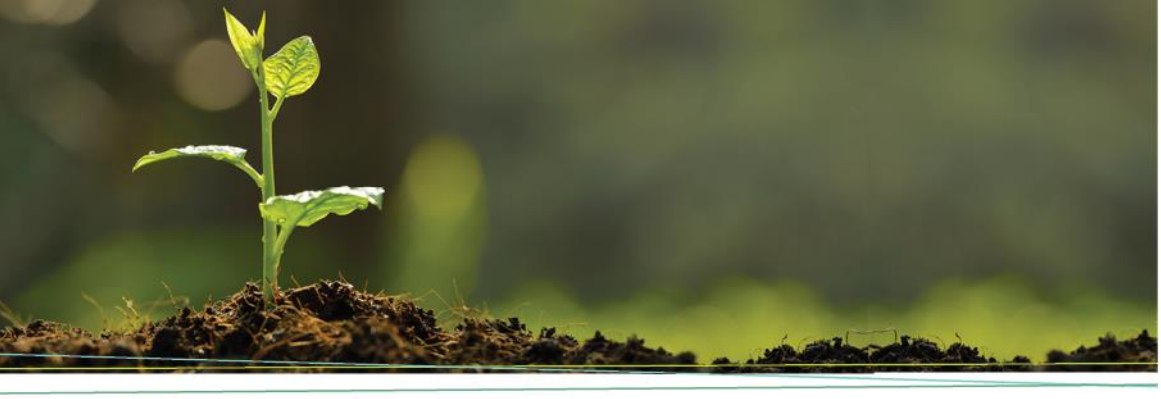

Focus Group SOIL-BORNE DISEASES

Mini-paper - *Less boxes and more horizons*

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Introduction

Writing a mini-paper about 'innovative out of the box' is a big challenge. How to approach it? Which aspects should be highlighted to be discussed in the next meeting? The concept of innovative itself implies a context. Many techniques considered nowadays 'old-fashioned' (ex: chemical fumigation with methyl the bromide) or 'common sense' (ex: use of clean seed and plant material) were once very innovative. Also 'old-fashioned' techniques can become innovative when small innovative changes are made (ex. 'green manures' vs. 'agro-ecological service crops'). On the other hand, the 'current innovative' ones are being generated (potential; ex: biological control) or are so new that the dimension of their impacts are still not known (Anaerobic Soil Disinfestations-ASD). So, it is convenient that we discuss some aspects of the current context of innovation.

What is needed to stimulate innovation and 'out of the box' thinking?

Establishing collaborations between people with different skills/expertises

Looking for synonyms of innovative, another interesting adjective appears: creative. Indeed, creativity is a very important skill involved in the process of finding new ways of solving problems, but it is not the only one. According to the theory of the professor and psychologist Robert Sternberg, people manage basically three types of skills. Some people are more analytical, other more creative and other more practical. To reach success, people need to identify their strong skills and search collaboration with people with complementary skills.
In our context, success means the development of new IPM-compatible techniques to manage one or, in most cases, several soil borne diseases that affect a crop in certain farming systems. Soil-borne diseases are very complex problems that may require steady persistence, motivation and solid collaboration.
Next to the fact that people with different personality skills need to collaborate, it is also important that people with different types of expertise - that maybe at first sight are not compatible - collaborate (ex. psychology and biology/ art and biology/ agriculture and ecology).

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Aspects to be discussed:

- How to establish and sustain collaborations in this period of crisis (reduced budget/professional evaluation systems that often stimulate competition)?
- What skills and professions are we missing in our Focus group? Economy, sociology and psychology could help to change behavior and implement an innovative approach on farm level. Further on data management (big data) and information specialists could help to develop tools on the implementation of IPM to control SBD.
- What are the developments in other sectors like automotive, aviation, pharma, chemistry, ICT, where agriculture could use the results to start innovations? E.g. Drones, satellites, MRI scans etc.
- How can we create a stimulating environment where people from different sectors and with different skills interact and opportunities to interact?

Establishing connections among disciplines (integrating knowledge)

At different moments of the discussion in Alicante, the necessity of 'integrated research' has been raised. The development of IPM for certain soil-borne diseases seems to be important, but the step to holist management of soil health and finally, plant health seems crucial. Currently, this is a hot topic. However, this concern is not new. Several aspects regarding this topic have been debated in the last 25 years (see for example the article of RJ Cook: Advances in plant health management in the twentieth century. Annu. Rev. Phytopathol. 2000. 38:95-116). There are still many questions regarding how to implement this idea in practice.
Aspects to be discussed:

- Are the professionals involved in research/implementation of techniques trained to establish connections and integrate specific knowledge of soil fertility, plant physiology, entomology, plant pathology… in such holistic approach?
  Some interesting initiatives as source of inspiration:
  http://www.europeanvoice.com/article/can-you-teach-people-to-be-innovative/ **http://www.dpm.ifas.ufl.edu/**
- How to promote cross-fertilization among totally different sectors?
- Building Decision Support Systems on soil quality may provide a platform where all disciplines meet and are forced to draw conclusions and give the best possible answers based on the knowledge available. Further on this reveals lacking information and knowledge and shows the hurdles.

