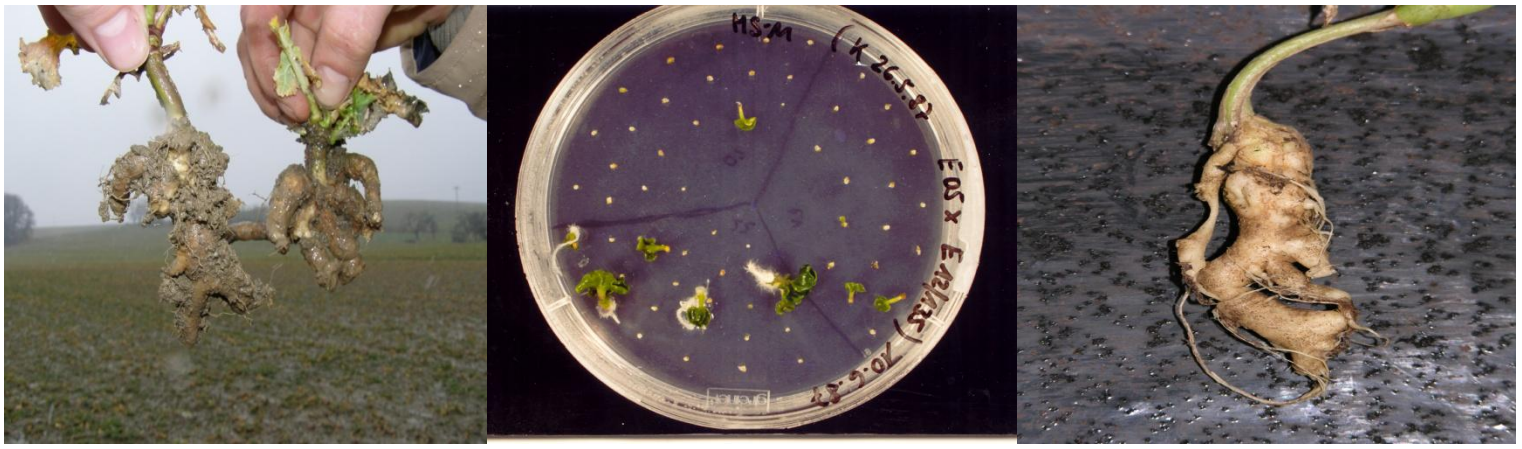

# Clubroot in Germany and Europe

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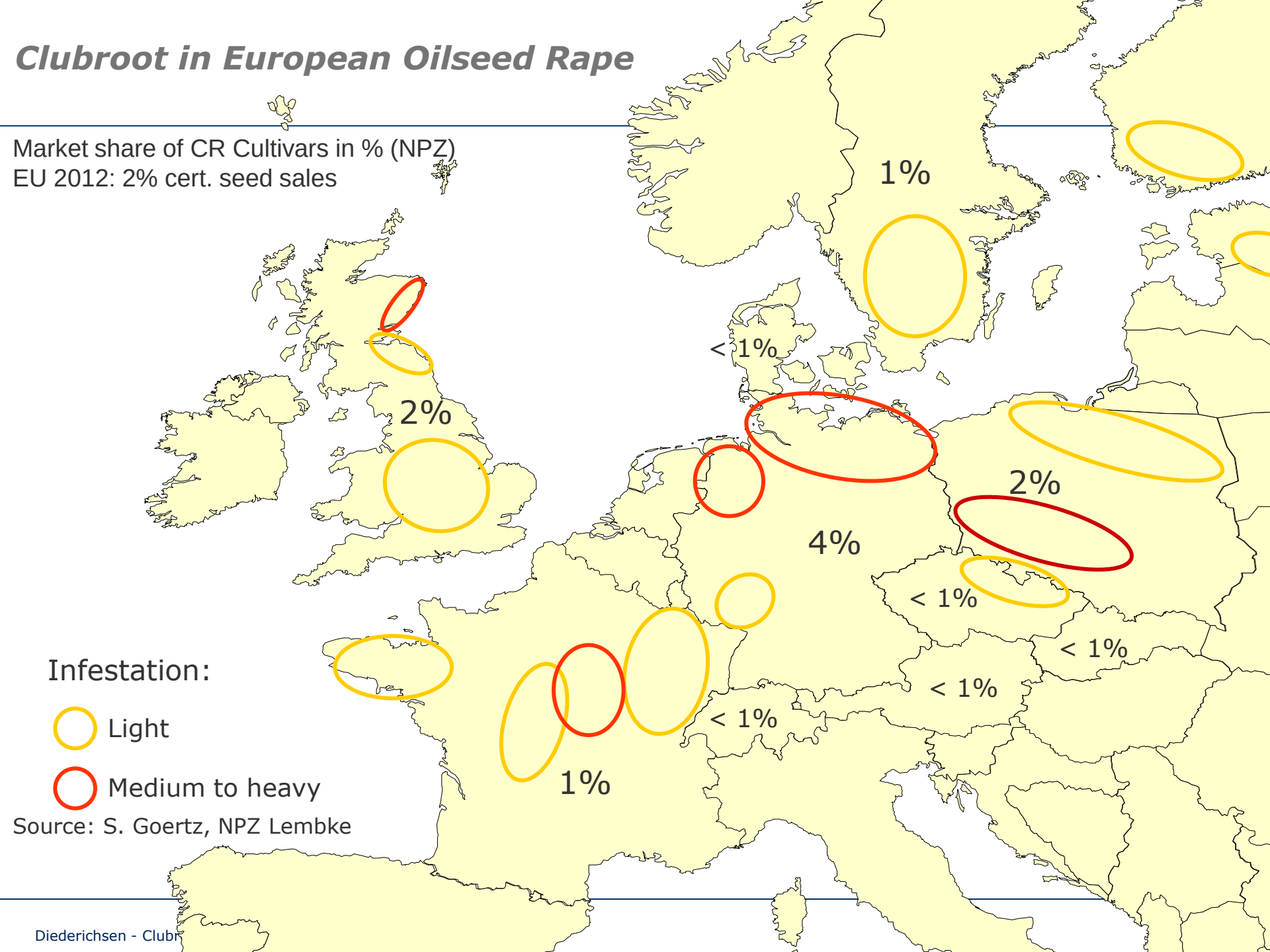
# Outline

