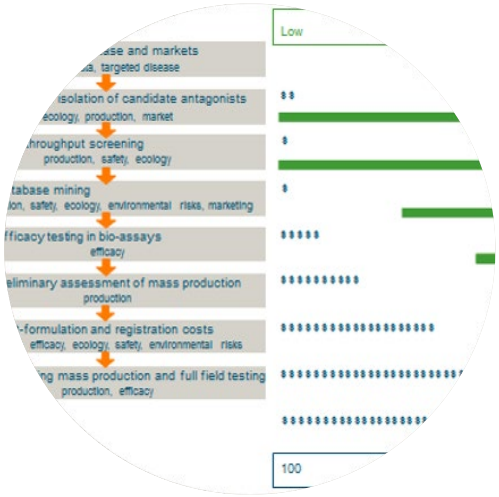
Biologische bestrijders, een overzicht

Najaarsbijeenkomst KNVP

"Biologische bestrijding in open teelten"

10 december 2019, Jürgen Köhl



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100years
1918 — 2018

Biologische bestrijders, een overzicht

Aantekeningen

- Geschiedenis, tegenwordige situatie, toekomstige ontwikkeling
- Gebruik van macrobials en microbials
- Natuurlijke buffering, akkerranden en suppressive soils
- Plagen en ziekten, eventueel onkruiden
- In open teelten

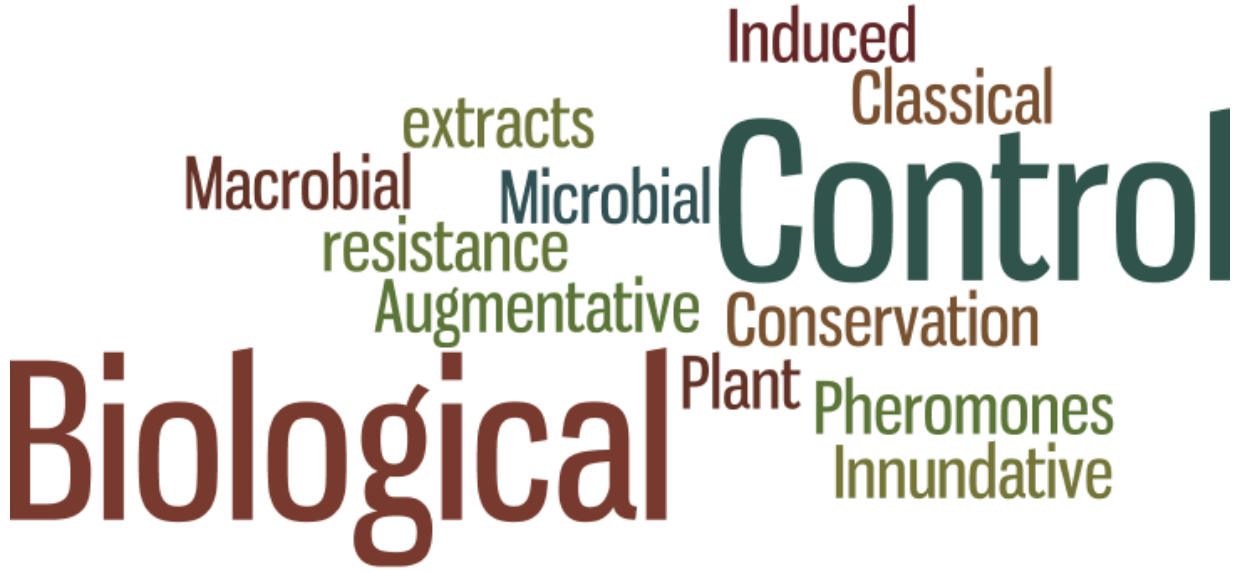
Ambitie

- Compleet overzicht over gebruik van biologische bestrijding in open teelten ?
- Ontwikkeling van gebruik van middel x ha, per ziekte en plagen per gewas ?

Realisatie

- Schets zonder al te veel harde getallen
- Met een bias richting schimmels
- en slides in het Engels

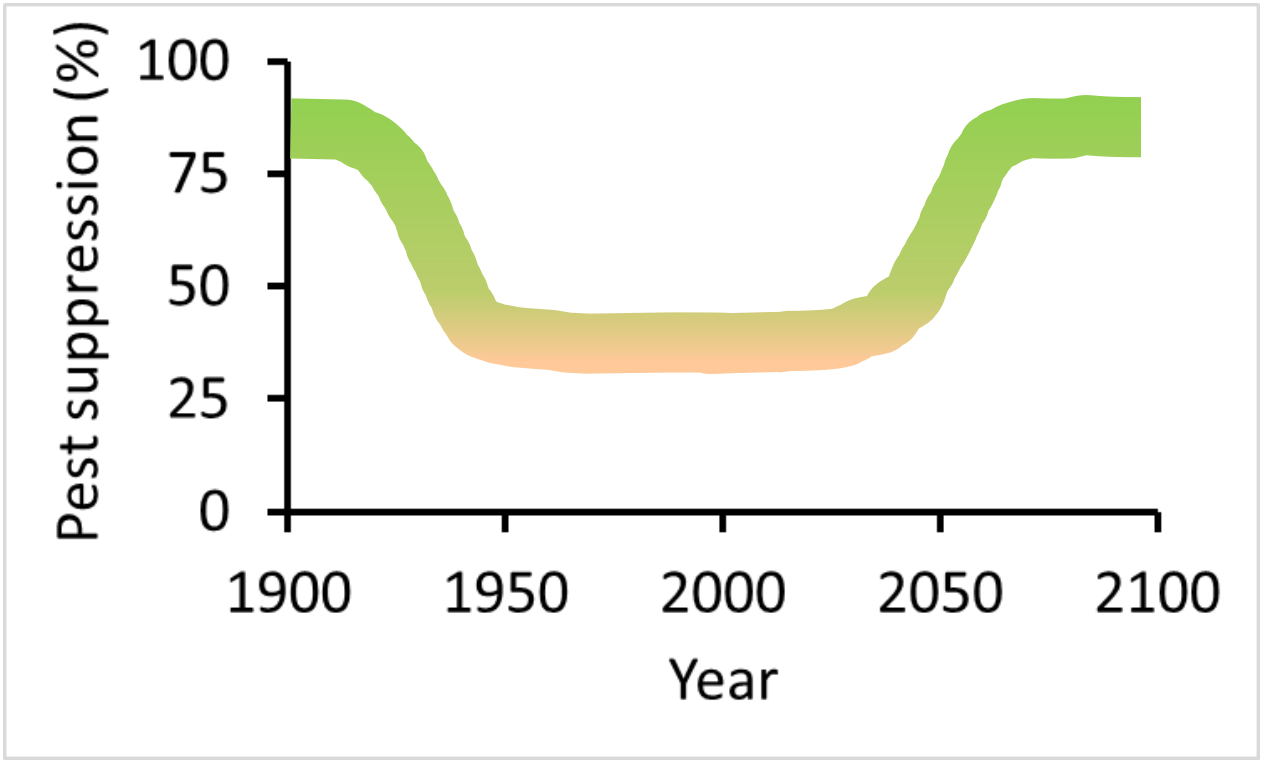
What is Biological Control ?