Which methodologies, tools and topics are involved in the development of innovative techniques in the 21st century?

Once innovative ideas are raised, a next important step is the development of the techniques to application in 'real life'. Below some examples of current difficulties/challenges that we are dealing with if we want to implement innovative IPM techniques for soil-borne diseases into practice.

Requirement of new types of experiments

In the context of sustainability, the impacts of new techniques in the long-term became an important aspect to be considered.
For example, in the last meeting, the use of BCA's was pointed as one of the most promising technique for high value crops (figure 1, minutes). If we check this figure in detail we see that 25% of the 'votes' were from practicers and 75%, from scientists. This suggests that some things are still missing from the point of view of application. Here, clearly, we have several aspects of this promising technique that need innovation. Short-term experiment is probably not the most

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adequate method to show the long-term benefits of introducing biocontrol agents. However, to test long-term effects of different soil managements (more than 2 years) in high value crops, such as lettuce in Belgium, are very difficult in practice. The growers cannot take risks and need to use efficiently (very intensive) their greenhouses and the research stations do not have enough greenhouses to implement these types of experiments combined with many other different experiments.
In addition to the use of BCA's, many other techniques that are currently been developed require more complex experiments (long-term, multiple disciplinary, etc) than those that we were previously used to perform.
Although soil is commonly treated as a single concept, any soil is a different environment hosting different populations of macro and microorganisms, having with different characteristics and problems.

Aspects to be discussed:

- How should we test the long-term effects in high value crops?
- How and where should we set up these types of experiments?
- Which variables should we measure?
- In addition, we know that the influence of soil type is also important. How to take this aspect in account, considering the limitation of space (greenhouses availability)?
- Design experiments that are convincing (show that BCA's can be as effective as chemical control, easy to apply, etc)
- How to get and keep a network of long term experiments in Europe where both biotic and abiotic indicators are measured in a standardized way.
- What possibilities are offered by Geo Information Systems in the Galilei (European satellites) and drone era?
- What are the other approaches (physical and chemical) that can be used as innovative techniques to promote soil quality and health?

Requirement of new tools to detect, quantify and predict

Monitoring was a very popular term in the meeting in Alicante. We need to be able not only to monitor (detect and quantify) the pathogens, but to predict their potential to cause disease in the short and long-term ('building soil health'). This type of prediction will probably require monitoring too.
Aspects to be discussed:

- What should we monitor to be able to predict the evolution of soil health ('stages of suppressiveness')? Many growers would probably be willing to pay for this type of analysis, if it would exist. Here is a field to be explored with innovative approaches.
- Or should we also develop indicators that are not laboratorial analysis-related?
- Is there the possibility of creating a molecular toolkit to assess the functions of the soils (metatranscriptome) and evaluate the impact of a certain treatment?

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Rethinking fertilization

The relationship between fertilization (inorganic and organic) and soil-borne diseases is another hot topic. Fertilization, soil conditioners and amendments can greatly influence the soil properties and the microbial population. Fertilization should be seen not only as addition of macro and micronutrients, but also a way to improve soil quality and health.
Aspects to be discussed:

- Specific nutrients for stimulation of broad spectrum resistance (ex: Si, N, S)
- Use of carriers of bioinocula, soil conditioners and amendments to promote soil health.

The era of communication: plant-plant, plant-microbe, plant-microbe-insect

Maybe this topic is one of the most 'scientifically active' nowadays. The recent meta-omics approach is able to provide insights on the community structure and diversity of the plant microbiome. Although the roots and the microorganisms associated (microbiome) seem to play relevant roles in plant resistance, the functional potential of the plant associated microbiota remains largely unknown (Schlaeppi & Bulgarelli. The Plant Microbiome at Work, MPMI, 2015, 28: 212-217). In addition, many studies have been published unrevealing the mechanisms involved in the plant active defense (hormones, proteins, volatile organic compounds-VOCs…), but the development of new IPM techniques based on this knowledge is still scarce.
Aspects to be discussed:

- How to translate this knowledge to practice?
  Interestingly, one of the participants in Alicante asked himself if it would not be possible to train a dog to detect levels of certain compounds in the soil or air that could indicate that the plants were reacting appropriately to a certain pathogen attack. This question triggered and inspired the development of this mini-paper.
- Soil metagenome is already fact, why not expanding the concept to soil transcriptome, proteome, metabolome, etc.?

Literature

- Cook RJ (2000). Advances in plant health management in the twentieth century. Annu. Rev. Phytopathol. 38:95-116.
- Schlaeppi K, Bulgarelli D (2015). The Plant Microbiome at Work, MPMI 28: 212-217.

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