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Managing the complex use of microbial biocontrol agents against plant diseases in a context of IPM

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➤ Managing the complex use of microbial biocontrol agents against plant diseases in a context of IPM



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Disease control = “weak link” of IPM in cropping systems ?

An increasing number of registered biocontrol products for disease management

At world level, against diseases of plants
(virus, bacteria, oomycetes, fungi)

91 microbial biocontrol strains

49 fungi/yeast/oomycetes
+ 37 bacteria/actinomycetes
+ 5 virus/phages

41 microbial strains approved in Europe

(EU pesticide database, 07/2023)

Mission accomplished ?

→ How are these products actually used by farmers?



BioControl
DOI 10.1007/s10526-017-9801-4



**Biological control using invertebrates and microorganisms:
plenty of new opportunities**

Joop C. van Lenteren · Karel Bolckmans · Jürgen Köhl ·
Willem J. Ravensberg · Alberto Urbaneja

Use of microbial biocontrol against diseases

Survey of French vegetable farmers and farm advisors

- **Online questionnaires disseminated** to more than 500 professionals (217 answers):

2 key lessons from the analysis of responses:

- ✓ Only few biocontrol products known (21/32) and used (15)
- ✓ **Efficacy perceived as low**

- **Face-to-face interviews performed** (42 / 217 respondents):

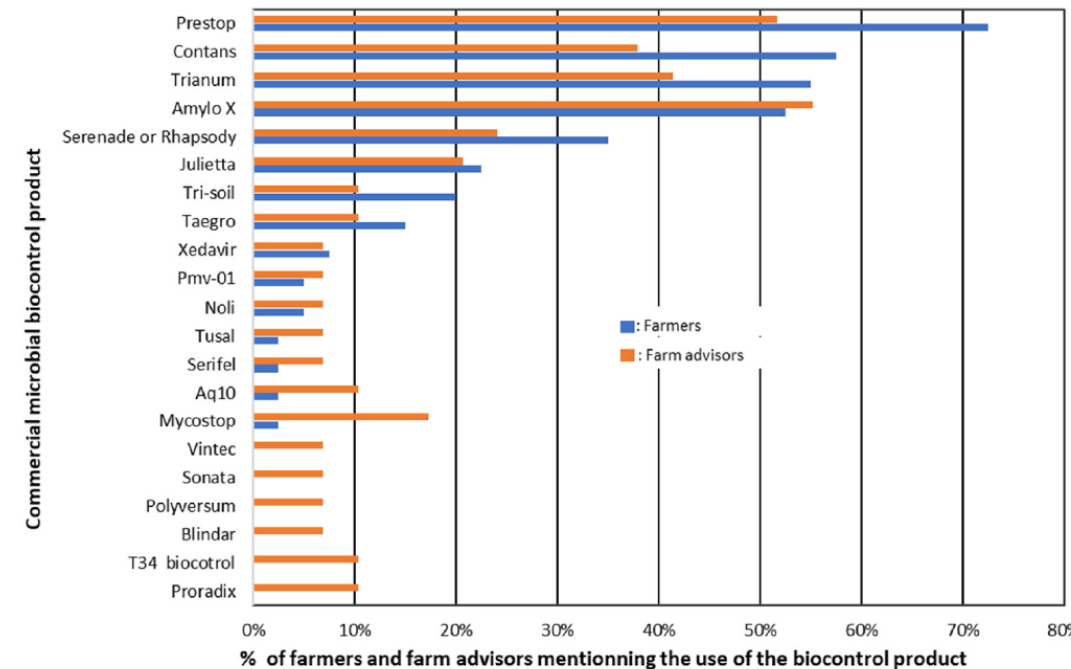
3 key lessons

- ✓ Aware of possible benefits of applying biocontrol products to manage plant diseases

But...

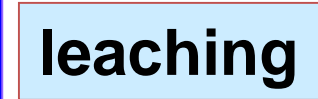
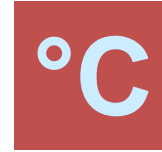
- ✓ Difficulties in using biocontrol (with other cultural practices) and need for guidelines
- ✓ **Unstable efficacy**

➔ **What are the possible causes for this instability in the efficacy of protection?**



Example of factors that can modulate the efficacy of biocontrol against plant diseases

Climatic conditions



Cultural practices

Agron. Sustain. Dev. (2014) 34:641–648
DOI 10.1007/s13593-013-0168-3

RESEARCH ARTICLE

Nitrogen fertilization impacts biocontrol of tomato gray mold

Manzoor A. Abro · François Lecompte · Marc Bardin · Philippe C. Nicot



Other phytosanitary treatments including biocontrol

Biological Control 46 (2008) 476–483

Compatibility between biopesticides used to control grey mould, powdery mildew and whitefly on tomato

