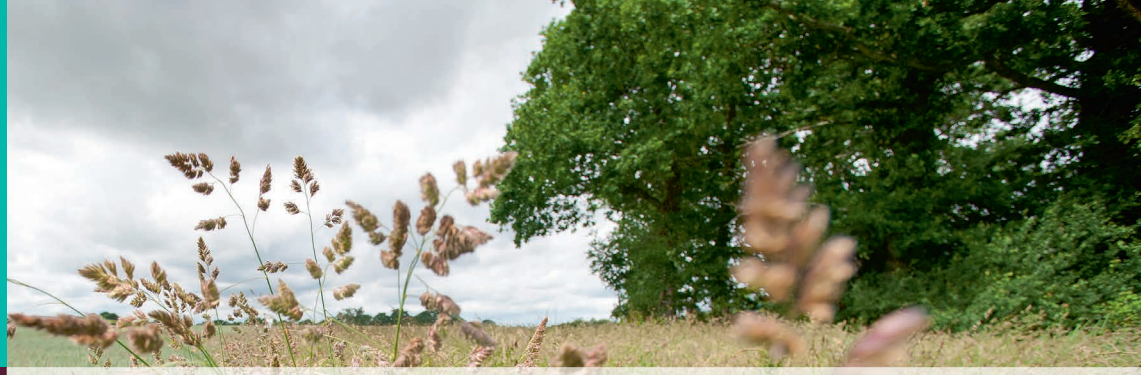
SMaCH METAPROGRAMME

Sustainable Management of Crop Health

INRA SCIENCE & IMPACT



MOBILISING NATURAL REGULATION, MONITORING, DIAGNOSIS AND PREDICTING RISK FOR CROP HEALTH

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Prevention is better...

Mobilising natural regulation, monitoring, diagnosis and predicting risks for crop health: these were the themes of INRA's SMaCH metaprogramme's 2014 call for projects. The six projects selected and two theses on the issue were unveiled at a seminar held on December 17 and 18, 2014, in Paris, France.

The sustainability of crop protection and reduced dependence on pesticides requires the development of a new paradigm based on mobilising natural regulation and on surveillance and risk management. Prevention is better than cure...

In order to expand integrative and preventive approaches to crop health, upstream of curative actions, INRA launched in 2014 a call for specific projects as part of its SMaCH metaprogramme*.

Six projects, called Reaction, Fladorisk, Gargamel, Copairnic, Lycovitis and Geek, were selected. They revolve around two approaches. Firstly, a better understanding of the services provided by biodiversity in terms of pest regulation and the capacity to contain pest outbreaks. And secondly, enriching and mobilising knowledge in terms of observation, monitoring, diagnosis, prevention and risk management.

The launch seminar, on December 17 and 18 in Paris, revealed that these six projects, alongside two theses, are mobilising a multidisciplinary scientific community. No fewer than six INRA research departments are involved: Plant Health and the Environment, Science for Action and Development, Environment and Agronomy, Forest, Grassland and Freshwater Ecology, Applied Mathematics and Informatics and Social Sciences, Agriculture and Food, Rural Development and Environment.

Finally, the majority of the projects are committed to work involving co-construction with stakeholders from the agricultural profession. These participatory approaches are needed to address the needs and constraints on the ground, and to lead to innovations in prevention and risk management, constructed with advisers and farmers, which can then be quickly deployed by the profession.

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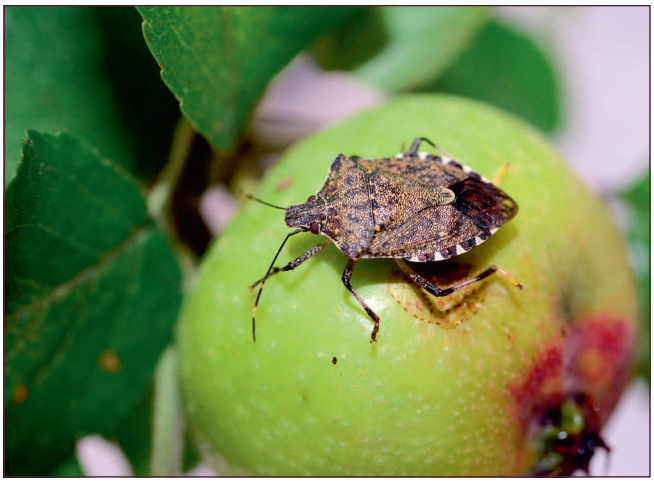
CONSTRUCING MORE ROBUST AGRICULTURAL SYSTEMS

