI.
- Developing the Geospatial Decision tools supporting (S_DSS) both crop health and reducing environmental pollution by building for each of these tools the data-modelling- Graphical Use Interface pipeline.
- Testing - from both a scientific and end-user viewpoint - of Geospatial Decision Supporting tools to reduce the use of agrochemicals and the environmental pollution.
***Methods:*** building the IT infrastructure including datacube and HPC services (e.g., GPU, COMPs), databases, Development of the GeoSpatial CyberInfrastructure to produce SDSS tools.
***Initial TRL:*** 4
***Final TRL:*** 7

**Deliverables**
**D2.3.1** Report on monitoring results obtained after 1st year remote and proximal sensing and plant phenotyping (M12)
**D2.3.2** Report on model testing concerning pest and weed prediction and control including crop growth, plant-pathogen interactions, agrochemical leaching also considering climate change (M20)
**D2.3.3.1** Report on design, testing, implementation and incentivation of smart automation systems for precision spraying (M28)
**D2.3.3.2** A simplified multicriteria DSS app supporting farmers in (i) selecting the best suite of monitoring approach for their needs and (ii) identifying main plant disease (M30)
**D2.3.4** Delivery of strategies for increasing (i) IPM, BCAs, (ii) user uptake and (iii) the socio-economic impact of IPM plans (M28)
**D2.3.5** Release of multidisciplinary S-DSS tools to reduce the use of agrochemicals (M30)

**Milestone**
**M2.3.1** Protocol in place for monitoring by remote and proximal sensing (M8)
**M2.3.2** List of predictive models for crops, pests and fertilizers management are finalised (M8)
**M2.3.3** Targeted approaches towards smart technologies for application of agrochemicals and IPM have been established (M18)
**M2.3.4** First groups of S-DSS tools are ready for testing (M22)

**Interactions with other spokes**

Monitoring technologies, crop modelling and precision agriculture technologies will be developed in close collaboration with Spoke 3 (*WP3.1 - Smart solutions for precise and sustainable management of agricultural systems*); strategies for IPM and reduced use agrochemicals will be developed in collaboration with Spoke 5 (*WP5.2 - Livestock management for improving resilience to climate change*), Spoke 6 (*WP6.1 - Farm management models to enhance sustainability and resilience in different agricultural scenarios*) and Spoke 7 (*WP7.1 - Integrated models to develop marginal areas*), defining tailored protocols for sustainable food and feed production in specific areas; the *geoSpatial CyberInfrastructure (GCI) for* DSS to reduce the use of agrochemicals will be developed by considering all smart technologies and strategies generated by Spoke 3 (*WP3.1 - Smart solutions for precise and sustainable management of agricultural systems*) and Spoke 4 (*WP4.2 – Smart climate agriculture and forestry: from sustainable products to the bioeconomy*) in relevant production scenarios.