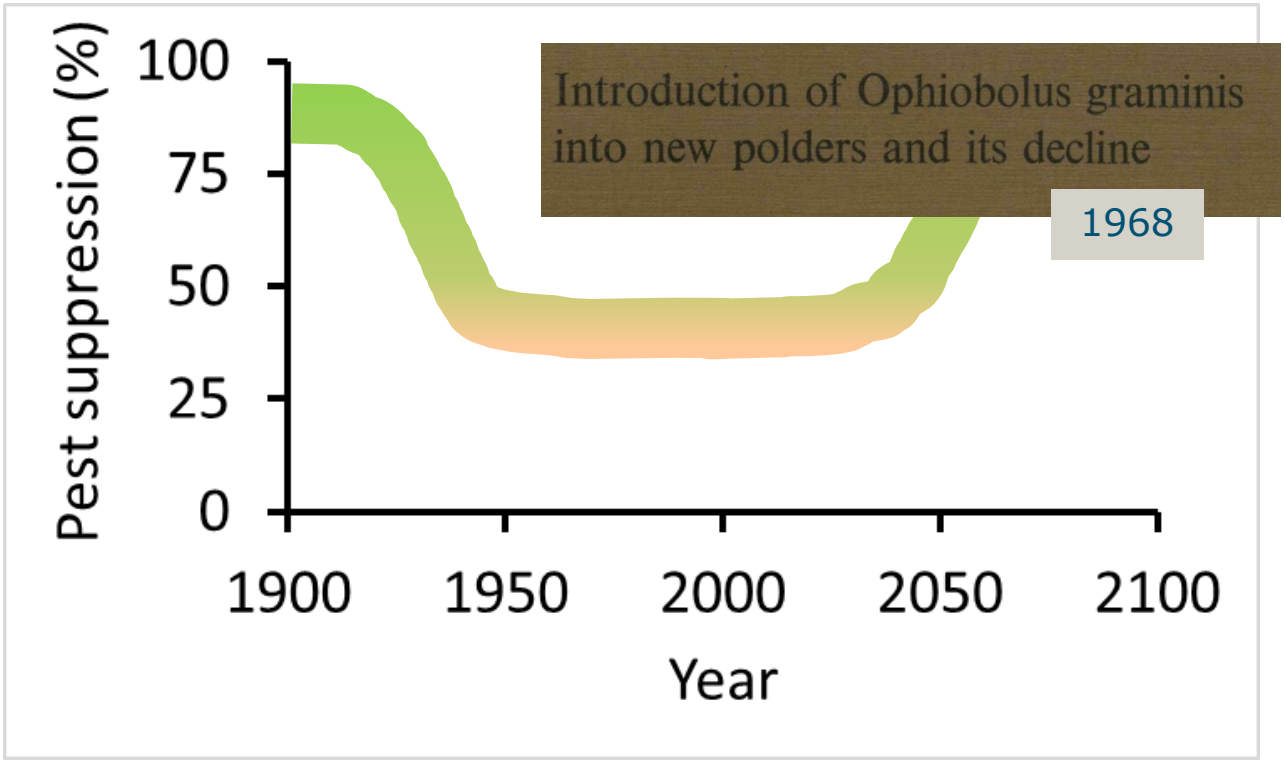
Definitions (Eilenberg et al., 2001)

- **Biological control**: '*The **use of living organisms to suppress** the population density or impact of a specific **pest organism**, making it less abundant or less damaging than it would otherwise be*'
- **Conservation biological control**: '*Modification of the environment or existing practices to **protect and enhance specific natural enemies** or other organisms to reduce the effect of pests*'
- **Inundation biological control**: '*The use of living organisms to **control** pests when control is achieved exclusively **by the released organisms** themselves*'

Conservation biological control: protect and enhance specific natural enemies



Conservation biological control



KOPPERT BIOLOGICAL SYSTEMS

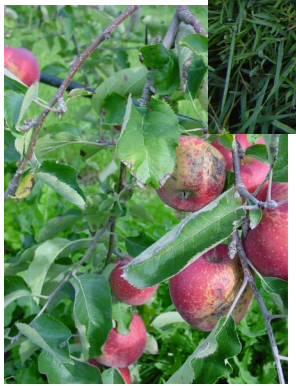
1967

- Jan Koppert
- Chemische bestrijding
- Afname in effectiviteit
- Op zoek naar alternatieven
- Hij was de eerste die een natuurlijke vijand introduceerde om een spintplaag te bestrijden
- Positieve resultaten en effecten

