

# **Soil health management and biodiversity: the central pillars of plant disease management in organic agriculture**

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1. Principles of Plant Protection in Organic Agriculture
2. Systems effects on diseases
  - Assessing yield losses in organic systems
3. The case of suppressive composts
4. Managing diseases with diversity
5. Breeding for diversity
6. Conclusions



# Consequences of organic agriculture for plant protection

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- Almost all measures are based on prevention
- There are not many options to correct errors during a season
- It may take years to build up a system but it can be destroyed within a very short time
- Plant protection in organic agriculture requires a broad knowledge of ecological interactions



# Principles of and approaches to plant protection in Organic Agriculture

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- rotations
- hygiene and seed health
- Resistance
- Soil Fertility management
- **biological systems management**
- **diversification strategies**
- **breeding goals**
- Direct control



## Biocontrol or Biological Systems management?

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- Biocontrol organisms are very expensive in development and use
- Is it a good idea to bring in biocontrol agents from other areas?
- There is often a lack of reliability
- Often extensive know-how is needed to use biocontrol
- It is an approach similar to using a pesticide rather than looking at the system as a whole



## Biocontrol or Biological Systems management?

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  - There is a lack of reliability
  - Often extensive know-how needed to use biocontrol
  - It is an approach similar to using a pesticide rather than looking at the system as a whole
- Biological systems management aims at enhancing natural biocontrol by building it into the system**



## Effects of the farming system: importance of wheat diseases

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Disease	Conventional	Organic
Rusts	++	(+)
Mildew	++	(+)
Fusarium	++	+ (seed borne)
Take-all	+(+)	0
Eye spot	++	(+)
DTR leaf spots	++	(+)
Septoria tritici	+	+
Septoria nodorum	+	+ (seed borne)
Tilletia caries etc.	-	++
Other seed borne diseases	-	+
Nematodes	+	+ (+?)

# Management options

Disease	Conventional	Organic
Rusts	Res. / Fung.	↓N, res.
Mildew	Res. / Fung.	↓N, res.
Fusarium	(Res. / Fung.)	↓N, rotations, res. Seed health
Take-all	Rotations	Rotations, soil OM
Eye spot	Rotations/Fung.	Rotations, soil OM
DTR leaf spots	Rotations/Fung.	Rotations
Septoria tritici	Res. / Fung.	Rotations, res.
Septoria nodorum	Fung.	Rotations, seed health, res.?
Tilletia caries etc.	Fung.	Seed health, res., Soil OM
Other seed borne diseases	Fung.	Seed health, res., Soil OM
Nematodes	Fallow	Rotations, res., biofumigation?



# *Fusarium* in conventional and organic farming

## Conventional farming

- little rotation, (often maize-wheat)
- Important soil borne disease
- Seed infections controlled through fungicides
- Fungicides may worsen infections.
  - Strobilurin effects?
- Mycotoxins often a problem



## Organic farming

- Soil borne inoculum rare due to rotations with non-hosts
- Infections in the field usually relatively moderate: Microbial control?
- Mycotoxins rarely high
- Seed infections need to be taken much more seriously once all seed has to be produced organically



## Fusarium in organic systems in the future

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- Will depend on the amount of maize and cereals in the rotations
- Will depend on seed health regulations
- Will depend on effective resistances

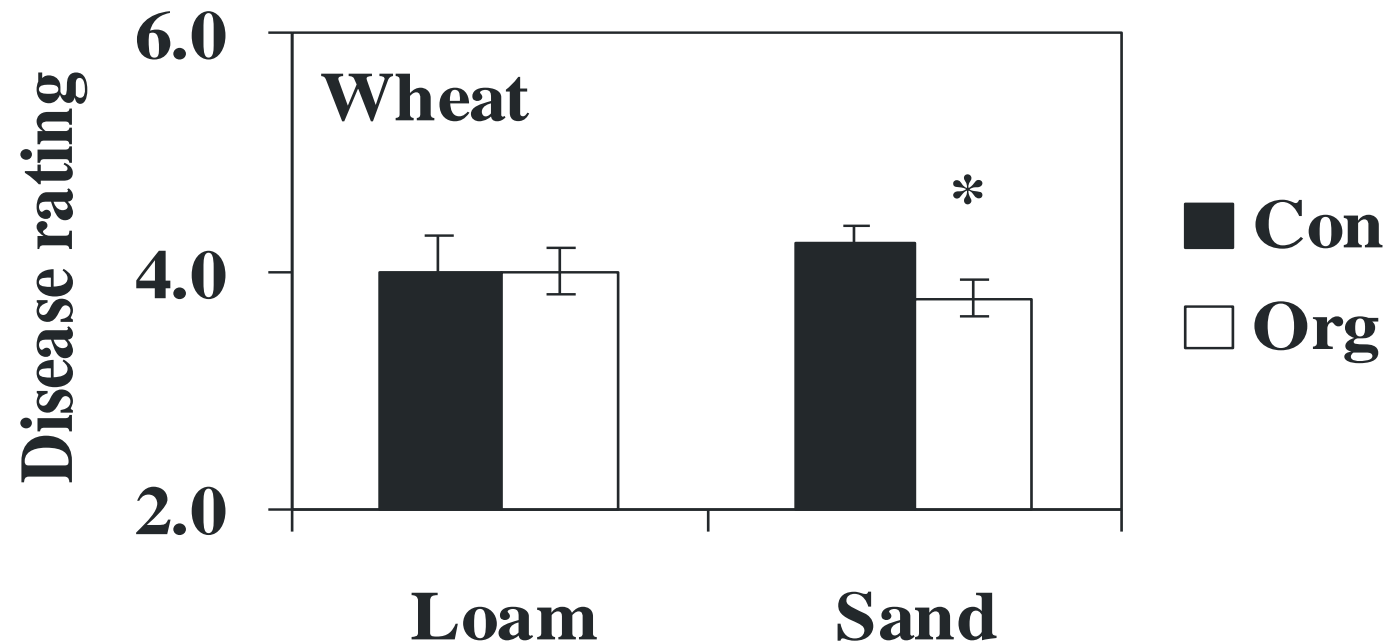
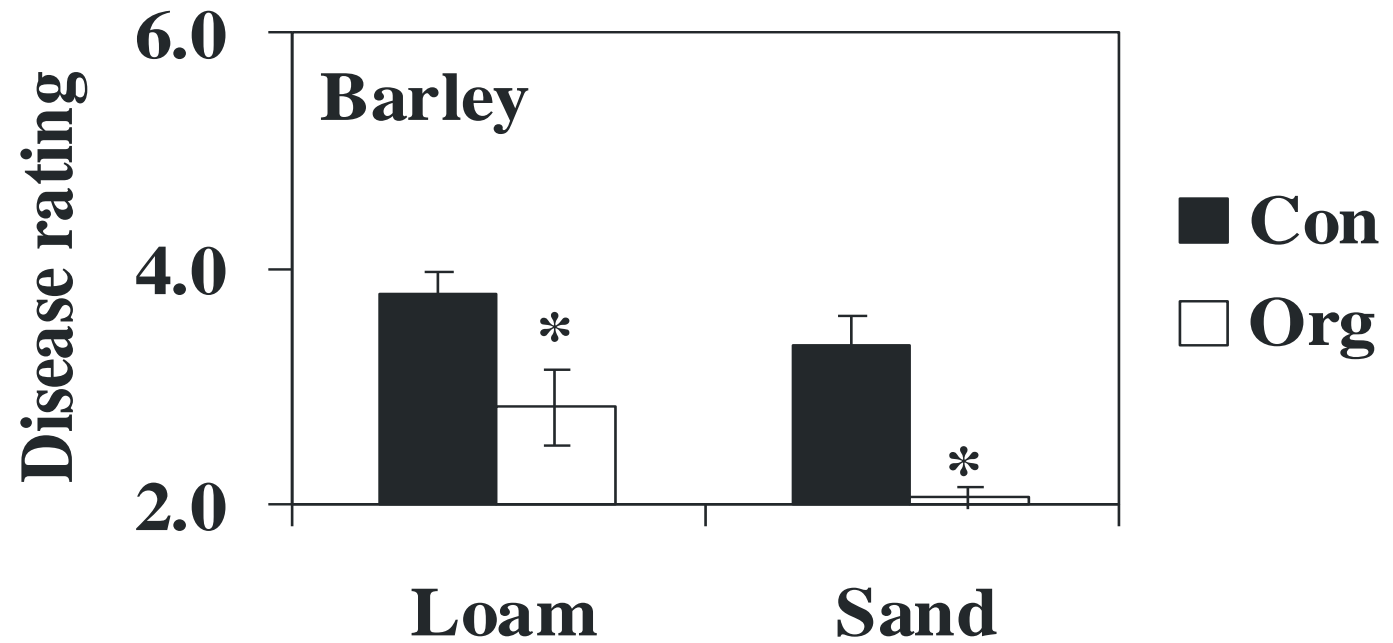