How do we reconcile agricultural production and sustainability? The answers lie firstly in mobilising natural regulation, and secondly in mobilising monitoring, diagnosis and the prediction of risks relating to crop health. This is why the six projects selected in 2014 under INRA's SMaCH metaprogramme seek to minimise a posteriori pest control through the a priori prevention of risk and the construction of more robust agricultural systems.



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Xavier Reboud

SMaCH metaprogramme director

"To support agroecological transition, we need to deepen our knowledge on the impact of practices on the health status of fields in the short and medium term."

Biological control of diseases and insect pests helps to secure agricultural production in terms of both quantity and quality, while reducing the dependence on pesticides and showing more respect for the environment. It's a challenge which requires a shift in paradigm aimed at the construction of cropping systems which are structurally more robust, reducing curative protection. Mobilising natural regulation and risk prevention are some of the solutions to be deployed.

Taking advantage of natural regulation

"The major role of biodiversity in ecosystem services is widely accepted but rarely quantified," stresses Xavier Reboud, director of the SMaCH metaprogramme and coordinator of the key action Biodiv - Biodiversity and crop protection. "However, the integrated management of plant health should take advantage of it." The field of investigation is large and the role of biodiversity in providing pest control should be clarified and qualified. "What level of pest control is possible? How predictable and stable are these regulations? What factors need to be taken into account? There are many questions to which we need to supply the answers," says Xavier Reboud. "We know that different processes slot together at different scales, from the local to the landscape."

Over the past decade, crops have faced an average of seven new invasive and destructive insects per year.

Among other things, INRA is seeking to provide simple indicators for evaluating the functional biodiversity involved in this natural regulation, to measure the beneficial biodiversity for plant protection offered by agricultural practices, the use of mixtures of species or varieties and landscape management. Finally, the Institute is seeking to use the levers that make up the agroecological infrastructure, such as hedges or grass strips. The objective is to help naturally maintain beneficial insects by providing 'bed and board'.

Monitoring, diagnosis and prediction

The construction of more robust cropping systems also requires prevention of the risks linked with plant protection. Monitoring of pests and diseases, and the ability to diagnose and predict are required.

"Nowadays there is an increased need for accurate and rapid diagnosis," notes Jean-Claude Streito, coordinator, with Valérie Laval, of the key action Sys3D - Systematics for diagnosis, detection and identification. "On the one hand, this is because current cultivation techniques are more demanding in terms of diagnostics and, on the other, because the required reduction in chemical use, the development of trade and climate change have lead to an amplification in pest emergence." Rapid identification of an invasive species can make it possible to intervene earlier and contain outbreaks. For Cindy Morris, coordinator, with Marc Barbier, of the key action Emerge - Managing emergencies, multidisciplinary research must now be conducted: "We need to understand the biological mechanisms of emerging diseases and pest invasions, but we must also take into account the social and economic aspects associated with them."

The development of information and communication technologies and the expansion of social networking can profoundly alter the epidemiological surveillance sector.

Interview

Marie Chave

Marie Chave, scientific manager for the Reaction project - Natural regulation and levers for action: focus on preventive bioprotection in tomato through mycorrhizal symbioses.

Why seek to develop mycorrhizal symbioses?