M. Bardin ^{a,*}, J. Fargues ^b, P.C. Nicot ^a

^aINRA, Unité de Pathologie Végétale, UR 407, F-84140 Montfavet, France
^bINRA, Centre de Biologie et de Gestion des Populations, Campus international de Baillarguet, CS 30 016, 34988 Montpellier-sur-Lez cedex, France

Resistance of the target pathogen to biocontrol

frontiers in Plant Science

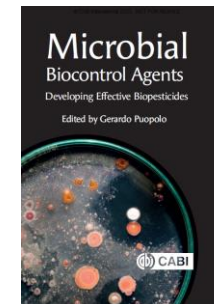
REVIEW published: 27 July 2015
doi: 10.3389/fpls.2015.00566

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

Marc Bardin ^{1*}, Sakhr Ajouz ¹, Morgane Comby ¹, Miguel Lopez-Ferber ¹, Benoit Graillet ^{2,3}, Myriam Stegwart ⁴ and Philippe C. Nicot ¹

¹Plant Pathology Unit, Institut National de la Recherche Agronomique, UR407, Montfavet, France, ²Laboratoire de Génie de l'Environnement Industriel, Ecole des Mines d'Albi, Institut Mines-Télécom, Albi, France, ³Natural Plant Protection, Arysta LifeScience Group, Pau, France, ⁴Plantes et Systèmes de Culture Horticoles Unit, Institut National de la Recherche Agronomique, UR1115, Avignon, France

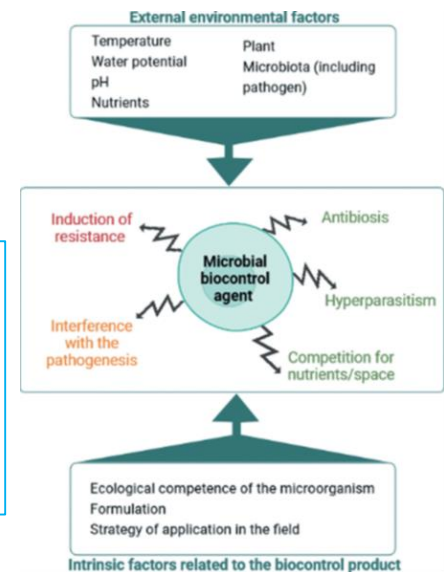
Mode(s) of action and their activation



Modes of Action of Microbial Biocontrol Agents against Plant Diseases

ESTELLE TURC^{1,2}, THOMAS PRESSECO^{1,3}, PHILIPPE C. NICOT¹ AND MARC BARDIN^{1*}

¹INRAE, Pathologie Végétale, Montfavet, France
²Groupe Eléphant Vert France, Serris, France
³INRAE, Ecodéveloppement, Avignon, France



Classification of efficacy factors for a biocontrol microbial strain

- Efficacy factors organized into 4 groups
- Each group includes a number of related factors
- Possible interactions between factors

- Type of disease
- Inoculum pressure
- Level of sensitivity

- Cultural practices
- Plant species, genotype
- Fertirrigation
- Phytosanitary treatments

Pathogen

Cropping practices

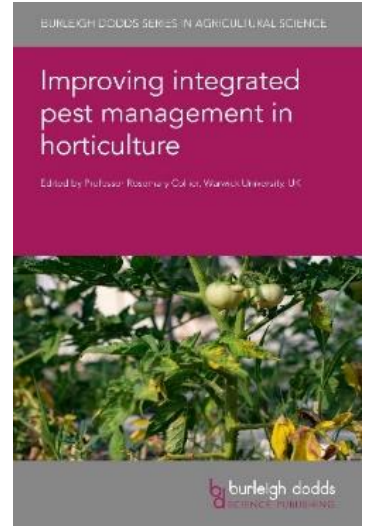
Biocontrol

Environnement

Efficacy

- Ecological competence of the microorganism
- Mode of action
- Dose / quality / formulation of product
- Method / condition of use

- Physical (T°C, humidity, light...)
- Chemical (pH, O₂, CO₂...)
- Biochemical (nutrients)
- Microbial



Advances in bioprotectants for plant disease control in horticulture

Philippe C. Nicot, Thomas Pressecq and Marc Bardin, INRAE, Pathologie Végétale, France

➔ **How to deal with this complexity and help farmers use biocontrol “correctly” ?**

How to deal with this complexity and help farmers?



- Develop **practical guidelines** helping the farmer to choose the most adequate products for specific situations, and to
- obtain indications about the most efficient way to use a biocontrol product

→ **Where to find the information needed for developing the guidelines?**



→ **the data available in scientific literature will make it possible to obtain this information**

✓ Is there a substantial amount of published knowledge on the factors governing the efficacy of microbial biocontrol agents?