## 2. System effects on diseases

**Take-all** in organic and conventional soils :

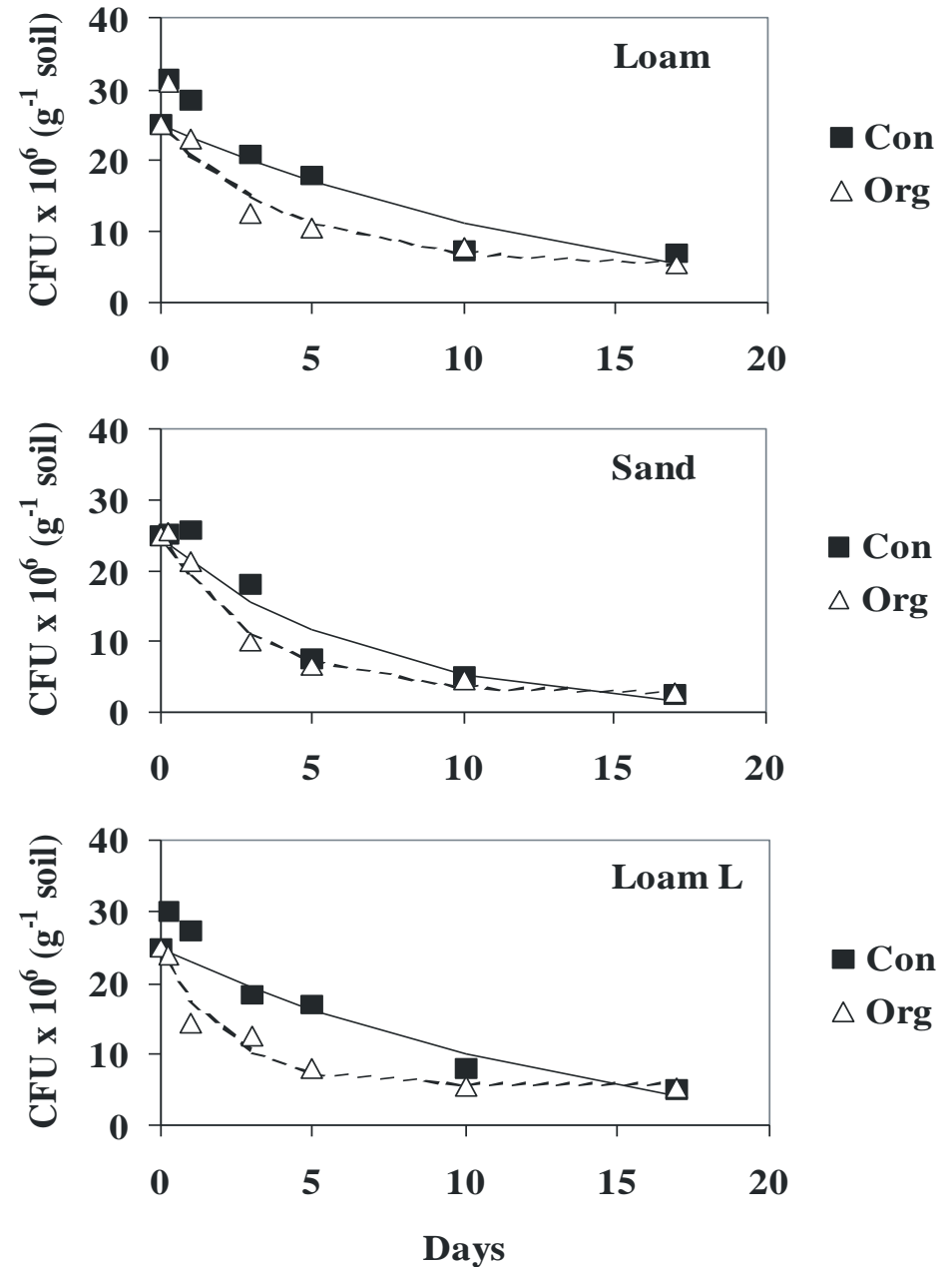
General suppressiveness due to high microbial activity.

(Hiddink et al., 2006, EJPP)

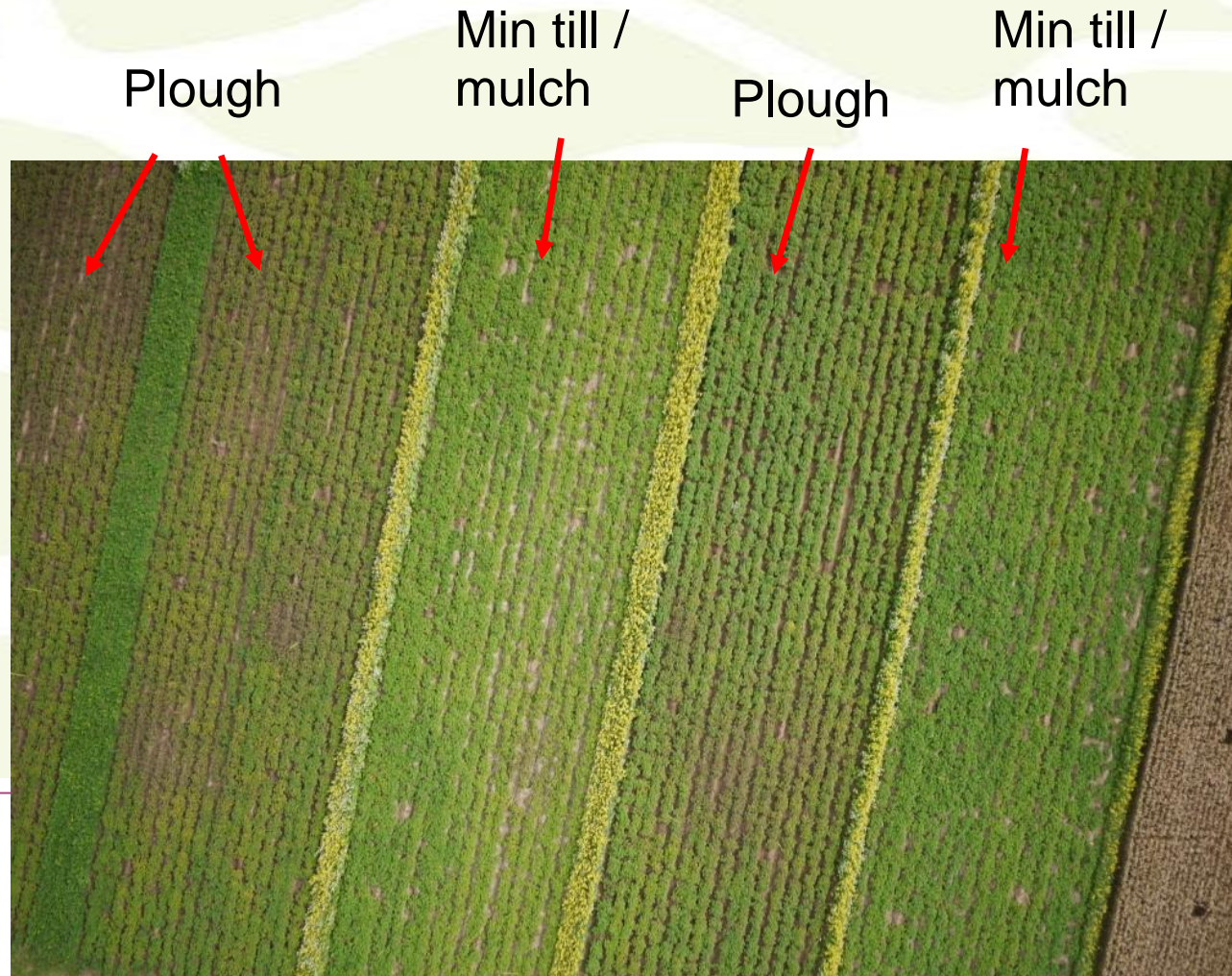


**Reduction of the biocontrol agent *Pseudomonas fluorescens* over time is faster in organic soils than in conventional soils due to higher biological activity in the organic soils.**