- Relevance of clubroot in Europe
- Clubroot control:
    - Integrated Pest Management
    - Host resistance
- Monitoring and resistance management
- Pathogen variation

# *Clubroot in European Oilseed Rape*

Market share of CR Cultivars in % (NPZ)
EU 2012: 2% cert. seed sales




Source: S. Goertz, NPZ Lembke

# *Integrated Control of Clubroot*

**Most relevant**:

- Avoid increase and spread of inoculum
- If clubroot is present, resistant crucifers only every 4-5th year
- Use of resistant cultivar while keeping wide rotation
- Increase of soil pH-value

- Control of cruciferous weeds, regrowth and volunteers (also in subsequent crops)

- Hygiene: Prevent spread of contaminated soil (machinery, animals, erosion, water run off, visitors) and infected roots

- Winter oilseed rape: Late sowing helps to escape the disease

- Grow resistant cultivar only upon confirmed incidence to prolong its efficacy

- If resistant cultivar is infected: No OSR cultivation until broader resistance in adapted cultivars is available

# Experiences from public advisors …

- Some farmers mix seeds from resistant cultivars with seeds from susceptible cultivars

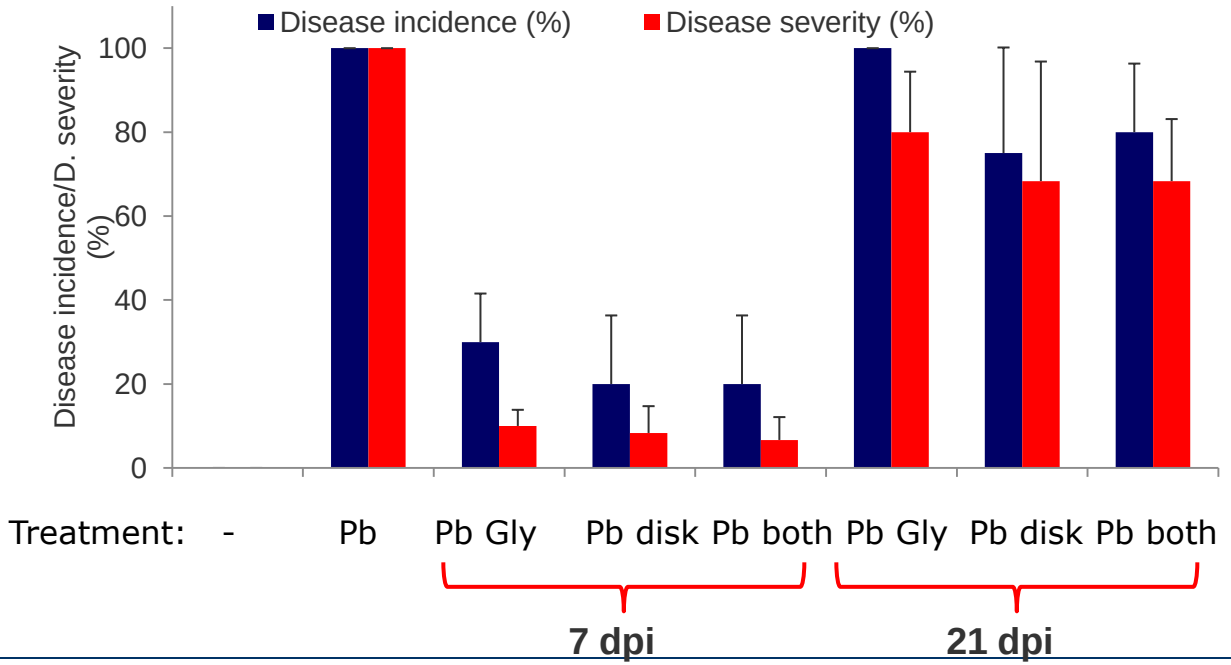
- Use of farm-saved seeds from hybrid cultivars, 25% susceptible plants

⇒ Risk of pathogen propagation!

