

Is the efficacy of biological control against plant diseases likely to be more durable than that of chemical pesticides

<u>Marc BARDIN</u>, Benoît GRAILLOT, Miguel LOPEZ-FERBER, Philippe NICOT, Myriam SIEGWART



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Biological control against plant diseases



→ Much research: identification of many biocontrol agents

Bibliographic approach

- **157 species of microorganisms** described as effective against five major airborne plant diseases, Botrytis, powdery mildew, rusts, downy mildews (+ *Phytophthora infestans*) and Brown rot
- 29 fungal/oomycetes species and 18 bacterial species: significant effect in the field to control one of the 5 major diseases



Classical and augmentative biologica control against diseases and pests:

status analysis and review of fac



Nicot et al, 2011 http://www.iobcwprs.org/pub/biological_control_against diversifying crop protection _diseases_and_pests_2011.pdf



end

Biological control against plant diseases



- → Much research: identification of many biocontrol agents
- → Marketing of several biocontrol agents against plant pathogens
 - In the European Union, biocontrol agents registered (2011): 15 microorganisms **4** plant extracts



Heilig et al, 2011 http://www.iobcwprs.org/pub/biological_control_against diseases and pests 2011.pdf



lassical and augmentative biolo control against diseases and pests

critical status analysis and review of factor



 In France (<u>http://e-phy.agriculture.gouv.fr/</u>, 01/2015) 10 microorganisms **2** plant extracts

Biological control against plant diseases



- → Much research: identification of many biocontrol agents
- Marketing of several biocontrol agents against plant pathogens
- ➔ Is the efficacy of biological control against plant diseases durable ?

The durability of a control method for plant protection depends on:

- the selection pressure exerted by it on populations of plant pathogens
- on the capacity of these pathogens to adapt to the control method

Lessons learned from the past



- Erosion of effectiveness of conventional plant protection methods
- Frequent and recurrent **apparition of resistance to fungicides** in major plant pathogenic fungal populations

• Breakdown of plant varietal resistances, especially that linked to major resistance genes

Lessons learned from the past



- Erosion of effectiveness of conventional plant protection methods
- Results concerning pest management in agricultural systems with biocontrol agents
- Resistance of various pests to one or several toxins of *Bacillus thuringensis* (Tabashnik, 1994. *Annual Review of Entomology*, 39:47)
- Populations of Cydia pomonella with reduced susceptibility to Cydia pomonella granulovirus detected in various regions on pome fruit orchards
 - → required the **recent development of a new product**.

Next talk by Samantha Besse











What about the durability of biocontrol for plant pathogens ?



- existence of **less sensitive isolates to biocontrol agents** in natural populations of plant pathogens ?
- capacity of plant pathogens to **adapt** to biological control ?

What about the durability of biocontrol for plant pathogens ?



Meta-analysis of the scientific literature

- Web of Sciences database (2014/07/21) = **7872** references on biological control against plant diseases
- Survey refined entering keywords describing the diversity or the durability of efficacy of biocontrol agents towards plant pathogens
 - = 867 references
- Most of the reports often consider a single strain of the pathogen
- Only 29 studies met criteria

What about the durability of biocontrol for plant pathogens ?



Meta-analysis of the scientific literature

• 26 references

→ variation in sensitivity of various isolates of plant pathogens to biocontrol agents

• 3 references

➔ potential of plant pathogens to overcome the effect of a biological control product

Existence of less sensitive isolates in natural populations of plant pathogens ?



Meta-analysis of the scientific literature

• 26 references

→ variation in sensitivity of various isolates of plant pathogens to biocontrol agents

Plant pathogens

- Fungi: 17
- Oomycetes: 5
- Bacteria: 4

3-204 isolates tested

Biocontrol agents

- Bacteria: 14
- Fungi: 7
- Plant extracts: 3
- Virus (mycovirus, phage): 2

Different modes of action



Capacity of plant pathogens to adapt to biological control ?



Meta-analysis of the scientific literature

• 3 references

➔ potential of plant pathogens to overcome the effect of a biological control product

Capacity of plant pathogens to adapt to biological control ?



Meta-analysis of the scientific literature

Botrytis cinerea: 2 studies

Bacillus subtilis /Astilbe hybrida

Successive treatments: control totally **ineffective** after 10 treatments

Li and Leifert. 1994. Z. Pfl. Pflanz. 101:414 Leifert *et al.* 1995. J. Applied Biol. 78:97 *In vitro* experimental evolution on pyrrolnitrin (20 generations)



High fitness cost

Ajouz *et al.* **2010. Plant Pathology 59:556** Ajouz *et al.* 2011. EJPP 129:31 Fillinger *et al.* 2012. PLoS One 7:e42520

Botrytis cinerea able to gradually build up a resistance to antibiotic producing biocontrol agents



Capacity of plant pathogens to adapt to biological control ?





15 generations realized on melon leaves in presence of plant extract from rhubarb (combination of mode of action)

No evolution of *Podosphaera xanthii* and *Pseudoperonospora cubensis* towards resistance to the plant extract from rhubarb



Diversity of sensitivity of pathogens to biocontrol agents

➔ importance of considering several strains of the pathogen when evaluating their efficacy : ensure a wide representation of the targeted plant pathogen population

Potential of pathogens to **increase their level of resistance** to biocontrol agents

characteristics linked to some plant pathogens? to biocontrol agents ?





Data too sparse to elaborate a general theory on the use of biocontrol agents in practice

Not possible to link specific traits of the **plant pathogens** or of the **biocontrol agents** to the loss of effectiveness of biocontrol

modes of action more prone to be overcome by plant pathogens ?





Significant research efforts needed

to anticipate the potential failure of biological control

- Survey of natural populations of plant pathogens to evaluate the diversity of sensitivity to biocontrol agents;
- Analysis of the **ability of plant pathogens to evolve** to a selective pressure exerted by a biocontrol agent.





Significant research efforts needed

to anticipate the potential failure of biological control

to integrate durability concerns

- in the screening procedure of new biocontrol agents
- in the **careful management of their use** once they become commercially available.



Thank you for your attention!



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