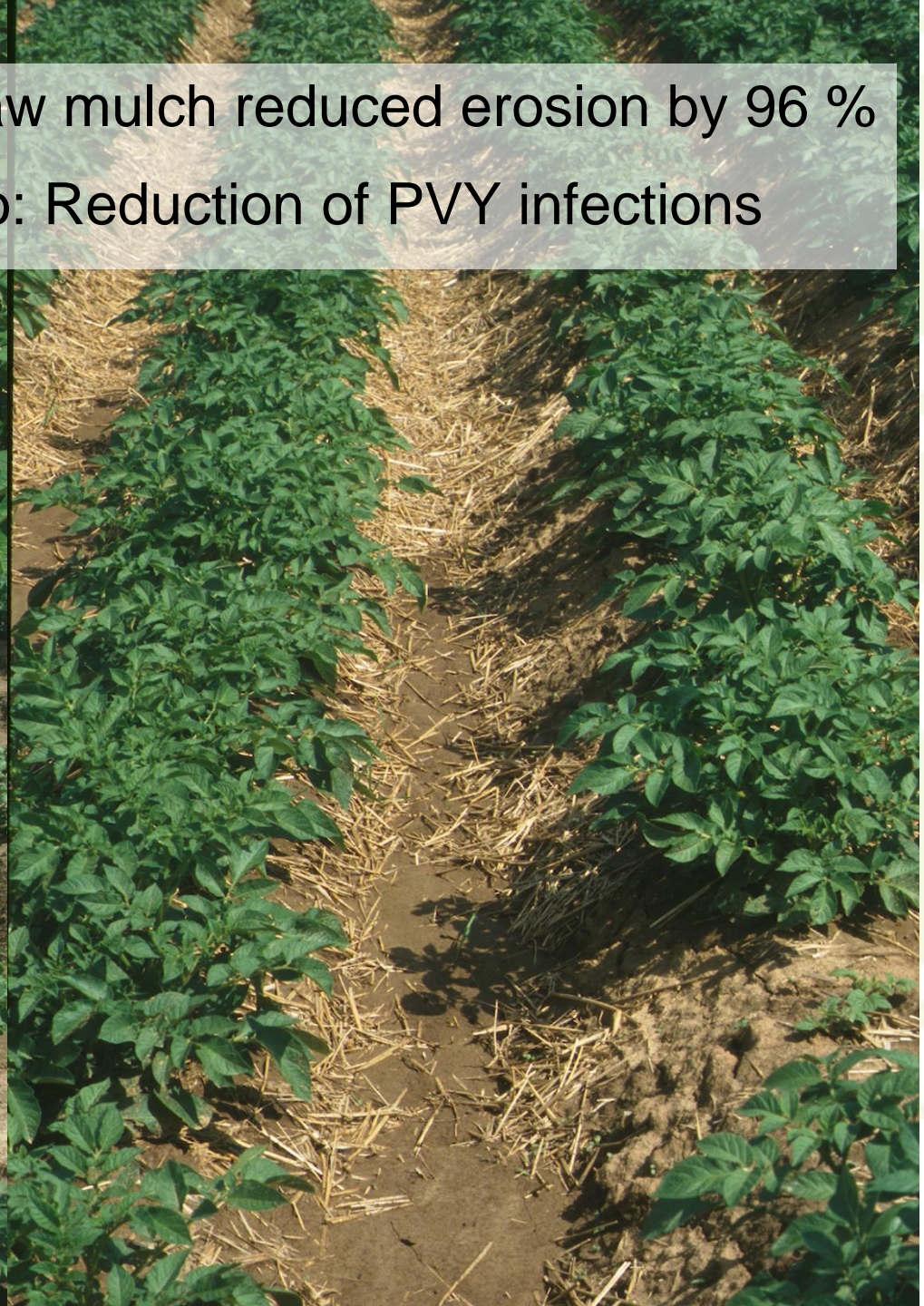
(Hiddink et al., 2006, EJPP)



Disease progress of *P. infestans* on potatoes with minimum tillage and a mulch of green peas and rye was delayed by more than 10 days in 2014.



Straw mulch reduced erosion by 96 %  
Also: Reduction of PVY infections



## Open questions: mulch and potatoes

- What is the optimum amount of materials?
- Optimum timing for application?
- Which materials to use?
  - Nutrition?
  - Weed management?
  - Soil temperature?



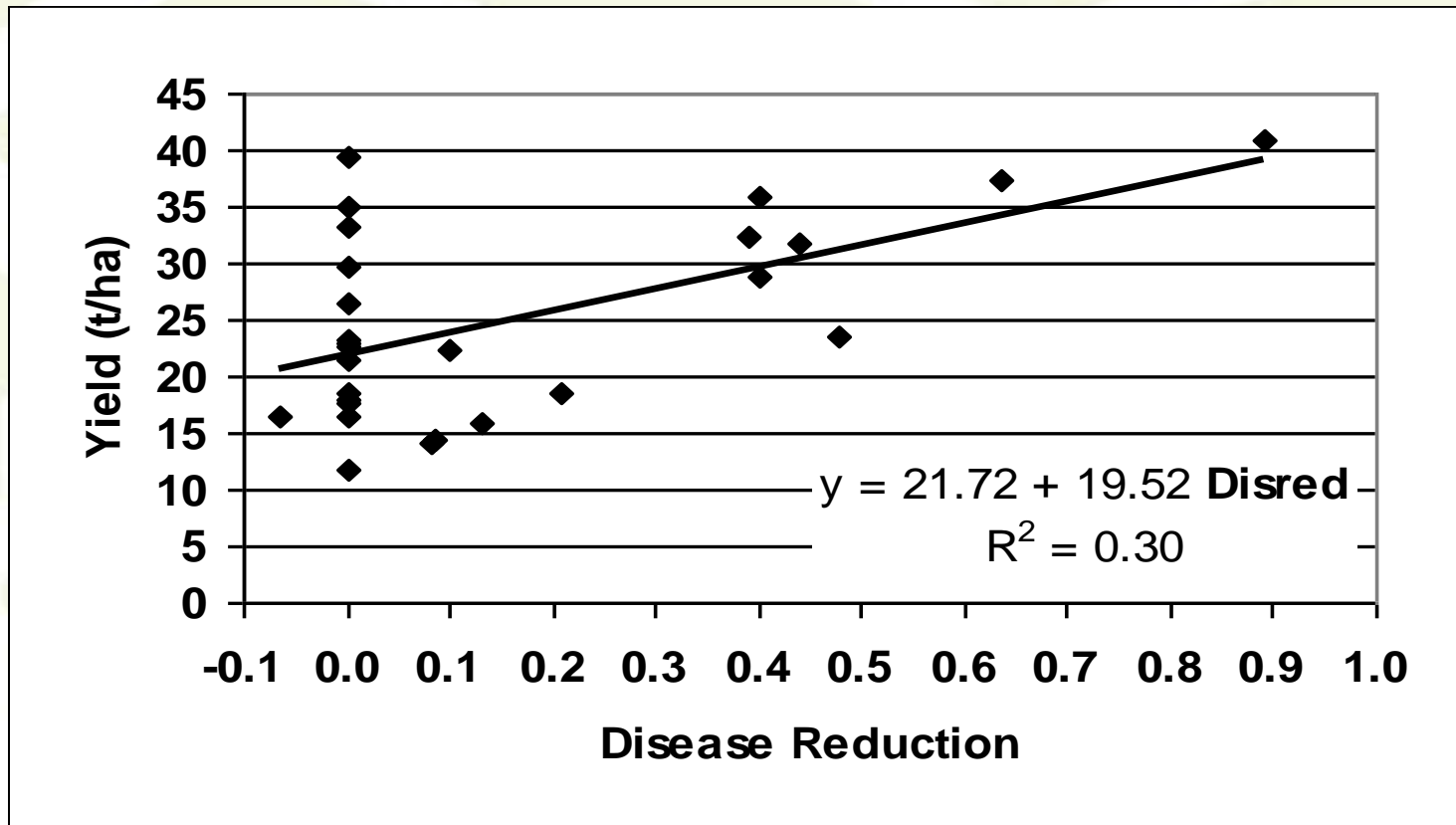
## Assessing yield losses in organic systems

- Often nutrients are limiting in organic systems
  - Severe symptoms may not be relevant if yields are limited by nutrient availability
- Usually no healthy control available
  - Hard to estimate potential yield in the system