✓ Is it possible to gather suitable information to develop guidelines for the practical application of these products by farmers?

Analysis of published knowledge on the factors that govern the efficacy of microbial biocontrol agents

1. Collect relevant peer-reviewed scientific articles

All publications on the **41 biocontrol microbial strains registered in Europe** (excluding reviews)

Research equation :

Full name of biocontrol agent (**species + strain name**)
OR current (and possibly previous) **commercial name**



- ✓ 808 publications collected about microbial strains registered in Europe
- ✓ Great majority of publications concerned strains in species of *Bacillus* (255 publications) and of *Trichoderma* (263 publications)
- ✓ Most studied strains: *B. amyloliquefaciens* QST 713 (133 publications) and *T. afroharzianum* T-22 (115 publications)

Analysis of published knowledge on the factors that govern the efficacy of microbial biocontrol agents

1. Collect relevant peer-reviewed articles

2. Review of scientific information on the efficacy factors

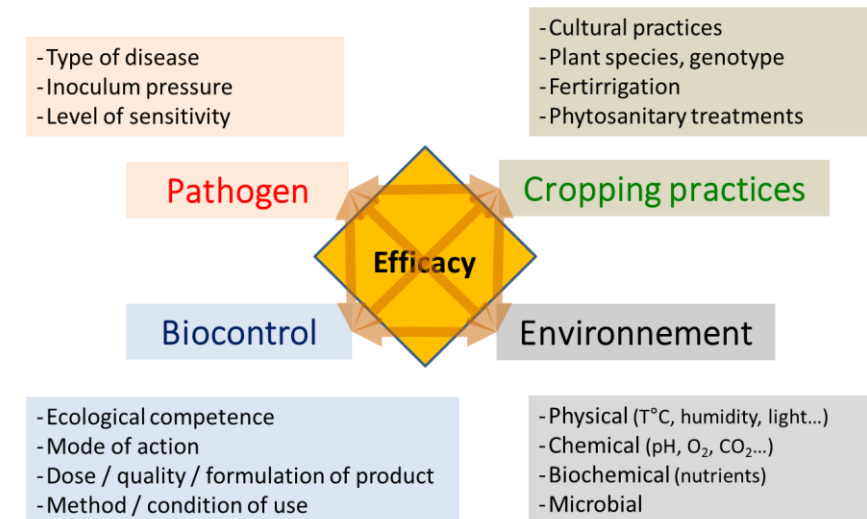
- ✓ 37% of articles with information on efficacy factors (296)
- ✓ Certain articles can include results for different factors of efficacy
- ✓ **No information** for 13 of the 41 strains registered in Europe

Analysis of published knowledge on the factors that govern the efficacy of microbial biocontrol agents

1. Collect relevant peer-reviewed articles
2. Review of scientific information on the efficacy factors
- 3. In-depth analysis of publications: extraction of data on efficacy factors**
 - a. Every publication analyzed according to the following framework:**

Context	Experimental conditions	Data on efficacy factors
<ul style="list-style-type: none">• Biocontrol name (strain, commercial product)• Crop• Pathogen targeted• ...	<ul style="list-style-type: none">• Experimental method (<i>in vitro</i>, controlled condition, in field...)• Biocontrol treatment (type, dose, timing, frequency)• Pathogen inoculation (natural or artificial, conditions)• ...	<ul style="list-style-type: none">• Efficacy factor(s) tested (group and sub-group)• Protective efficacy value• Effect of factor(s) tested on efficacy (quantitative data if available)• ...

✓ For a given scientific paper, several relevant information units can be obtained



Analysis of published knowledge on the factors that govern the efficacy of microbial biocontrol agents