# Prevention of Pathogen Multiplication in Volunteers

- In summer resting spores are present already after 1 week post emergence in volunteer plants (temperature!)
- Prevent multiplication by early destruction of volunteers: Shallow disk or glyphosate or both
- Reduction of symptoms after both treatments when applied 7 dpi
- First indications of reduced resting spore viability after early treatment

Data: N. Zamani-Noor, JKI Braunschweig



# *Breeding: Traditional Resistance Sources*

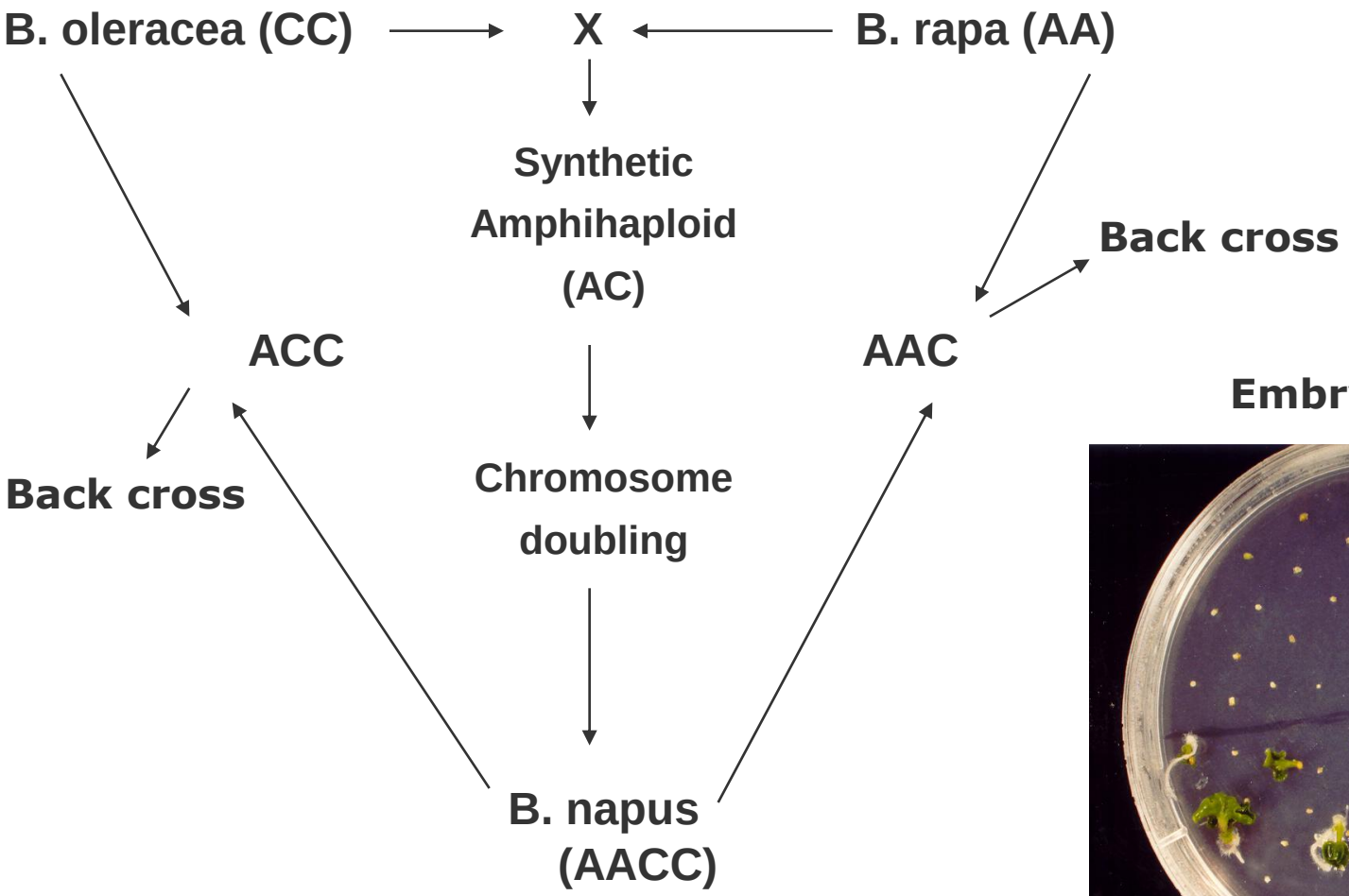
***Brassica napus***: Swedes (‚Wilhelmsburger'), fodder rape (‚Nevin'),
Race-specific resistance

***B. oleracea***: Some kale cultivars, white cabbage, broccoli,
Race-specific and broad-spectrum resistance

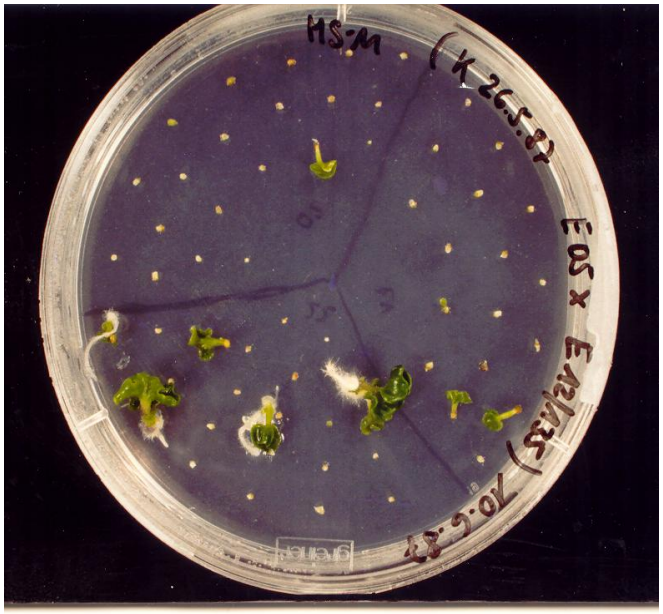
***B. rapa***: Stubble turnips
Race-specific resistance