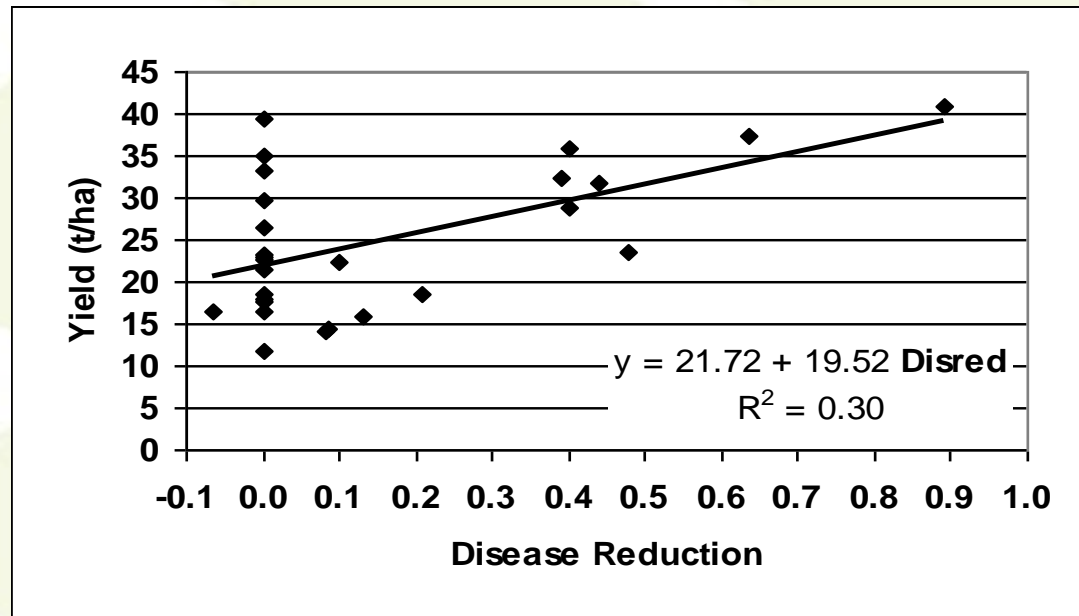




## Effects of disease reduction by copper on potato yield



# Effects of disease reduction on potato yield



- Yield prediction is only possible if N supply is integrated in the model
- Very relevant in organic systems, to help reduce copper inputs.



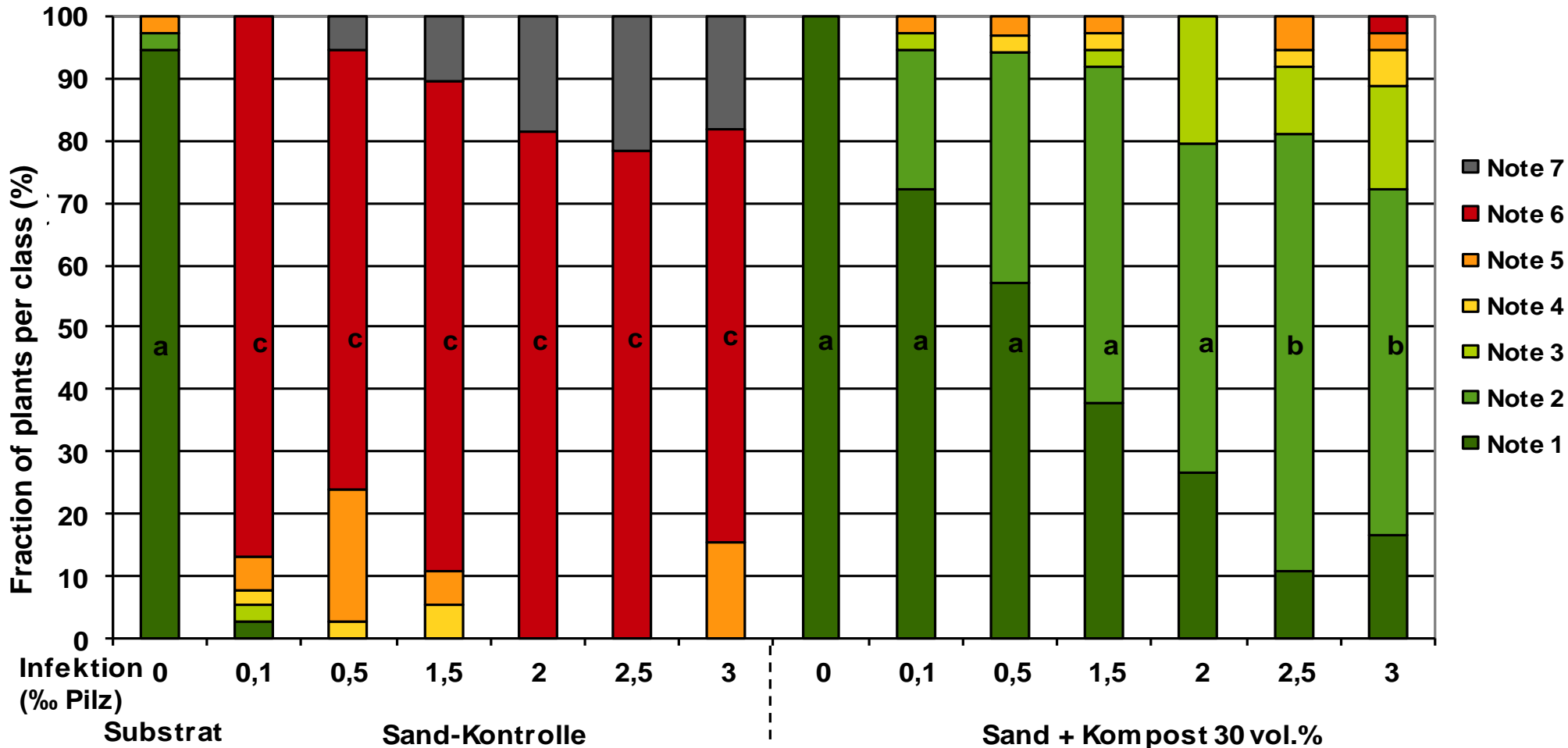
### **3. Managing soil borne pathogens with suppressive composts**

**From basic research to practical application**

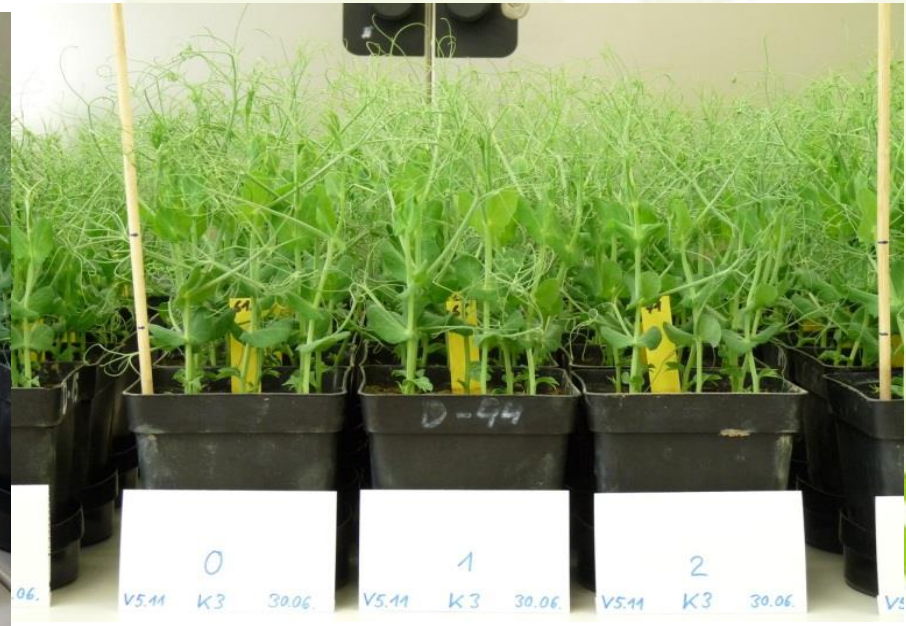
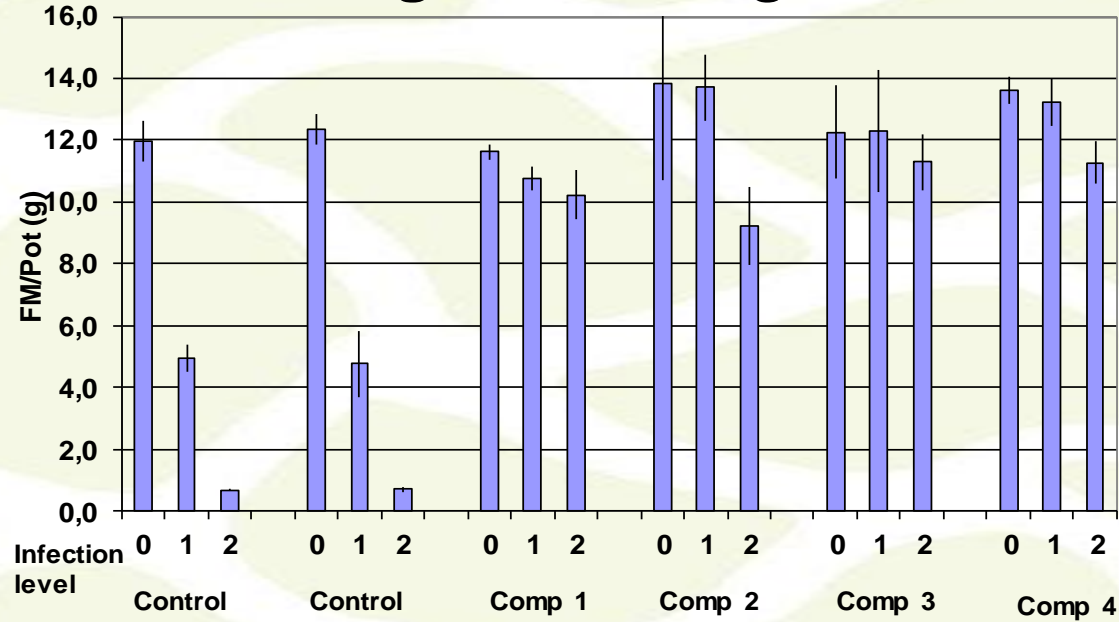




