Innovative bio-based pesticides to minimize chemical residue risk on food

Executive summary

The objectives of the project INNOVA were:

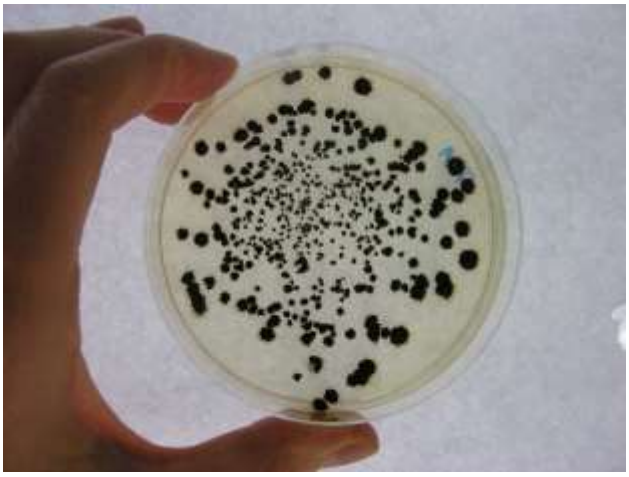
- **To identify innovative biopesticides** to help growers to produce residues-free products focusing of the most critical crops and growing stages in term of risk of pesticide residues on final food and to select the potential biopesticides according their intrinsic technological qualities.
- **To identify the suitable formulations of the innovative biopesticides**, in terms of shelf life and efficacy against pests and to scale-up the production.
- To deepen the research on **some specific aspects requested for the registration** of the new bioproducts.
- To identify the **best application strategies in IPM** and the suitable market strategies.

Work performed in the project

The first part of the project have been devoted to identify innovative biopesticides to help growers to produce pesticide residues-free products, by focusing on the most critical crops and growing stages in terms of risk of pesticide residues on final food and to select the potential biopesticides according their intrinsic technological qualities.

The crops with the higher risk of chemical residues (number and level) and the target pests/diseases have been identified based on public reports (EFSA journal) and database (FAO, EU pesticide DB) and with the input of the experts (crop managers) of Belchim Crop Protection.

The new innovative biopesticide candidates were classified in term of potential efficacy against the selected pests/diseases, based on the existing knowledge on mechanism of action, genetics, and behavior in the environment. Forty-seven candidates were evaluated in this first step. The candidates were classified in term of way of production, efficiency and cost of production/formulation. Two new technologies to be used in combination with the bioproducts to improve their efficacy were also assessed.



Preliminary small-scale trials were carried out both in greenhouse and open field in order to confirm the efficacy of the new innovative biopesticides against the selected target pests/pathogens. Ten active ingredients were selected for the following development.

Biocontrol agent developed in the project INNOVA

For each of the ten candidate biopesticides, the most important aspects to be addressed with the formulation (persistence/survival, UV protection, desiccation, temperature degradation, rainfastness, etc.), according to the nature of the biopesticide and the use on the crop, were then identified. In particular, the most important aspects for the microbial agents when applied on the phyllosphere were prologanting the viability, and

decreasing the damages due to UV, desiccation and unsuitable temperature, while increasing survival and multiplication was the most important aspect when applied in soil. Increase of rainfastness and decrease volatilization were the most import aspect for the botanical extracts. To increase and speed up conidia germination the addition of activators was identified as a crucial point. For the selected natural molecules, the work focused on co-formulants that can increase the uptake by the pathogens' cells. A specific carrier to increase the persistency and efficacy in soil of a selected microbial fungicide was designed. Nutritional compounds to increase survival and colonization of pruning wounds and leaves by microbial biocontrol agents were also selected. The possibility to develop a slow-release encapsulation for volatile bio-based botanical extract was explored. Possible lures to increase attractiveness of a candidate insecticide were assessed. The various prototype formulations for each of the ten potential new active substances were compared in term of increase efficacy of the compound against the selected pests and pathogens, in lab trials. A database of suitable products and related formulations in term of industrial production was completed and six candidates were selected for the pilot production. The quality of each batch was analyzed in order to check the consistency of production. The cost of production of the various prototype formulated products was assessed and compared, in order to select the best production process and formulation.

Picture: Formulated biocontrol agent (wettable granules) developed in the project INNOVA

The guidelines for registration of pesticides (Regulation 1107/2009) were followed to verify the feasibility of registration for the six selected candidates. In particular, the expected metabolic profile of the selected microbial active ingredients was assessed based on the genome sequencing of the strains and the chemical composition of the plant extracts in the technical grade was analyzed. For each of the six selected products an extensive literature search was carried out, especially in term of possible risk for humans and environment. The mechanism of action of the selected biopesticides was investigated in lab trials. Some small-scale tests to check eco-toxicology of biopesticides (possible side effects against: microbial populations in soil and phyllosphere with metagenomics approaches, some microbial biocontrol agents with dual culture tests, aquatic organism (*Daphnia magna*), parasitoids/predators (*Aphidius rhopalosiphi*, *Typhlodromus pyri*) were carried out. The fate in the environment was tested for two microbial biopesticides (colony forming units and quantitative PCR) and the residues in the environment was tested for a natural rare molecule (chemical analysis). Possible side effects on vinification of a microbial biopesticide and a natural rare molecule were also assessed.