1. Collect relevant peer-reviewed articles
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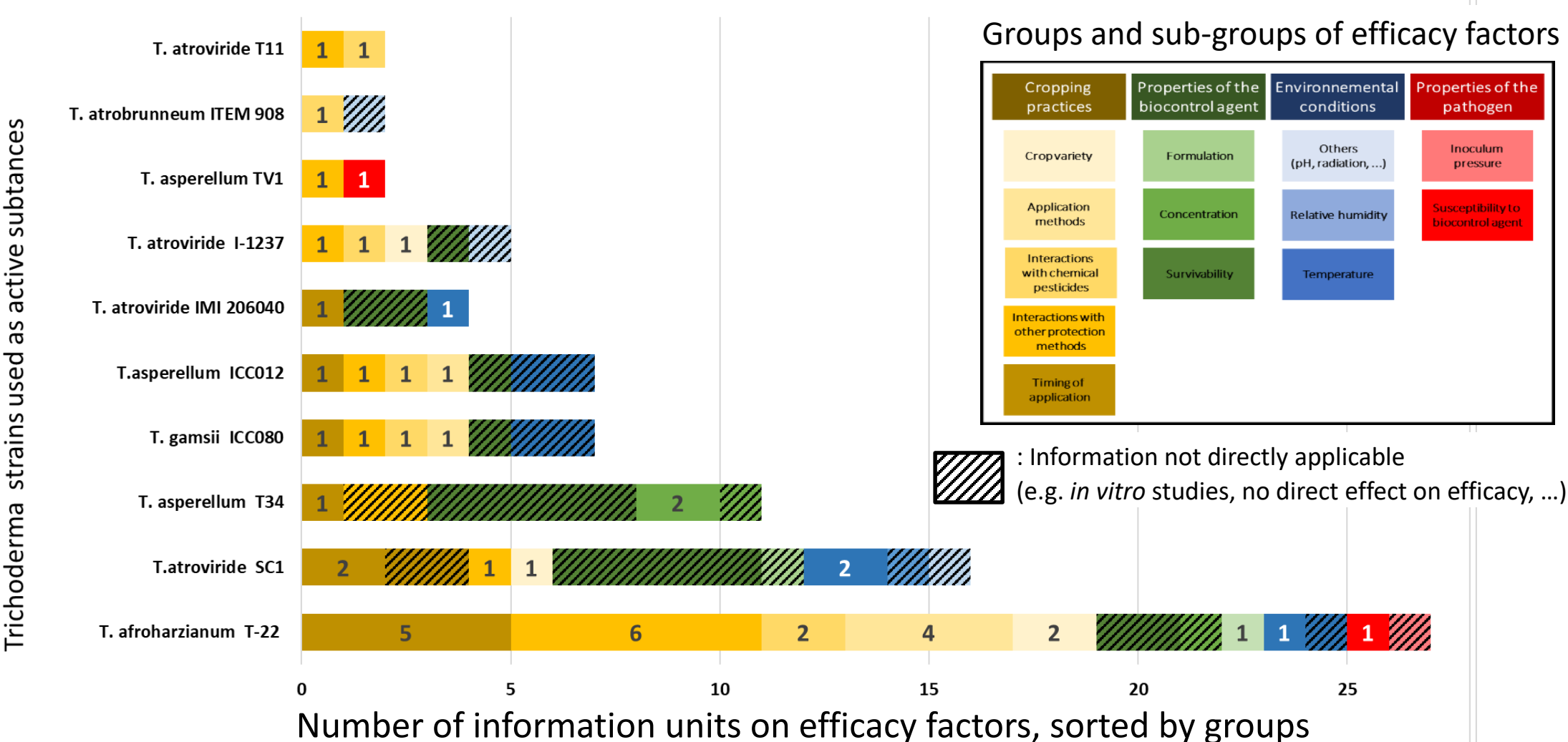
b. Build a database on efficacy factors of microbial biocontrol agents against plant diseases

=> analysis of the database:

- ✓ Not much quantitative data available
- ✓ Very heterogenous distribution of information among biocontrol strains and among types of efficacy factors

Example of *Trichoderma* strains: there are data, but ...

- ✓ Some data not relevant (e.g. strain name not indicated)
- ✓ Little information available / commercial strain / efficacy factor
- ✓ Information not directly applicable (e.g. data obtained under artificial conditions)



Conclusion

- Is there a substantial amount of published knowledge on the factors governing the efficacy of microbial biocontrol agents ?

→ Most of the data currently published on microbial biocontrol agents in scientific journals do not involve commercial strains or efficacy factors

- Is it possible to gather suitable information to develop guidelines for the practical application of these products by farmers ?

→ Tremendous amount of additional data required for the development of guidelines for farmers

What's next ?

- **Increase the availability of data in future published articles for integration into the database**
 - ✓ Clearly indicate the strain name of the biocontrol agent used in the study
 - ✓ Share data more widely, including “negative” results
- **Obtain more data on biocontrol agent efficacy factors**
 - ✓ Make agreements with companies (in progress)
 - ✓ Carry out experiments under production conditions, recording as many variables as possible (climatic conditions in particular)
- **Translate this scientific knowledge into decision rules**
 - ✓ Transform the data collected in the database into operational information
 - ✓ Integrate this information into a decision support system useful to farmers

DeciControl



http://ephytia.inra.fr/fr/P/175/Deci_Control



Thank you 谢谢



阿维尼翁, 普罗旺斯

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Marc
TCHAMITCHIAN



EU-China joint action
to increase the development
and adoption of IPM tools



CULTIVER
PROTÉGER
autrement



MINISTÈRE
DE LA TRANSITION
ÉCOLOGIQUE ET SOLIDAIRE

MINISTÈRE
DE L'AGRICULTURE
ET DE L'ALIMENTATION

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