# Effects of compost on *Phoma medicaginis* on pea



# Compost screening *P. medicaginis* – Biomass peas



# Development of machinery for compost application at sowing and planting

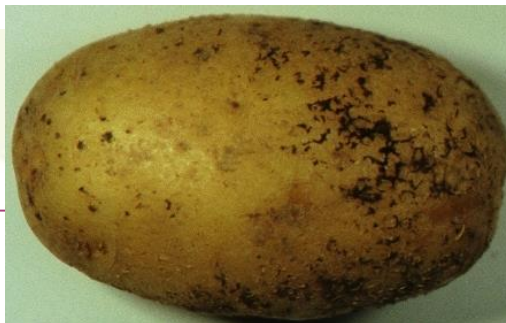
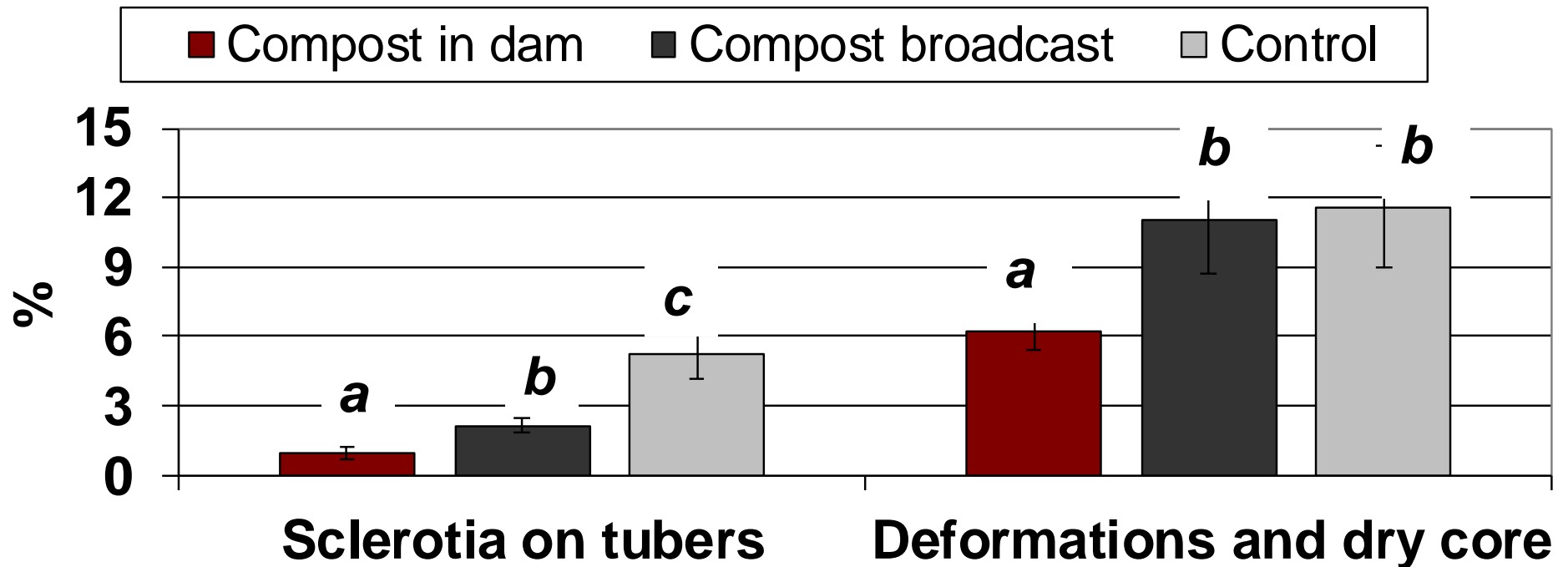




organicagric



# Effects of applying compost (5 t DM/ha) in the dam or broadcast in potatoes on *Rhizoctonia solani*





# 4. Managing diseases with diversity

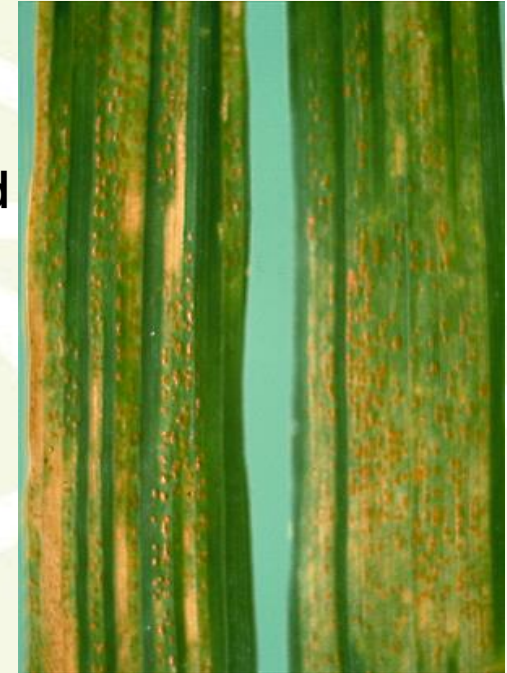
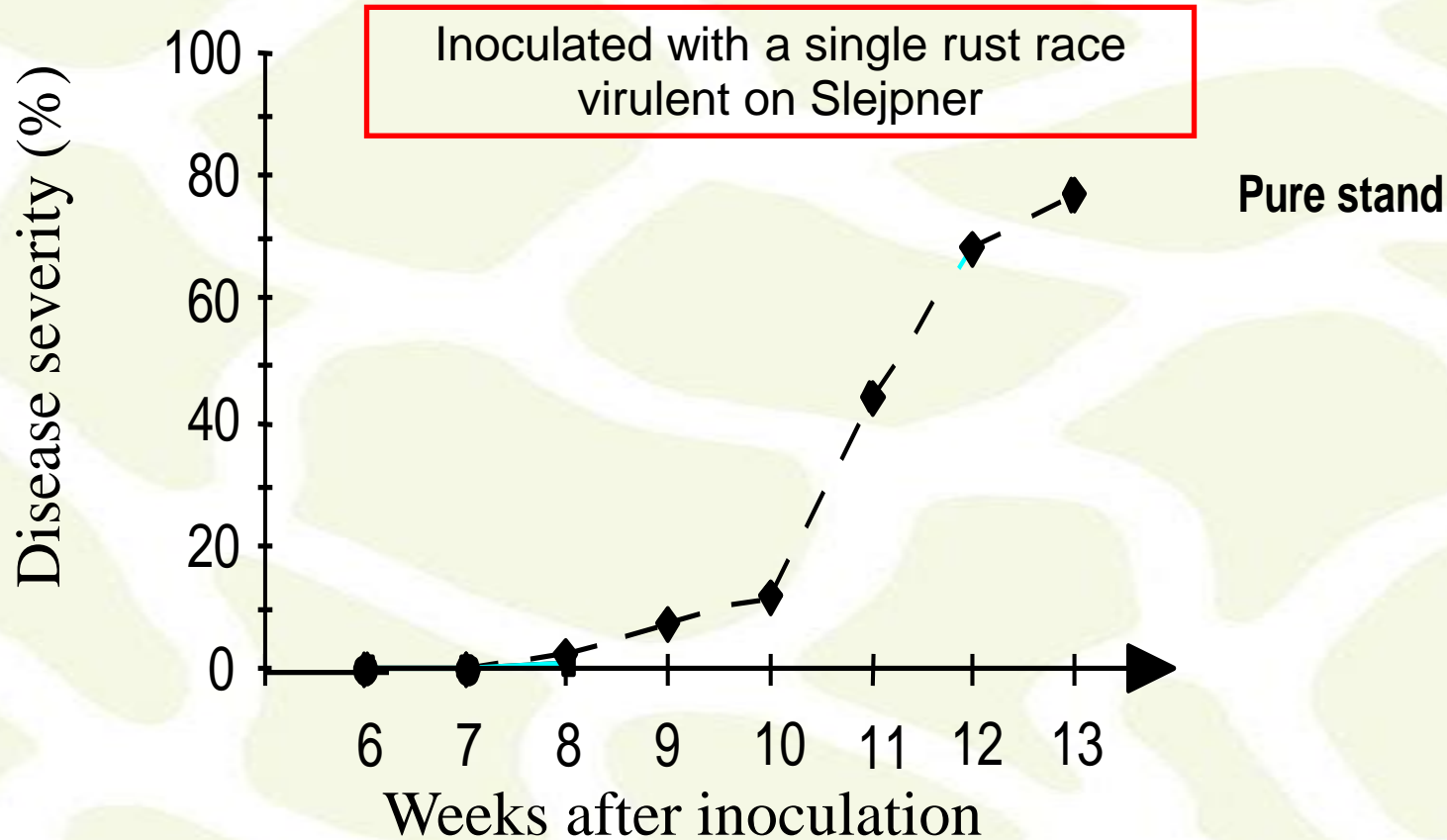
## Mechanism that can be exploited