Small scale trial on strawberry

Five candidates were selected for the small-scale trials to define dosage and timing of application and the integration with chemicals. Based on the small scale trials the five candidates were tested with a suitable experimental design following EPPO standards and protocols on strawberry, cucurbits, basil, grapevine, apple, bean and wheat against powdery mildew, downy mildew, grey mold, trunk diseases, Rosellinia root rot and Fusarium head blight, mites, aphids, whiteflies, thrips, leaf miners, *Drosophila suzukii* and as dessicant/herbicide. All trials were carried out at least twice, in at least two locations or two seasons/environmental conditions. The results in term of efficacy and reduction of residues in the food were compared with conventional standard pest management strategies.

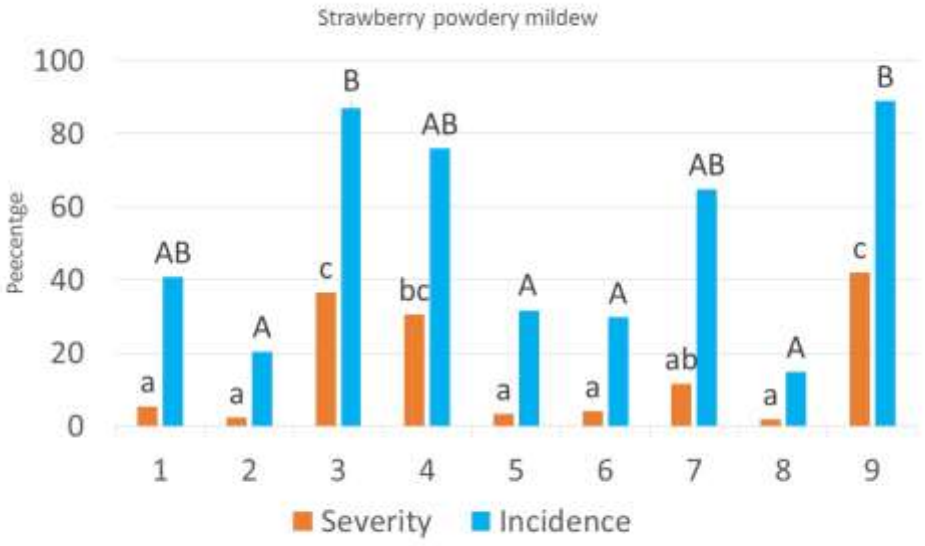
Picture: Lab trials with a bioinsecticide against Drosophila suzukii

Results and their potential impact and use (including the socio-economic impact and the wider societal implications of the project so far).

Four bioproducts (a microbial biofungicide, one plant extracts and two natural molecules) were developed and the registration process as plant protection products (two bio fungicides, one bio insecticide and one bioherbicide) is already started.

The registration of the first commercial plant protection products is expected from 2017 and it is expected to be completed by the end of 2021 for all the four candidates. Their integration into strategies will allow a significant reduction of residues in food on the most problematic crops. All products are also expected to be authorized for the use in organic agriculture, thus contributing to the competiveness of this sector.

Picture: Efficacy trial on tomato



Example of efficacy trial - Efficacy against powdery mildew of strawberry of experimental products (1-7 experimental products; 8 Sulphur; 9 untreated control)

The immediate benefit we achieved is a better coordination of the activities in a strongly fragmented sector like the development of biopesticides, especially between academia and industry. The INNOVA project is also increasing, broadening and enriching the expertise of the researchers involved in the program in all the research areas of developing bio-based plant protection products in a scientific multidisciplinary context. Several results of the project have been already published on peer review journals and presented at scientific conferences. The results related to the four final products have been also disseminated at technical conferences and open-days and in technical journals targeting a public of agronomists, field advisors and growers. The project was presents to students (high school and university) as a successful example of integration of research between Academia and Industry.

In Europe, the future approach in the agricultural production should be probably radically changed. The bio-economy is a key element also in agriculture for sustainable and green growth in Europe. Concerns on chemical pesticides are continuously increasing. Advancements and innovation in bio-based pesticides research will allow Europe to improve the use of safe, low impact and renewable biological plant protection products besides widening a promising market. The increased replacement of chemicals with biopesticides holds a great potential: it can help reducing the use of chemical in agriculture while improving the economic and environmental sustainability of pesticide industries. The development of innovative bio-based pesticides will ensure sustainable resource use and alleviating stress on the environment. The new bio-based plant protection products developed in INNOVA project will be valuable tools to achieve a sustainable use of pesticides in agriculture.

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