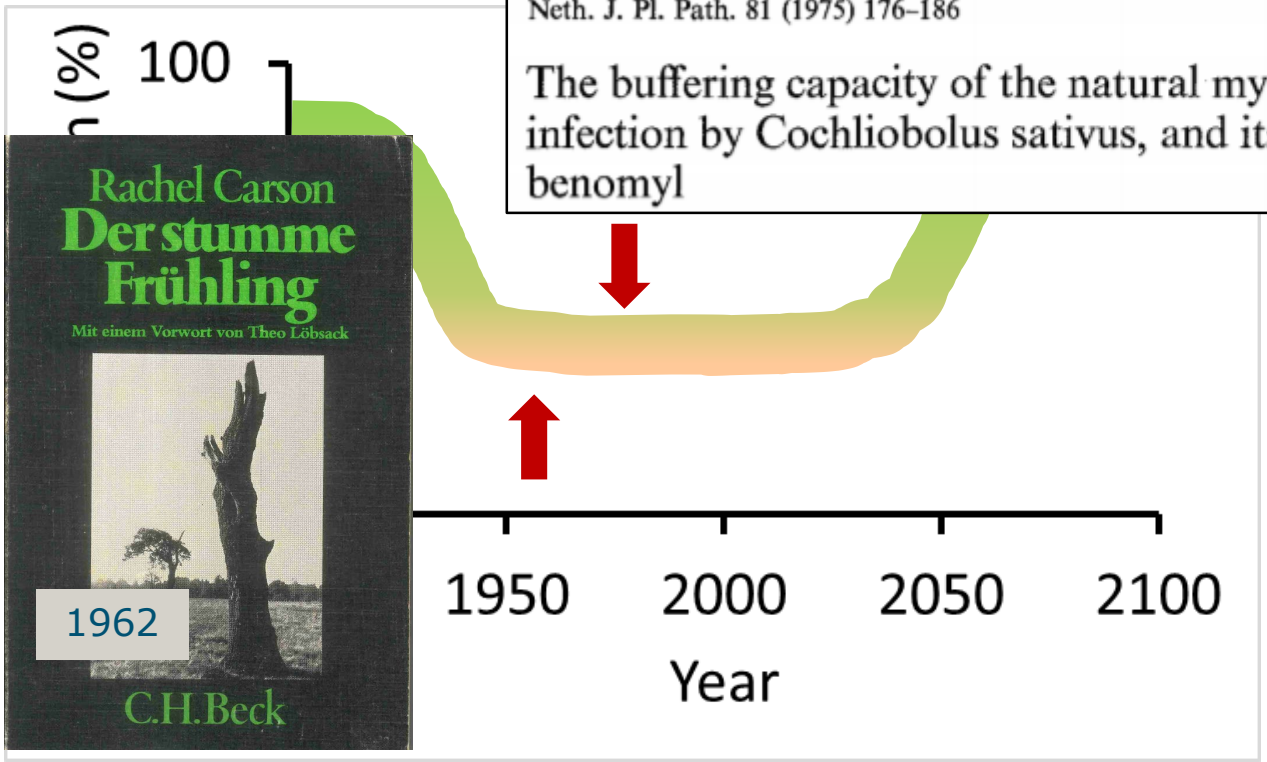
Hij stond voor een fundamentele keuze

Cropping systems with high input of chemical crop protection

- Systems become increasingly dependent on chemical crop protection
- Natural enemies and antagonists became victims of crop protection
- New pests and diseases occur and cause damage



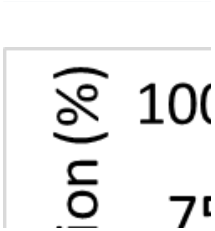
Conservation biological control



Neth. J. Pl. Path. 81 (1975) 176–186

The buffering capacity of the natural mycoflora of rye leaves to infection by Cochliobolus sativus, and its susceptibility to benomyl

Conservation biological control



Toekomstvisie gewasbescherming 2030, naar weerbare planten en teeltsystemen

Gewasbescherming in maatschappelijke context

“LNV-visie gewasbescherming kan actieplan akkerbouw versterken”

23-04-2019

De Toekomstvisie gewasbescherm
actieplan Plantgezondheid van BC
teru

ijk voor een rendabele en
voor is de inzet van
). Hiervoor hebben telers

Tweede Kamer

Commissie LNV

16 juli 2019

Ambities in Toekomstvisie gewasbescherming 2030 zijn meer dan noodzakelijk

In april stuurde Carola Schouten, minister van Landbouw, Natuur en Voedselkwaliteit, haar 'Toekomstvisie gewasbescherming 2030, naar weerbare planten en teeltsystemen' naar de Tweede Kamer, vergezeld van het 'Pakket van maatregelen emissiereductie gewasbescherming

Gerelateerd

Resilient cropping systems

- Crops fitting to region
- Resistant cultivars
- Crop rotation
- limited and selective use of pesticides