- Increased distance between plants
- barrier effects
- selection effects
- competitive effects
- time effects due to rotation
- Scale effect
- **induced resistance**
- **systems effects**
- **co-evolutionary interactions: the case for breeding for diversity**



## Induced resistance

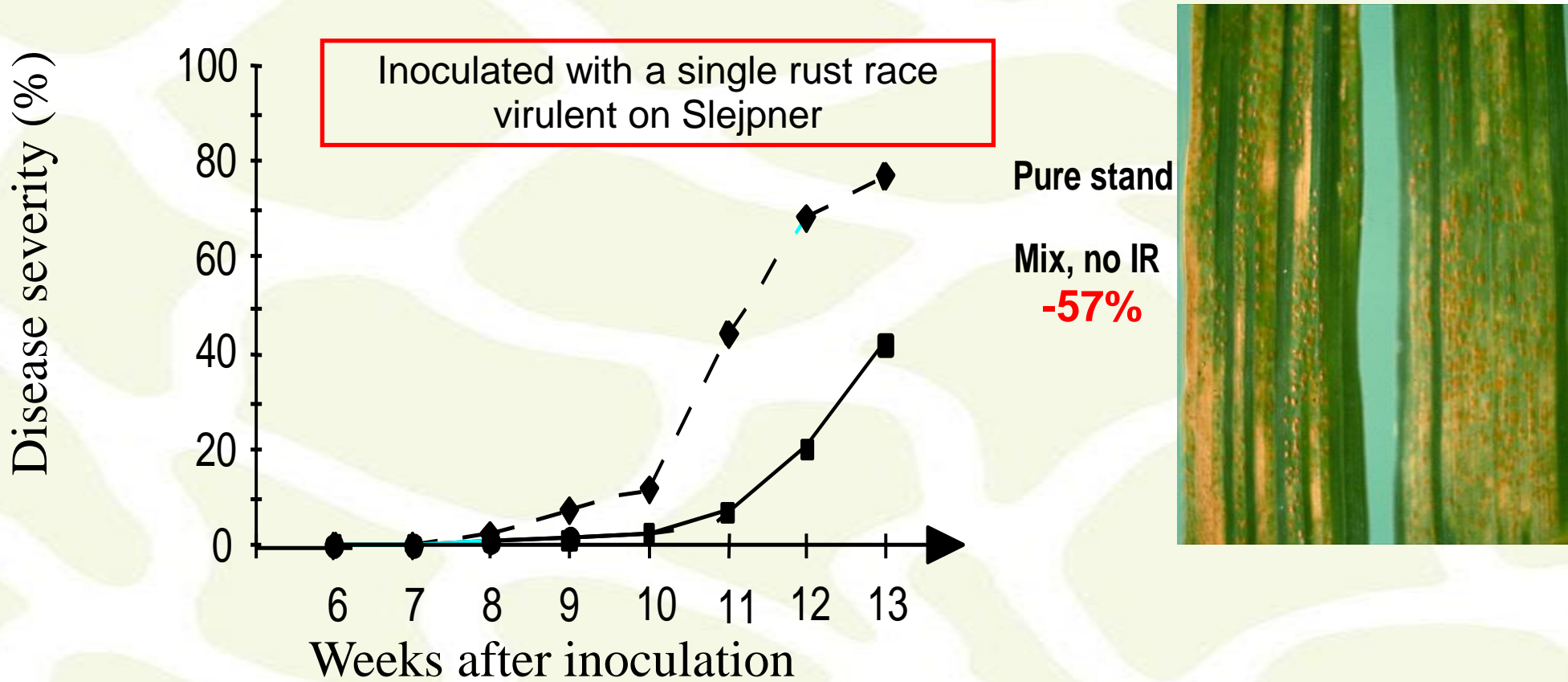
### Yellow rust on the wheat cultivar Slejpner



Data from C. de Vallavieille-Pope, INRA



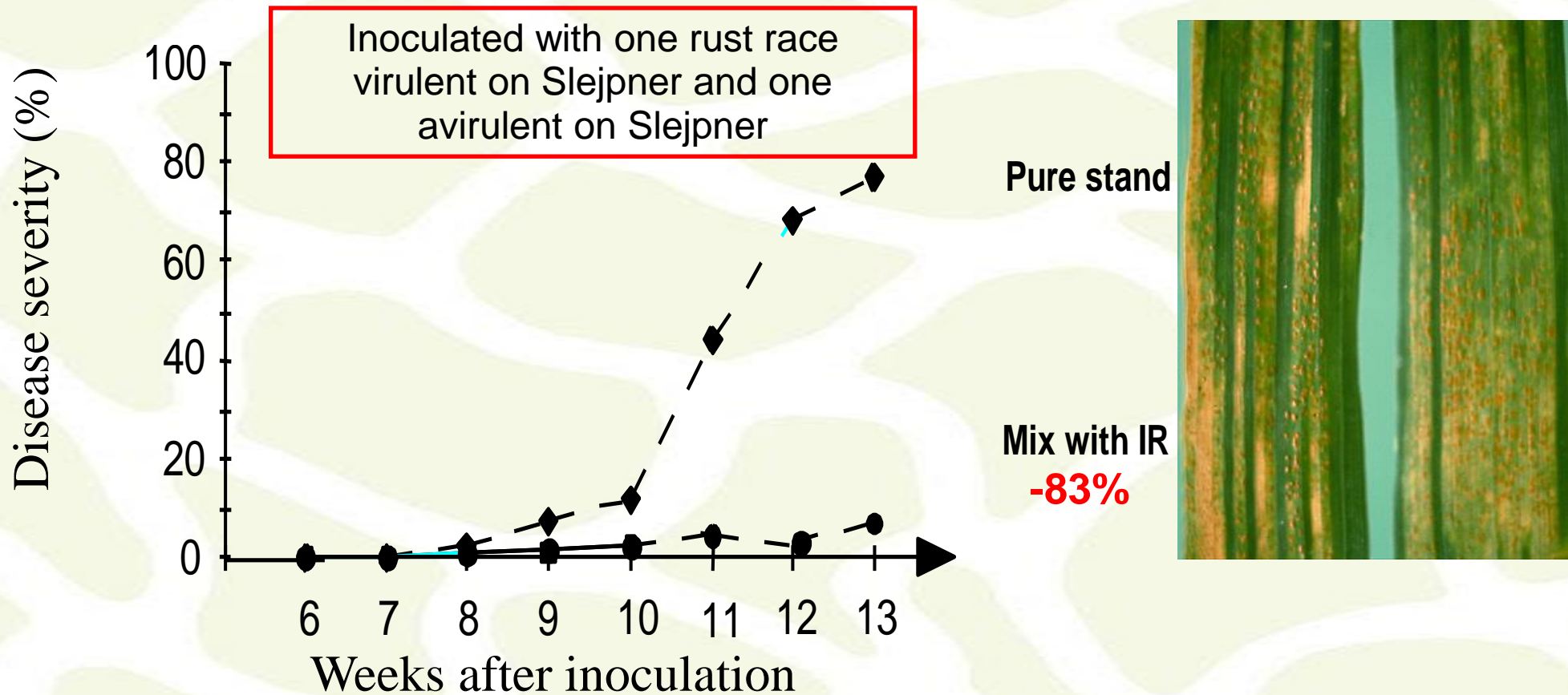
# Induced resistance and diversity: Yellow rust on wheat cultivar Slejpner mixed with a fully resistant cultivar