***Raphanus sativus***: Many cultivars show different levels of resistance
Broad spectrum resistance?

# *Interspecific transfer*




**Embryo rescue**



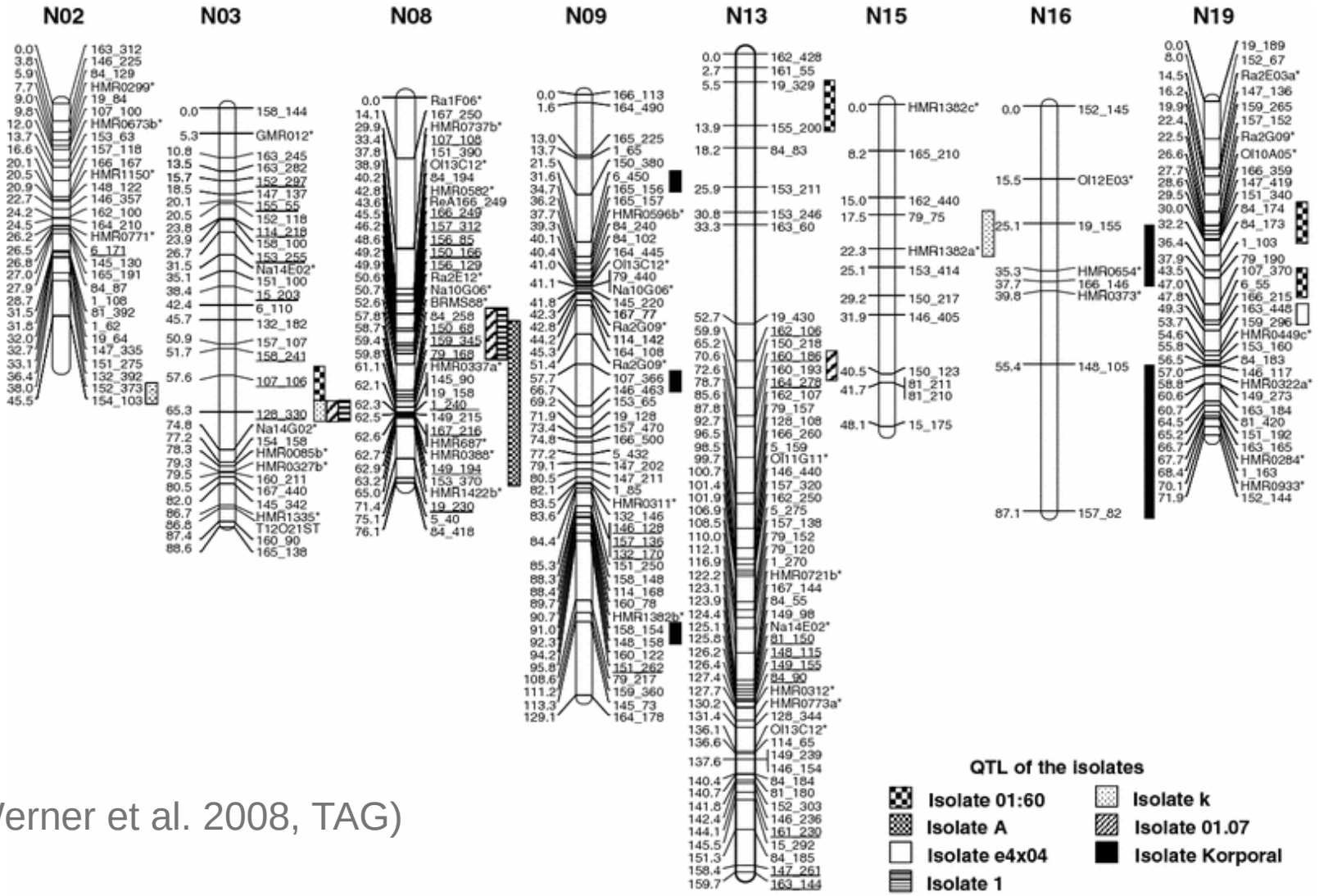
# *Clubroot resistant cultivars*

- *B. napus* ‚Wilhelmsburger' x ***B. oleracea***
  Cabbage cultivars ‚Acadie', ‚Richelain' (St.Jean-sur-Richelieu, Canada)

- *B. rapa* (turnip) x *B. oleracea* ⟹ Synthetic ***B. napus***
  ‚Mendel' (NPZ Lembke), ‚Tosca' (SW Seeds), ‚Invitation' (Swede, SCRI), new releases

- *B. rapa* (turnip) x ***B. oleracea***
  ‚Clapton', ‚Kilafur' etc. (Syngenta Seeds)

# Mapping of Clubroot Resistance Genes in *B. napus*




(Werner et al. 2008, TAG)