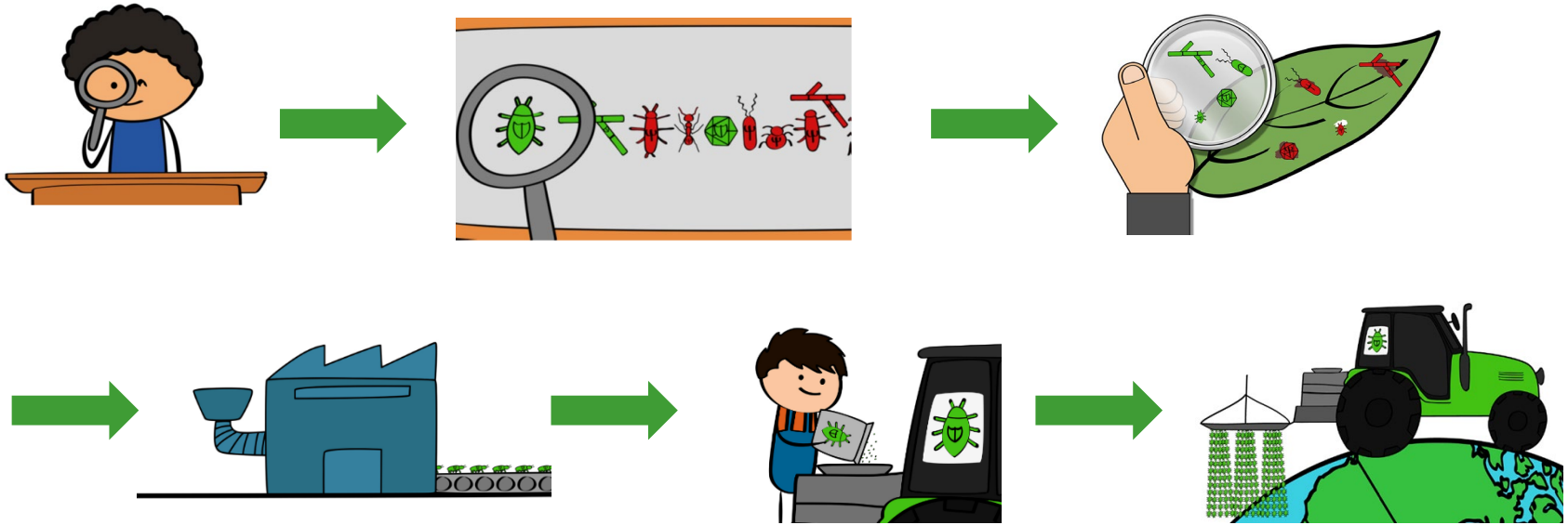
Natural enemies - Insects

- provisioning food or shelter
- flower strips
- strip cropping
- ...

Antagonists - Microorganisms

- Enhance suppressive soils
- Soil Health Treatments: plant material, chitin, composts, ...
- Microbiome research from description to functions to measures
- ...

Use of biocontrol products: Inundative biological control



BIOCOMES
New biological control products
for sustainable farming and forestry

YouTube - What is biological control?

Use of biocontrol products in open field crops

- Mass produced and released natural enemies
- Registered microbial crop protection products

Limitations for use in open fields

- Costs
- Regulations
- Huge surfaces and volumes
- Environmental conditions: humidity, temperature, rain, UV

Costs: Limitation for biocontrol in open field?

Greenhouse crops

- Costs: 666,000 €/ha
- Yield: 718,000 €/ha

Arable crops

- Costs: 4200 €/ha
- Yield: 4800 €/ha

(www.agrimatie; WUR)

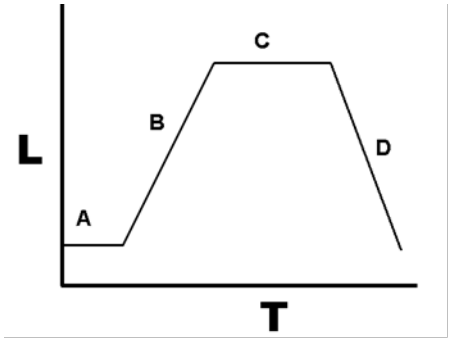
- Smaller market for selective products

➔ Allow true price including

- externalized costs for chemical crop protection caused by residues in drinking water etc.
- and benefits by maintaining natural enemies and antagonists

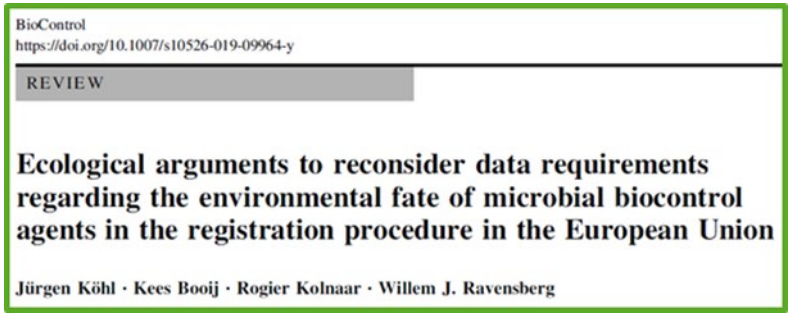
Regulations: Limitation for biocontrol in open field?

- More questions on population dynamics and mode of action for open field than for greenhouse applications
- Living organisms with potential to grow, to change, to spread and to produce relevant antibiotic compounds



L = log(numbers) versus T (time.). Wikipedia.org

Fear 1: Unlimited growth in open field environment



BioControl
https://doi.org/10.1007/s10526-019-09964-y

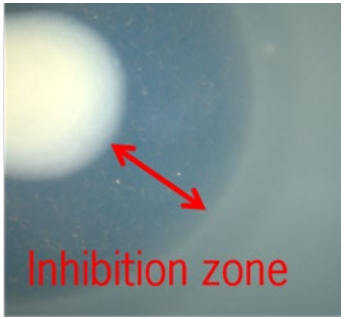
REVIEW

Ecological arguments to reconsider data requirements regarding the environmental fate of microbial biocontrol agents in the registration procedure in the European Union

Jürgen Köhl · Kees Booij · Rogier Kolnaar · Willem J. Ravensberg

Regulations: Limitation for biocontrol in open field?

Fear 2: Continuous production of secondary metabolites accumulating in the open field environment



- Huge variety produced in natural environment
- *In situ* in micro niches
- Various functions
- Low concentrations
- Short lifespan

Köhl, Kolnaar & Ravensberg, 2019. Mode of action of microbial biological control agents against plant diseases: relevance beyond efficacy.
doi: 10.3389/fpls.2019.00845

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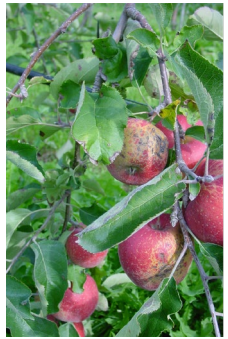
Huge surfaces and volumes:
Limitation for biocontrol in open field?

'... Biocontrol was achieved at an application rate of 1 g per kg of soil ...'