Data from C. de Vallavieille-Pope, INRA



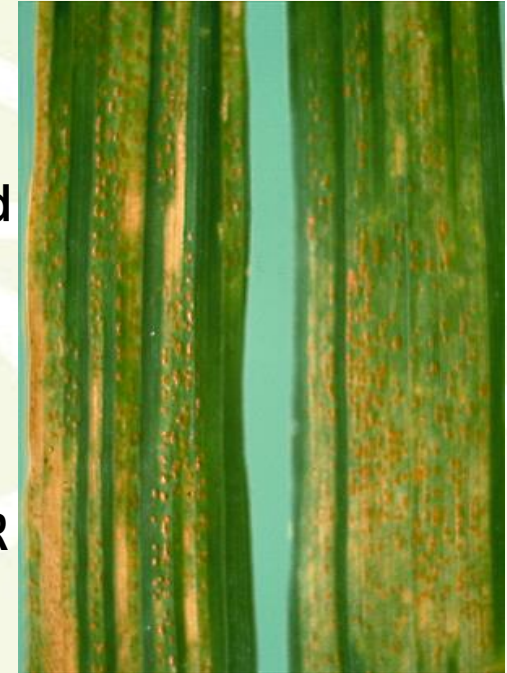
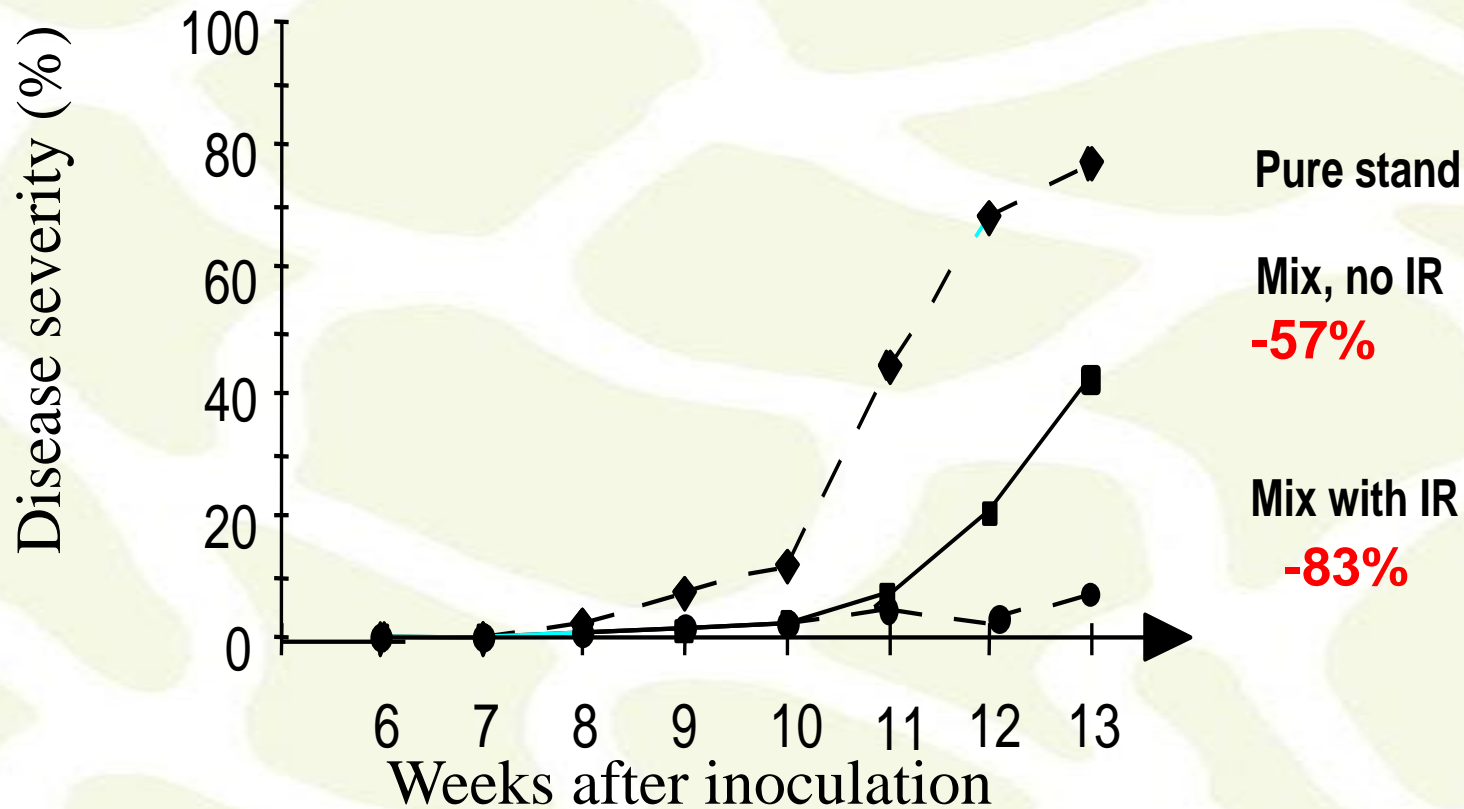
## Induced resistance: Yellow rust on wheat cultivar Slejpner with a cultivar susceptible to a second rust race



Data from C. de Vallavieille-Pope, INRA



# Yellow rust on wheat cultivar Slejpner with and without induced resistance



Data from C. de Vallavieille-Pope, INRA



In diversified systems a greater variety of pathogen species and races are present thus allowing for more effective triggering of induced resistance



## 5. Breeding for diversity to deal with changing and unpredictable environmental conditions

System management has to deal with all problems at the same time

- Soil and climatic variation
- Variable pressure from pests, pathogens, and weeds
- Adaptability of pests, pathogens, and weeds over time



# Introducing genetic diversity for disease and other stress control into agroecosystems

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1. Use cultivar and species mixtures
2. Add diversity in the breeding process
  - Wheat evolutionary breeding in Europe: Composite Crosses
  - coffee in Colombia (>300 000ha)





# The wheat composite crosses in Europe

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Intercross of 20 parents in all possible combinations

Parents were selected from the best cultivars from the second half of the 20<sup>th</sup> century