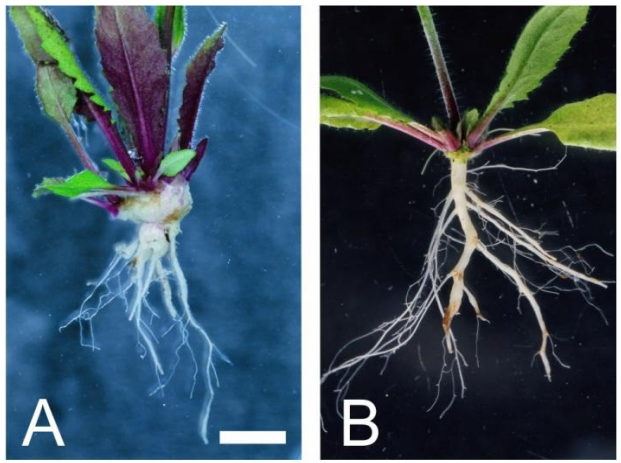
# Resistance Genetics in Different Crucifers

| Species | Chromosome | QTL | Race-specificity | Comment |
|---|---|---|---|---|
| ***B. rapa*** | | | | |
| | A1 | Crr2 | Race-specific | |
| | A2 | CRc | Race-specific | |
| | A3 | CRa, CRb, Crr3, CRk | Many races | Closely linked or identical, dominant |
| | A8 | Crr1 | Few races | Co-dominant |
| ***B. oleracea*** | | | | |
| | C2 | PbBo-Anju1 | ? | Major locus |
| | (LG 1) | PbBo-1 | Broad-spectrum | Identical with PbBo-Anju1? |
| ***B. napus*** | | | | |
| | A3 | PbBn-01:07-1, PbBn-1-1, PbBn-k-2 | Few races | Closely linked or identical genes |
| | A8 | PbBn-01:07.2, PbBn-1.2, | Few races | Closely linked or identical genes |
| | C9 | PbBn-e4x04 | Race-specific | |
| ***Raphanus sativus*** | | | | |
| | (LG1) | Crs1 | ? | Major locus, syntenic to A03 locus? |

Sources: Rocherieux et al. 2004, Werner et al. 2008, Diederichsen et al. 2009, Piao et al. 2009, Nagaoka et al. 2012, Kamei et al. 2010)

# Cloning of *RPB1* from Arabidopsis (Rehn, Siemens et al.)

- *RPB1* confers race-specific resistance to isolate e
- Locus is present in a few ecotypes: Tsu-0, RLD, Ze-0
- No homologous allele in susceptible ecotypes
- Two *RPB1*-like genes in close vicinity (*RPB1a, RPB1b*)
- Based on sequence analysis: Membrane-bound protein, no LRR-kinase




Clubroot reaction of Col-0 (A, susceptible) and transgenic Col-0 expressing *RPB1*(B, resistant) against isolate e3.

# *Breeding of cv. ‚Mendel‘*

1987: Kale ECD-15 (CC) x Stubble turnip ECD-04 (AA)

↓

Synthetic *B. napus* 15/04 (AACC) x *B. napus* ‘Falcon’
Cooperation FU Berlin – Norddeutsche Pflanzenzucht NPZ (1989)

↓

Selection of resistant DH-line in greenhouse and field

↓

2001: Approval of ‘Mendel’ in Germany (UK: 2000)
(1 dominant, race-specific resistance gene)

Foto: U. Preiss, Bad Kreuznach

# Yield effects of clubroot resistance

| Cultivar | Clubroot Reaction | Seed Yield | | | | TKW g | Seeding Rate | Plants/ $m^2$ |
|---|---|---|---|---|---|---|---|---|
| | | rel. | dt/ha | Min | Max | | | |
| Mendel H | res | 100 | 43,0 | 28,0 | 47,0 | 4,1 | 45 | 27 |
| Talent H | sus | 53 | 23,0 | 9,0 | 44,0 | 3,5 | 45 | 11 |
| Tosca L | res | 77 | 33,0 | 26,0 | 36,0 | 3,3 | 60 | 50 |
| Express L | sus | 35 | 15,0 | 10,0 | 20,0 | 3,4 | 60 | 10 |

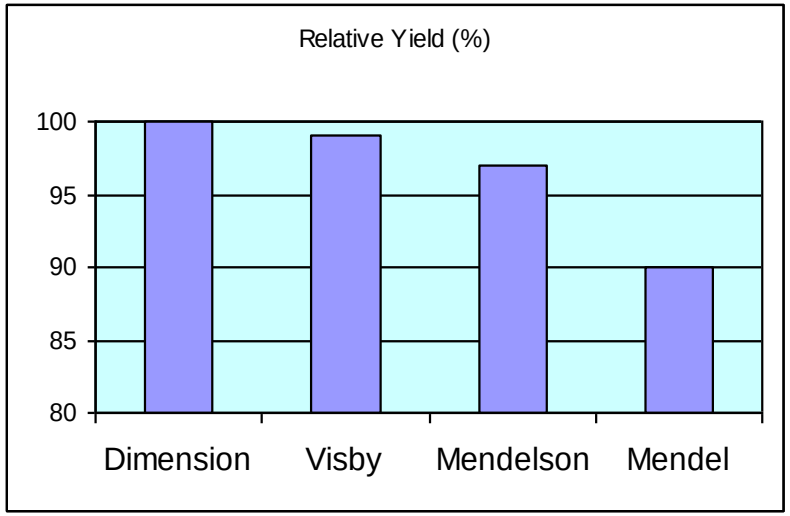
Source: W. Sauermann 2012 („Bauernblatt“), data from an official trial in Schleswig- Holstein in 2002