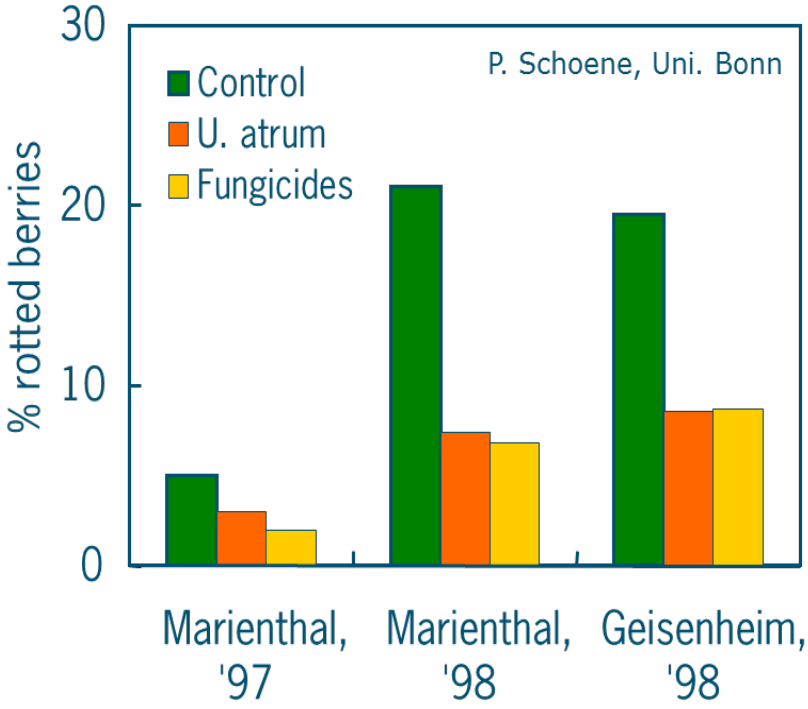
➔ Equals 2000 kg per ha !

➔ Select for antagonists with low application rates per ha



➔ Upscale production facilities and adapt BCAs to upscaling

Biocontrol of *Botrytis* with *Ulocladium atrum* 385



Significant results in

- Grapevine
- Strawberry
- Onion
- Carrots
- Cyclamen
- Potted roses
- Hydrangea
- Pelargonium
- Tomato

15 years of science

>30 scientific publications

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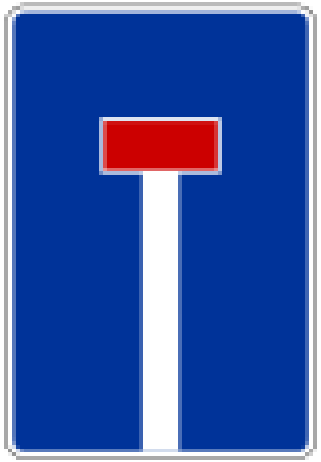
Biocontrol of *Botrytis* with *Ulocladium atrum* 385

Spore production

Preparation of spore suspension

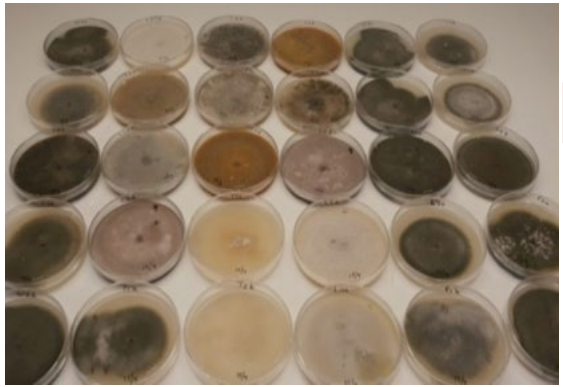


Industrial scaling up of production:

"At a particular effective rate of spores per ha the large spore size does not allow an economically viable production of the antagonist"

Peter Lüth, managing director of the former company Prophyta

Biocontrol of apple scab: Selection of *Cladosporium cladosporioides* H39



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Effect of *Cladosporium* H39 on apple scab Bavendorf, Golden Delicious, summer season 2013

Treatment	Number of applications	Scab incidence (efficacy) on leaves	Scab incidence (efficacy) on fruits
Untreated control	-	17.6 a	70.8 a
Dodine, after infection	10	1.1 b (94)	0.6 b (99)
H39, after infection, $2x10^6$ ml^{-1}	10	0.7 b (96)	3.5 b (95)
H39, after infection, $6x10^6$ ml^{-1}	10	0.3 b (98)	4.6 b (94)

- 2x10 conidia per ml equals 30 g of conidia per ha

✓Select for antagonists with low application rates per ha

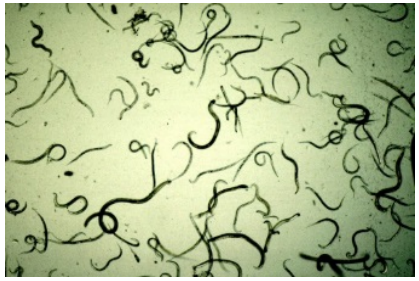
Bavendorf, Golden Delicious, primary season 2013

untreated control

H39

Production technologies entomopathogenic nematodes

- E-NEMA is marketing EPN products
- BIOCOMES investigated genetic improvement of EPNs' longevity, virulence and stress tolerance
- Improvement of shelf life and field persistence allows use of EPN in huge markets for arable crops such as maize