Because these symbioses are among the natural regulations that are interesting to use in order to reduce inputs, fertilisers as well as pesticides. The vast majority of plant species have the ability to develop a symbiotic association between their roots and a diversity of fungal species, forming what are called mycorrhizae. But with the intensification of agriculture and large inputs of fertiliser, this combination is no longer used by plants. Nevertheless, it allows the crop to develop its root area, to better supply water and mineral elements and provides it with bioprotection, notably by stimulating its natural defence system.

Do we need to rethink cropping systems to encourage mycorrhization?

Yes, this is why the Reaction project is aiming to co-construct, with farmers, new cropping systems. The redeployment of this natural regulation in the field, implemented in tomato in this project, could eventually prove useful to many other crops.

Interview

Sylvie Malembic

Sylvie Malembic-Maher, co-manager, with Adrien Rusch, of the Fladorisk project - Flavescence dorée of vines: the influence of the wild environment and a comparative analysis of regional systems for disease management.

"The Fladorisk project brings together INRA sociologists, ecologists, pathologists and entomologists and has several objectives. We want to measure the new risks of contamination induced by wild plants surrounding vineyards, such as alders, clematis and regrowth from rootstock, which may constitute reservoirs for flavescence dorée. We want to take into account the services provided by the wild environment in terms of natural regulation, as it provides accommodation for beneficials which are useful for protection in vineyards. We also want to help regional systems for flavescence dorée management take into account the wild environment, involving all stakeholders.

The collective control of this quarantine disease is essential because the sustainability of vineyards is at stake. Our aim is to better support this mandatory control, which currently involves more than half of France's wine-growing area and generates tensions on the ground. Our work is being set up with all the actors involved in controlling this disease, researchers and the various organisations responsible for the environmental management of vineyards. And we are working in four regions: Alsace, Burgundy, Provence-Alpes-Côte d'Azur and Aquitaine."

Interview

Antoine Gardarin

Antoine Gardarin, scientific manager of the Gargamel project – Agroecological pest management for field crops using floral mixtures.

Can flower strips limit the use of insecticides in field crops?

This is what we are seeking to quantify. The issue is important since this family of pesticides accounts for half of all the treatments in oilseed rape and peas. The attraction of flower strips for pest beneficials is more or less known. But their contribution to the health of the crop has not yet been established. Currently, because of a lack of knowledge, their botanical composition and management has not yet been rationalised in terms of pest regulation.

The Gargamel project is seeking to encourage natural pest regulation?

Our objective is to offer methods designed to quantify, for each flower strip and particular cropping system, this natural regulation. These monitoring methods must be harmonised and simple enough in terms of implementation in order to allow any organisation to participate in a network for characterising this biological regulation. Initially, researchers will create a network of different partners who are already experimenting with flower strips in order to foster knowledge sharing.

Gaëlle Marliac

conducted her thesis at INRA Avignon: Intensification of organic agriculture - consequences on the regulation of phytophagous insects in apple orchards.

Organic agriculture is often viewed as a single system. However, its development in the field reveals various intensifications, with different protection strategies, combining numerous practices: the use of protective nets, biocontrol agents, landscape management, resistant varieties etc.

My thesis, conducted between 2011 and 2014 at INRA, has shown that these different strategies do not offer the same level of control of codling moth, the main pest in apple.

Twenty orchards, adopting different strategies, were monitored for beneficials and an estimate made of the predation function of these beneficials. The results show that while the spider community is unaffected by the control method, that of earwigs is sensitive to the control methods used. Finally, the codling moth predation rate by natural enemies is greater in the intensification strategy we have called 'ecological' and which is based on biological control and habitat management."

Jean-Pierre Rossi

Jean-Pierre Rossi, scientific manager of the Geek project - Google trends network and pest outbreak.

"Queries on Google-like search engines feed very large databases. The team in the Geek project intends to use these elements to track crop pest species and predict invasions. Researchers are trying to validate the possibility of using this data in the case of an insect pest of Asian origin, the brown marmorated stink bug. This bug, which appeared in the US in the 1990s, causes significant damage to fruit and vegetable crops.