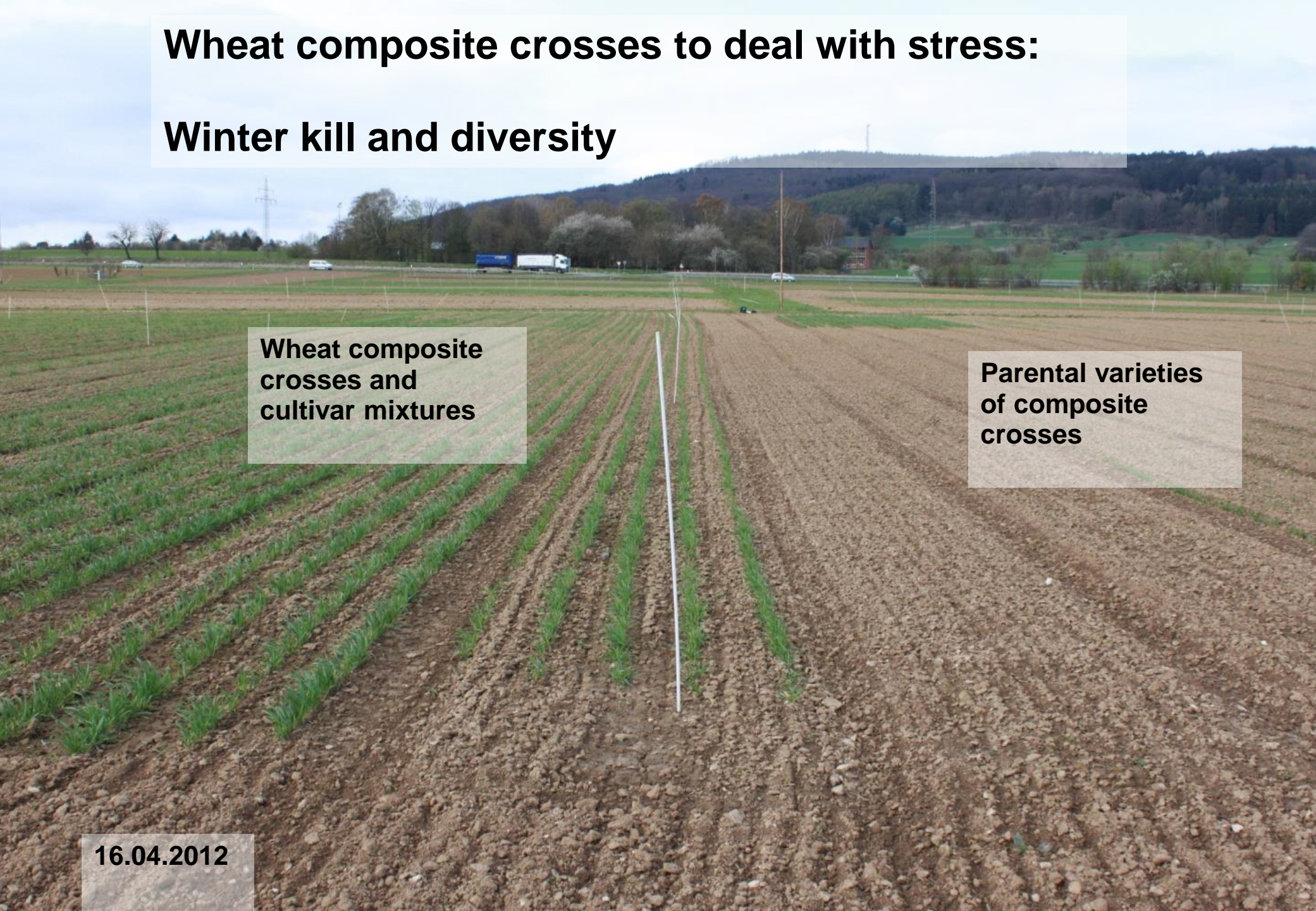
Populations are exposed to natural selection in many different sites throughout Europe since 2001





# Wheat composite crosses to deal with stress:

## Winter kill and diversity



Wheat composite crosses and cultivar mixtures

Parental varieties of composite crosses

16.04.2012



**Diversity and disease severity:**

**Leaf rust in 2009**

**Compostite cross of Wheat**

**Pure stand of Bussard**

**2014:  
Severe yellow rust  
epidemic due to a new  
race**

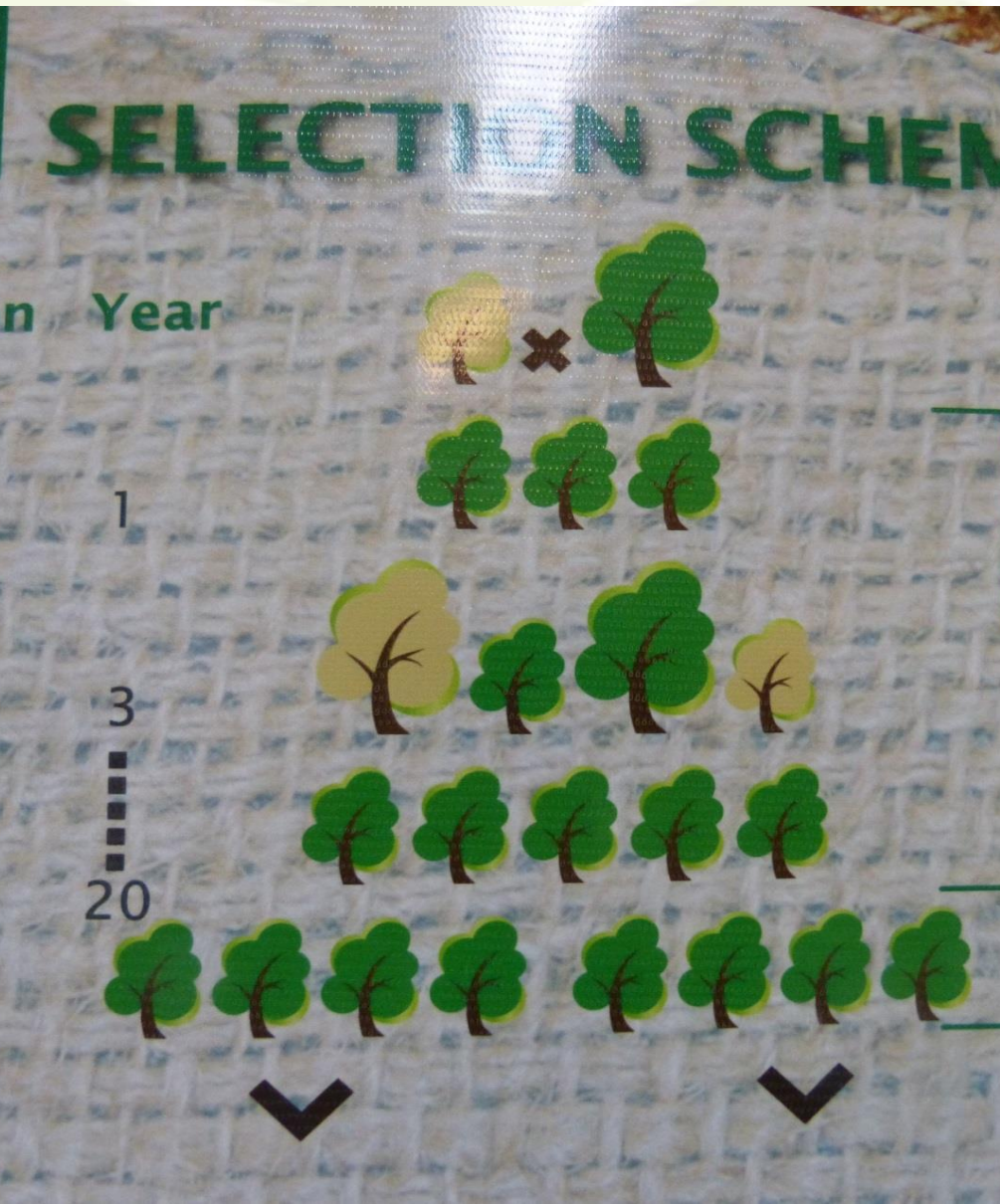


**Top: Composite cross**

**Right:  
Variety Akteur**



# Coffee multilines to control coffee rust in Colombia



**Pre-emptive breeding was conducted before coffee rust even arrived in South America in the 1970s.**

**In the breeding program coffee is selected for uniformity in quality but for diversity in resistance to rust.**

**Each year the mixture composition for seed for new plantations is changed. In this way while all grow the variety Colombia plantations are not identical for their resistance to rust.**

# Diversification since 2005: Regional populations

Castillo variety

Castillo Paraguaicito  
Castillo Trinidad  
Castillo Pueblo Bello  
Castillo Santa Bárbara

After 2005



# New Coffee rust races threaten Central American coffee production in the past few years

Firefox - taz.de

www.taz.de/1/archiv/digitaz/artikel/?ressort=wu&dig=2013%2F01%2F02%2Fa0069&cHash=3cf422ada481e8cfa283df6f765524b1

Meistbesucht Erste Schritte The OSCAR Project: H... Internal Homepage: lo... Doodle: Wochenenden APS Organic Book - Fo... ICPP2013 Editorial M

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POLITIK ZUKUNFT NETZ DEBATTE LEBEN SPORT WAHRHEIT BERLIN NORD ARCHIV ZEITUNG BLOGS BEWEGUNG

die tageszeitung von heute

Hier können Sie durch die aktuelle Ausgabe der Zeitung blättern:

02.01.2013 Nächster

## Der sterbenskranke Muntermacher

KLIMAWANDEL In Mittelamerika breitet sich eine Kaffeeseuche aus und bedroht die Existenz von Millionen von Kleinbauern

## Reasons according to the newspaper: Climate change



# Colombia: No problem with the new races

- 2009: 360 000 ha Multilines (=1/3 of area)
- 2013: 700 000 ha Multilines (=2/3 of area)
- Yearly savings of fungicides > 100 Mio \$ US

Could it be the new race is just another example of breakdown of resistance due to the growing of genetically uniform and static crops

# Conclusions

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- Organic systems have little means to reduce biotic and abiotic variation
- The importance of diseases is affected in organic systems by
  - Nutrition
  - Soil health and fertility effects
  - Diversity effects
- The interactive effects make predictions difficult
- Only flexible systems can adequately react to biotic and abiotic stress over time
- This requires the generation of functional diversity at all levels