Heterorhabditis

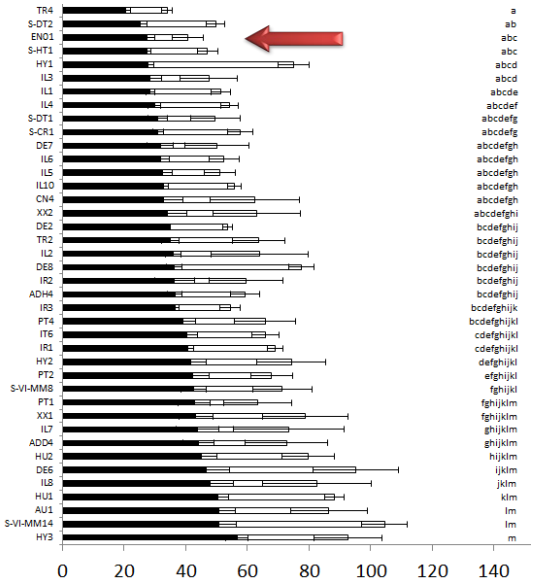
Western Corn Rootworm

e-nema®

BIOCOMES
New biological control products for sustainable farming and forestry

Improvement of entomopathogenic nematodes

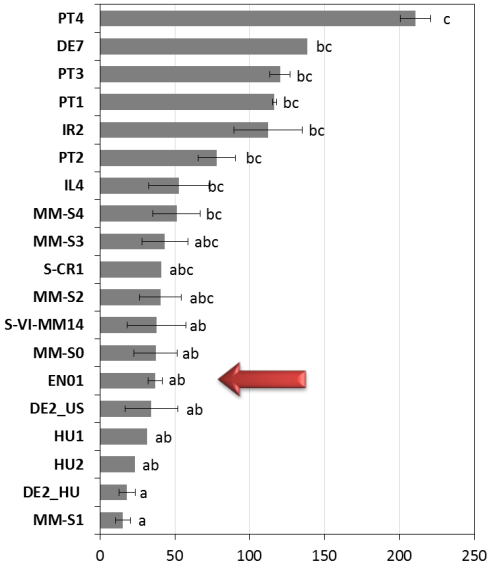
Longevity



Mean survival time (days)

X

Virulence



Mean letal dose (LD_{50})

- Search for molecular markers based on sequence information
- Successful marker-assisted selection

e-nema®

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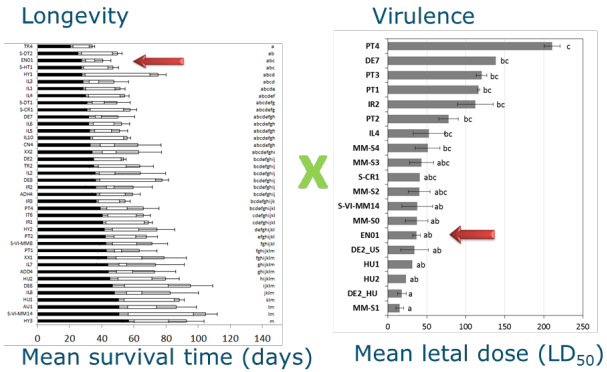
New biological control products for sustainable farming and forestry

Huge surfaces and volumes:
Limitation for biocontrol in open field?

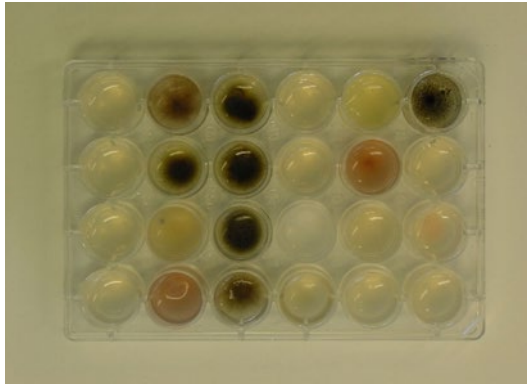
- ✓ Upscale production facilities and adapt BCAs to upscaling



e-nema®

Environmental conditions - humidity, temperature, rainfall, UV: Limitation for biocontrol in open field?

'... further research is needed to develop formulations protecting the antagonists against drought and UV irradiation ...'



➔ Screening of candidate antagonists

- Cold tolerance: Germination & growth at 5°C
- Survival of UV-B
- Drought tolerance: Germination & growth at -7MPa

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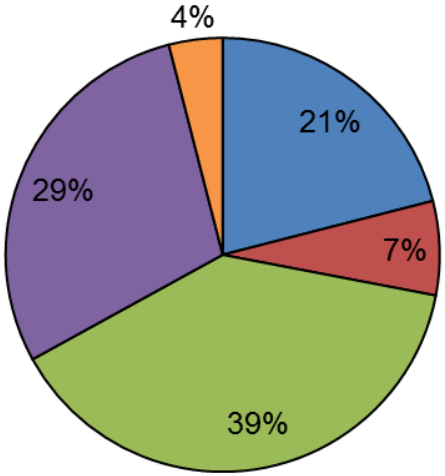
Biocontrol of powdery mildew in wheat

>1200 fungal isolates from Germany, Sweden and The Netherlands

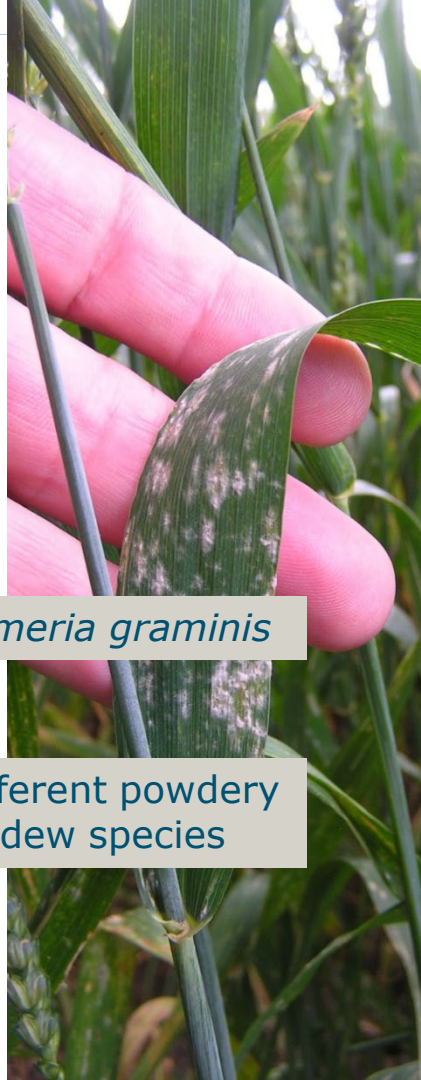


- wheat
- other cereals
- grasses

Blumeria graminis

- herbal plants
- trees

Different powdery mildew species



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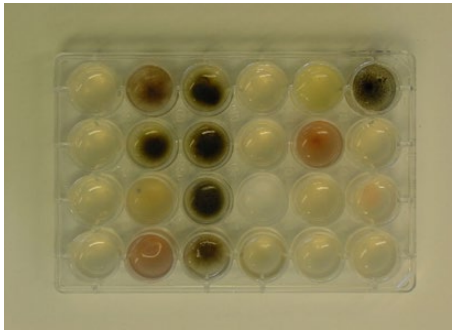
New biological control products for sustainable farming and forestry