Citizens are susceptible to this insect: when swarming, its gregarious behavior leads it to form groups inside homes during the autumn, causing a flow of queries on search engines. In France, we recently launched an application for tablets and smartphones to help the public precisely recognise the bug, which will allow us to gather as much relevant information as possible.

The objective, ultimately, is to feed modelling tools to forecast epidemic outbreaks and to disseminate the knowledge to researchers and the agricultural sector."

Christel Leyronas

"Interview

Christel Leyronas, scientific manager of the Copairnic project - Understanding and predicting grey mould epidemics caused by *Botrytis cinerea*: Towards an alert system for epidemic risk.

***Botrytis cinerea* causes significant damage to some crops, such as tomato and strawberry. Why do producers have difficulty controlling this fungus, which is responsible for grey mould?**
There are not many tools available to predict attacks. And the prediction models available are based solely on local climatic variables, which is not enough. In the Copairnic project, we are seeking to take into account the abundance of airborne inoculum, either from local sources or of more distant origin, carried by air masses over long distances. The objective is to create a Decision Support System, a DSS, which allows producers to better position treatments and, in the case of protected crops, better manage climatic conditions and ventilation systems.

Are you working with actors in the field?
The DRAAF (Regional Directorate of Food, Agriculture and Forestry) in Provence-Alpes-Côte d'Azur (PACA) is a partner. Surveys have been conducted with advisers, chambers of agriculture and experimental stations in the PACA, Languedoc-Roussillon and Rhône Alpes regions. They are expecting a DSS which helps organise crop sites and rationalise advice, based on scientific knowledge. Such a tool would also be a medium for communication.

"Interview

Martin Godefroid

Martin Godefroid conducted his thesis at the Centre for Biology and Management of Populations (CBGP) in Montpellier: Better prediction of quarantine arthropod invasion risks.

"Species are not genetically homogeneous entities. Among quarantine organisms, harmful pests which countries try to prevent colonising their territory, the evolutionary lineages of the same species may present different invasion risks. My thesis focuses on the case of arthropods, the second most invasive group after plants. Currently, phytosanitary risk analysis, which makes it possible to decide whether or not a pest should be on the quarantine list, is based on the species. The project is seeking to go beyond this level by exploring different taxonomic ranks as a basic ecological unit for these risk analyses. Risk is currently poorly calculated: it is over or underestimated, sometimes leading to mandatory control measures which are unnecessary. We have shown that for *Dendroctonus valens* Leconte, an extremely damaging arthropod pest for conifers which has a large intraspecific diversity, some lines could have a different invasion potential in Europe according to climatic conditions. Maybe not all lines merit the same control methods. There are molecular tools to quickly distinguish these lines."

Valérie Laval

"Interview

Valérie Laval, scientific manager of the Lycovitis project – From visual diagnostics to sequencing: Sys3D, an integrative diagnostic tool for tomato and vine.

What is the objective of the Lycovitis project?
It is aiming to create a database for conducting simple, reliable and speedy diagnoses on the health status in tomato plants and vines. Identification will be facilitated by the provision of accurate photos of symptoms and the possibility, in the longer term, to conduct a molecular diagnosis. The producer will therefore be able to better characterise the attacks from a wide range of pests. Our ultimate ambition is to create a platform integrating visual diagnostic tools, genetic sequencing databases and Decision Support Systems to aid epidemiological surveillance.

How will you ensure the reliability of your model?
We will aggregate the knowledge from specialists on these two crops. Many molecular sequences already exist for insects, bacteria, viruses, phytoplasmas, nematodes and beneficials. We have also launched market research to identify the needs and expectations of producers, as well as a cost analysis. These studies will be conducted in 2015.

* The SMaCH metaprogramme (Sustainable Management of Crop Health), established by INRA for the decade 2010-2020, represents a new way of managing multidisciplinary programmes on plant health, making it possible to co-construct in a coherent manner agricultural systems which are productive yet less sensitive to diseases and insect pests, and meeting the three pillars of sustainable development: economic performance, social performance and environmental performance.

www.smach.inra.fr

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