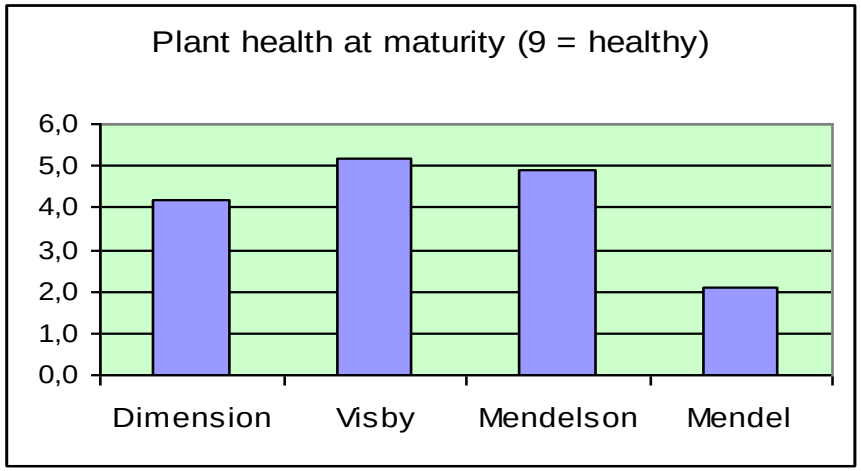
In 2011: Two official cultivar trials in Sl-H affected by clubroot, yield loss of susceptible cultivars between 15 to 40% compared to „Mendel“

# From ‚Mendel' to ‚Mendelson'

**‚Mendelson: Same resistance, better agronomy**

| Cultivar | Pb Schip-horst | Pb Löstrup | Pb NPZ18 | Pb Kiesow |
|---|---|---|---|---|
| Mendel | res | res | res | sus |
| Mendelson | res | res | res | sus |
| Granaat | sus | sus | sus | sus |




New CR *B. napus* cultivars in the market:

- Mendelson, Cracker (NPZ)
- SY Alister (Syngenta Seeds)
- Andromeda (Limagrain)

# Outlook on next generation of resistant *B. napus*

| | | Disease Index (DI) | | |
|---|---|---|---|---|
| ***P. brassicae* Isolate** | **Origin** | **Mendel** | **NPZ-CR21** | **Chinese Cabbage** |
| **Leduc** | CA (Edmonton) | 67 | 40 | 100 |
| **Wusterhusen** | D (Meck.-Pomerania) | 98 | 92 | 100 |
| **Dersekow** | D (Meck.-Pomerania) | 73 | 21 | 100 |
| **b** | D (Westphalia) | 10 | 6 | 100 |
| **Pol4** | PL (Silesia) | 71 | 16 | 100 |
| **k** | D (Schleswig) | 63 | 5 | 100 |
| **HRO1** | D (Rostock) | 27 | 3 | 100 |
| **Schwaan** | D (Meck.-Pomerania) | 71 | 31 | 100 |
| **N19** | D (Schl.-Holstein) | 67 | 7 | 100 |
| **SS2** | F (Brittany) | 0 | 0 | 98 |
| **L1** | D (Schl.-Holstein) | 67 | 42 | 100 |
| **CZ1** | CZ (NE Bohemia) | 77 | 24 | 100 |
| **Qsch** | D (Saarland) | 39 | 0 | 100 |
| **Vissch1** | D (Schl.-Holstein) | 3 | 0 | 99 |
| **BB1** | UK (Scotland) | 3 | 0 | 100 |
| **WY1** | UK (Scotland) | 0 | 0 | 100 |
| | Mean: | **46** | **18** | **100** |