Pre-screening



Pre-screening

- Cold tolerance: Germination & growth at 5°C
- Survival of UV-B
- Drought tolerance: Germination & growth at -7MPa

➢ 85% out of 862 isolates fulfilled all criteria

➢ None of additionally tested isolates of *Trichoderma* spp. and *Clonostachys* spp. fulfils all criteria

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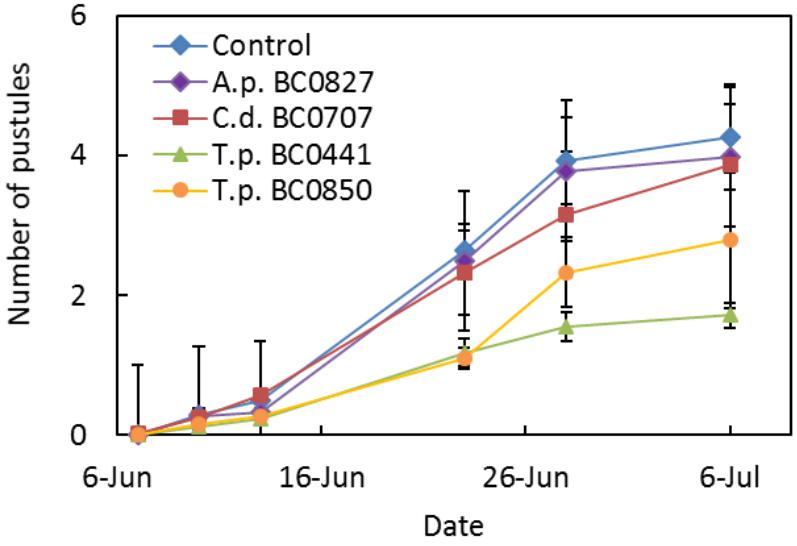
Environmental conditions - humidity, temperature, rainfall, UV: Limitation for biocontrol in open field?

- Isolates from the appropriate niche are adapted to that niche
- Environmental conditions have impact on pathogen, antagonist and their interactions ...
- ... but do not limit use of biocontrol in the open field

Powdery mildew- Field

Tilletiopsis pallescens reduced

- Number of pustules
- Leaf coverage with pustules
- Speed of development of epidemic



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BIOCOMES
New biological control products for sustainable farming and forestry

Agro Plantarum

BIOCOMES project

- 13 Industrial partners
- 14 Research institutes and universities
- Development of 11 new BCAs and 2 new production technologies **for open field crops**
- December 2013 – November 2017
- www.biocomes.eu
- Wageningen UR: Project-coordination & communication

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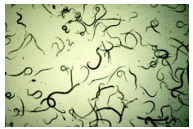
BIOCOMES: some major results

- Tomato leaf miner – *Tuta absoluta*
  - ⇨ entomopathogenic virus
  - ⇨ registration of 'Tutavir'



- Genetic improvement of entomopathogenic nematodes
  - ⇨ Application

- Powdery mildew of wheat – *Blumeria graminis* f.sp. *tritici*
  - ⇨ Selection of new antagonists
  - ⇨ Spore production in follow-up project

Andermatt Biocontrol

JKI Julius Kühn-Institut

upna Universidad Pública de Navarra Nafarroako Unibertsitate Publikoa

hellafarm S.A.

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BAYER

Agro Plantarum

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Bernard Blum Award ABIM 2019

Commercial production

Natural enemies / invertebrates (worldwide)

- 354 species by approx. 500 companies

Microorganisms (AUS, BR, CA, EU, J, NZ, USA)

- 209 strains registered from 94 species
- approx. 200 manufacturers

Table 1 Worldwide use of major augmentative biological control programs (after van Lenteren and Bueno 2003), with updates and supported with references when large differences in areas under control existed between 2003 and 2016

Natural enemy	Pest and crop	Area under control (in ha)
Trichogramma spp.	Lepidopteran pests in vegetables, cereals, cotton	10 million, former USSR[a]
Trichoderma spp.	Soil diseases various crops	5 million, Brazil, Europe[b]
Trichogramma spp.	Lepidopteran pests in various crops, forests	4 million, China[c]
Cotesia spp.	Sugarcane borers	3.6 million, South America, China[d]

Number of registered BCAs

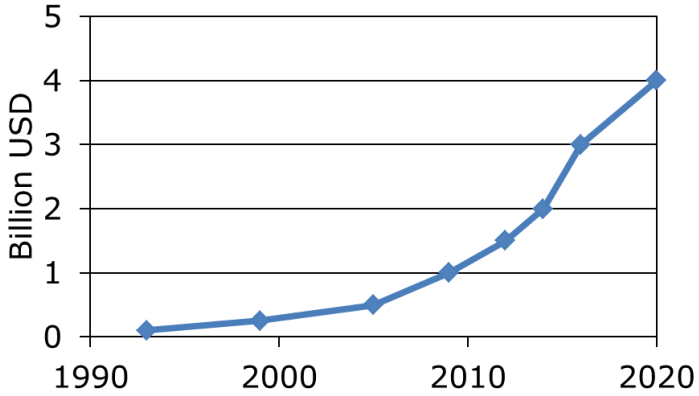
Region	Targets				
	Fungal diseases	Bacterial diseases	Viral diseases	Pests	Weeds
Australia	1	0	0	13	0
Brazil	8	0	0	20	0
Canada	17	5	0	25	8
EU	33	2	3	30	0
Japan	5	7	0	9	0
New Zealand	12	2	0	14	0
USA	31	6	0	35	5

Registered biological control products against selected soil pathogens in the Netherlands in arable crops

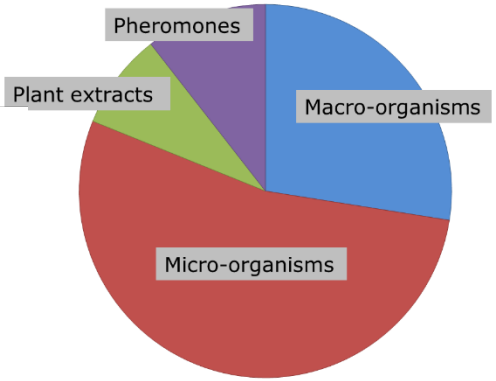
- 7 antagonists
- 8 products
- No information on crops and use

Pathogen	Antagonist	Product
Ditylenchus dipsaci	*Bacillus firmus* I-1582	VOTiVO
Heterodera schachtii	*Bacillus firmus* I-1582	VOTiVO
Pratylenchus	*Bacillus firmus* I-1582	VOTiVO
Plenodomus lingam	*Bacillus amyloliquefaciens* MBI600	IntegralPro
Pythium ultimum group	*Bacillus amyloliquefaciens* QST713	Serenade
	Streptomyces griseoviridis K61	Mycostop
	Trichoderma harzianum T22	Trianum-P, -G
Pythium violae	*Bacillus amyloliquefaciens* QST713	Texio
Rhizoctonia solani	*Bacillus amyloliquefaciens* QST713	Serenade
	Pseudomonas sp. strain DSMZ13134	ProradixAgro
	Trichoderma harzianum T22	Trianum-P, -G
Sclerotinia minor	*Coniothyrium minitans* CON/M/91-8	CONTANS
Sclerotinia sclerotiorum	*Bacillus amyloliquefaciens* QST713	Serenade
	Coniothyrium minitans CON/M/91-8	CONTANS

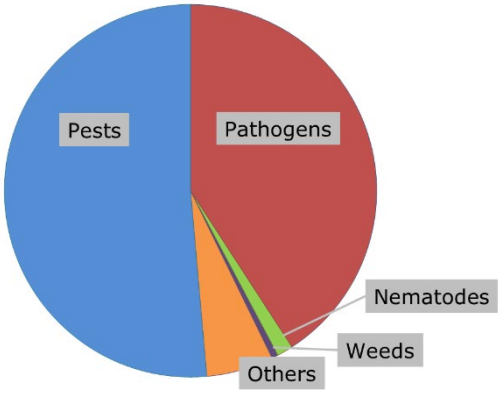
Biocontrol market



Product groups



Biocontrol targets



- 4 % of global pesticide market
- 16% CAGR

Data from:
Keynote_Dunham_ABIM_2015.pdf
www.abim.ch

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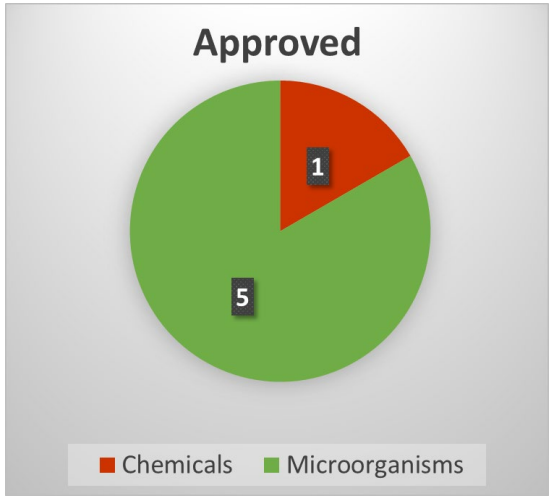
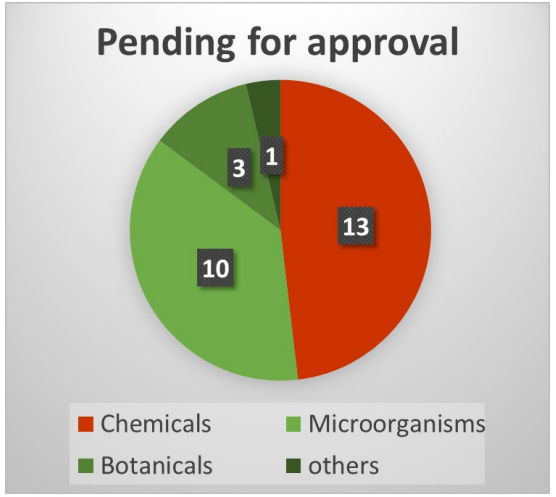
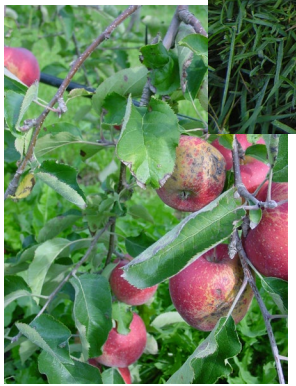
Approval of new active substances in EU – 2017 (Source: EU pesticides database)





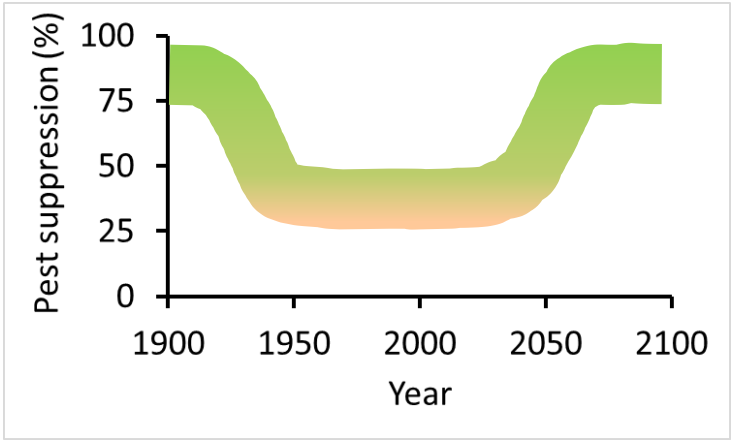
Cropping systems with high input of chemical crop protection

- Systems become increasingly dependent on chemical crop protection
- Natural enemies and antagonists became victims of crop protection
- New pests and diseases occur and cause damage



Cropping systems with selective biological crop protection

- Systems become increasingly independent of chemical crop protection
- Increasing resilience against pests and diseases through natural enemies and antagonists



- Biocontrol products needed to support transition and to control last '5%' of damage by pests and diseases in resilient cropping systems

Thank you for your attention and discussion

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