# Monitoring for virulent isolates on ‚Mendel‘

- On demand

- Official advisors

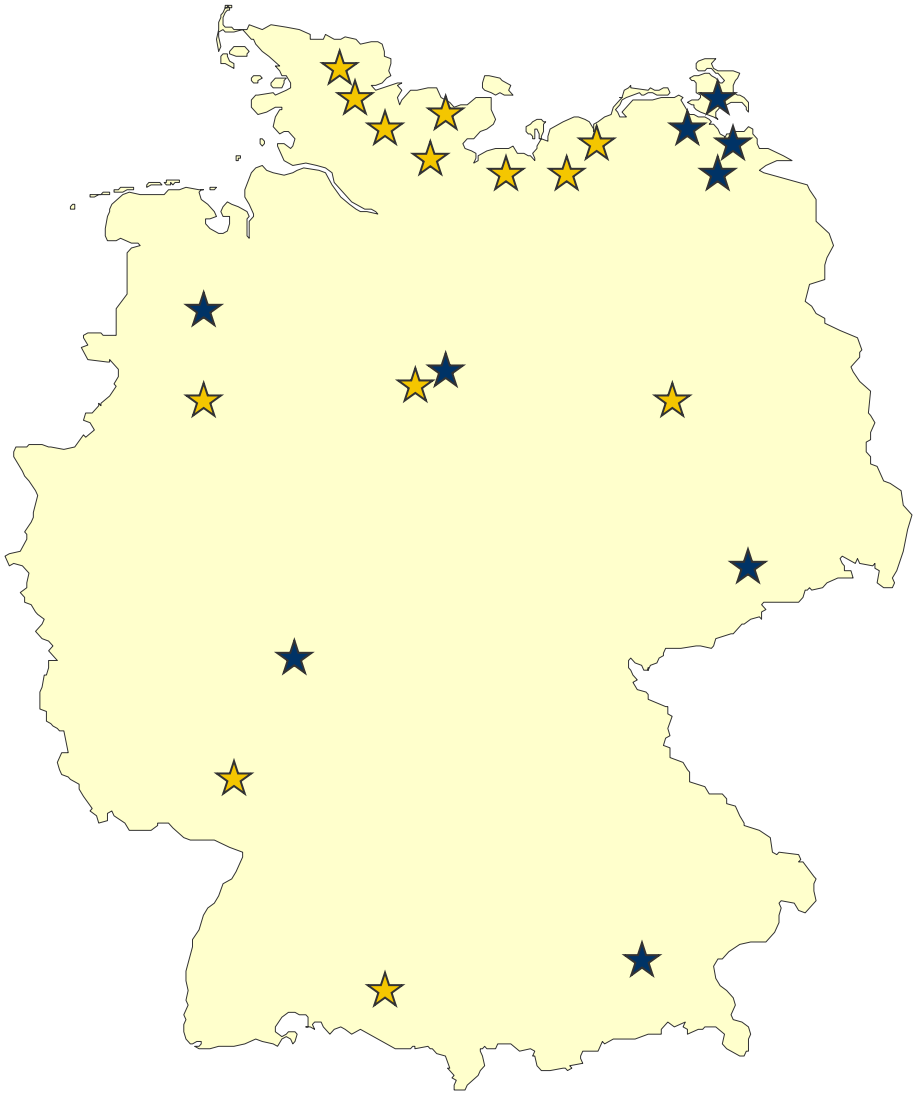
- Advisors of NPZ breeding company or Rapool GmbH

Exclude infected volunteers:

- Check identity of infected plants with ‚Mendel‘- specific markers

- Confirm virulence of local isolate on ‚Mendel‘ in greenhouse assay

# Clubroot Incidences in German ‚Mendel' Crops



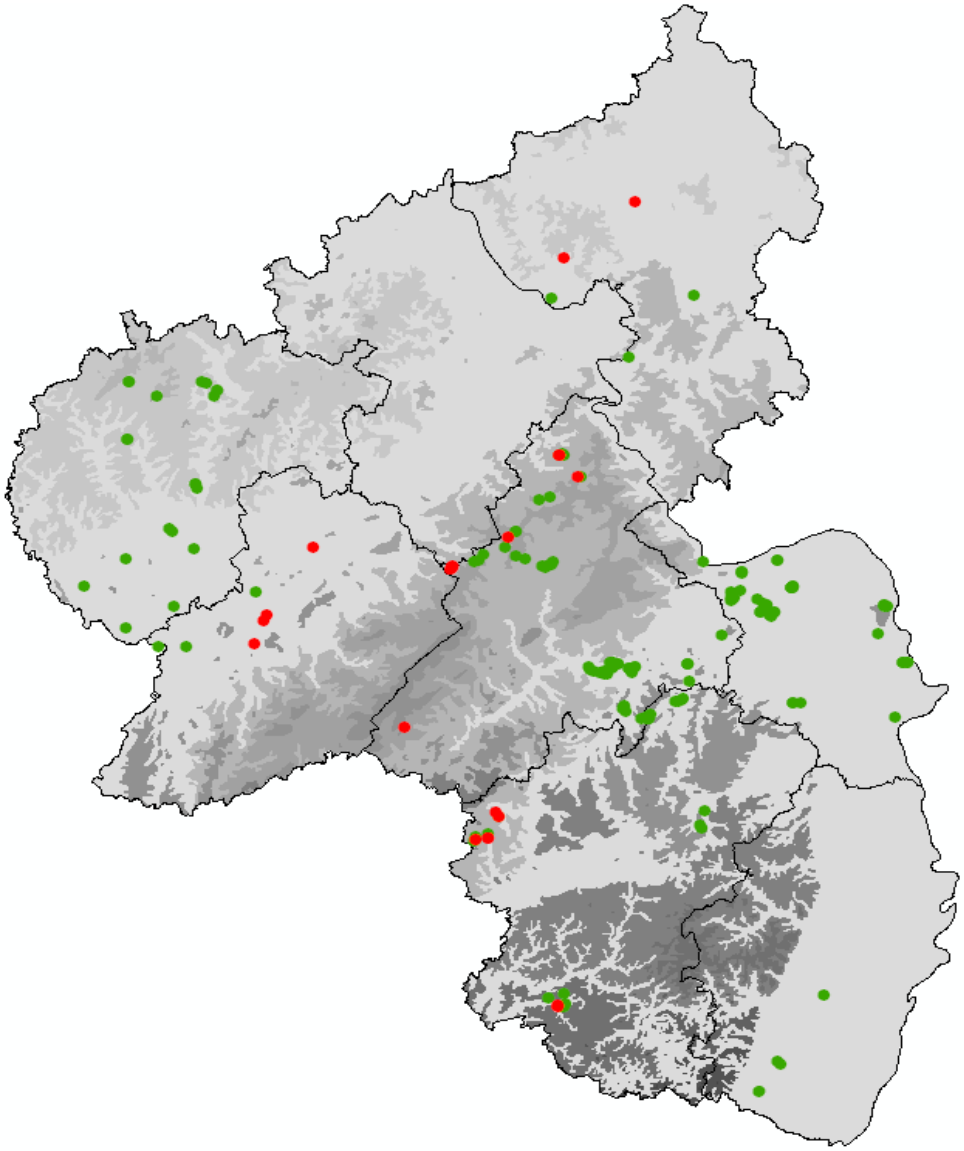
★ = Clubroot on susceptible OSR

★ = Clubroot also on ‚Mendel'

Clubroot on ‚Mendel' outside of Germany:

Some cases in Poland, a few cases in the UK, none in France, Sweden?

# Unbiased monitoring in *B. napus* crops



Monitoring for *P. brassicae* in *B. napus* crops (2005 – 2010):

- Soil samples from crops, all cultivars, independent of previous disease reports
- Test for presence of *P. brassicae* in Bioassay using soil samples
- 16% of 453 samples were tested positive for *P. brassicae* (red dots)
- ‚Mendel' resistant against 97% of local isolates

(Data from U. Preiss, DLR-RNH Bad Kreuznach)

# Characterization of pathogen variation

Two different attempts in Germany:

- Pathogenicity testing using different tester sets, JKI Quedlinburg and Limagrain, W. Lüders (poster)
- Molecular differentiation of Pb isolates, B. Strehlow University Rostock, separation of isolates from Northern Germany vs South- Western isolates

- INRA France: Ongoing project (pathogenicity)
- Poland: See posters from Kaczmarek et al. and Niemann et al.

# Clubroot research in France

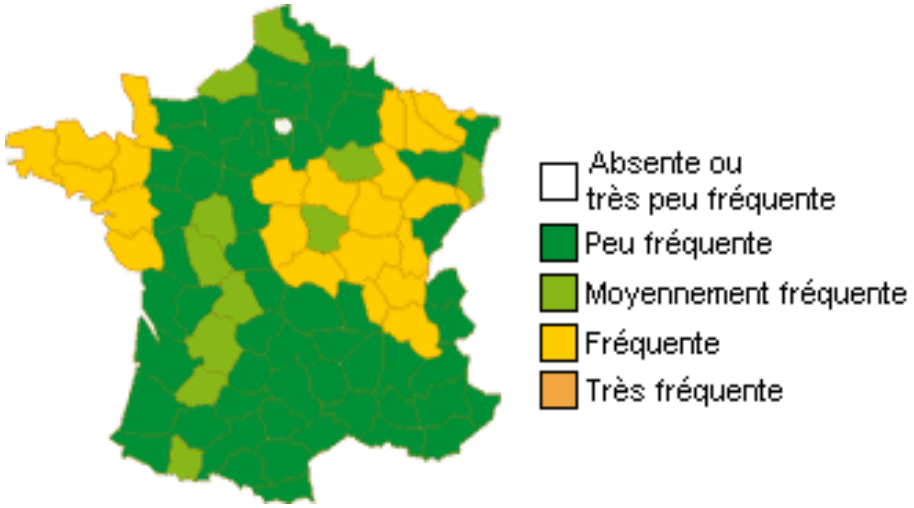
- CETIOM: Monitoring for clubroot incidences, online questionaire

- INRA: Coordination and execution of different research projects on clubroot

  - Mapping and use of quantitative resistance in *Brassica* breeding (*napus, oleracea*)

  - Study the molecular basis of quantitative resistance in Arabidopsis

  - Metabolomics of clubroot disease



# Summary

❖Clubroot is of increasing relevance for oilseed rape in Europe

❖Resistant cultivars have a central role in integrated clubroot control

❖Resistance sources are present in *Brassica* gene pool

❖Race-specific effects of resistance loci are of key relevance for breeding

❖So far, occurrence of compatible pathotypes remains locally

❖Incidences of compatible isolates on resistant cultivars are getting slowly more frequent and widespread

# Acknowledgements


- Norddeutsche Pflanzenzucht (NPZ), Dr. Martin Frauen
- Prof. Thomas Schmülling, Freie Universität Berlin
- Field consultants of NPZ, Rapool and Saaten- Union
- Public advisors: Margit Nagel, Pflanzenschutzdienst Greifswald, M-V, Uwe Preiss, DLR-RLP Bad Kreuznach


Thank you for your attention!

# *Clubroot Disease (Plasmodiophora brassicae)*

**Conditions** needed for clubroot disease:

- Soil-pH < 7
- Soil moisture > 60% soil water capacity
- Soil temperature > 12-16°C
- Inoculum load > 1000 resting spores per plant
- Young roots with root hairs of Crucifer hosts

**Multiplication**: 100.000fold increase per generation (<6 weeks)

**Longevity** of resting spores: 20 years, half life time 3.6 years

**Spread**s with soil (machinery, erosion, animals, drain water, seed potatoes) or infected transplants, no seed transmission

**Ca. 10% of cropping area of crucifers world wide is infested, yield losses up to 100%**

# Use of Quantitative Clubroot Resistance ?

- All known clubroot resistance loci show qualitative or quantitative reactions depending on *P. brassicae* isolate and/ or environmental conditions

- Race- specificity is the major issue, broadness!

- Specific combining effects of certain resistance loci have been described

→ Selection of resistance loci should be based on knowledge of their specific effects