

Black root rot of strawberries: Current knowledge and perspectives

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Jordbærkonference, Brædstrup (5 Nov. 2019)

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History of root diseases in Northern Germany

1960s — Verticillium wilt (*Verticillium dahliae*)

1980s — Rhizome rot (*Phytophthora cactorum*)
Red root rot (*P. fragariae*)

1990s — Increase in black root rot:
Verticillium? ⟷ nematodes?
Rhizoctonia? *Phytophthora*?

2005 — First analyses: no known pathogen

5005 roots

2017

Erwerbs-Obstbau (2017) 59:157–169
DOI 10.1007/s10341-017-0343-9

CrossMark

ORIGINAL ARTICLE

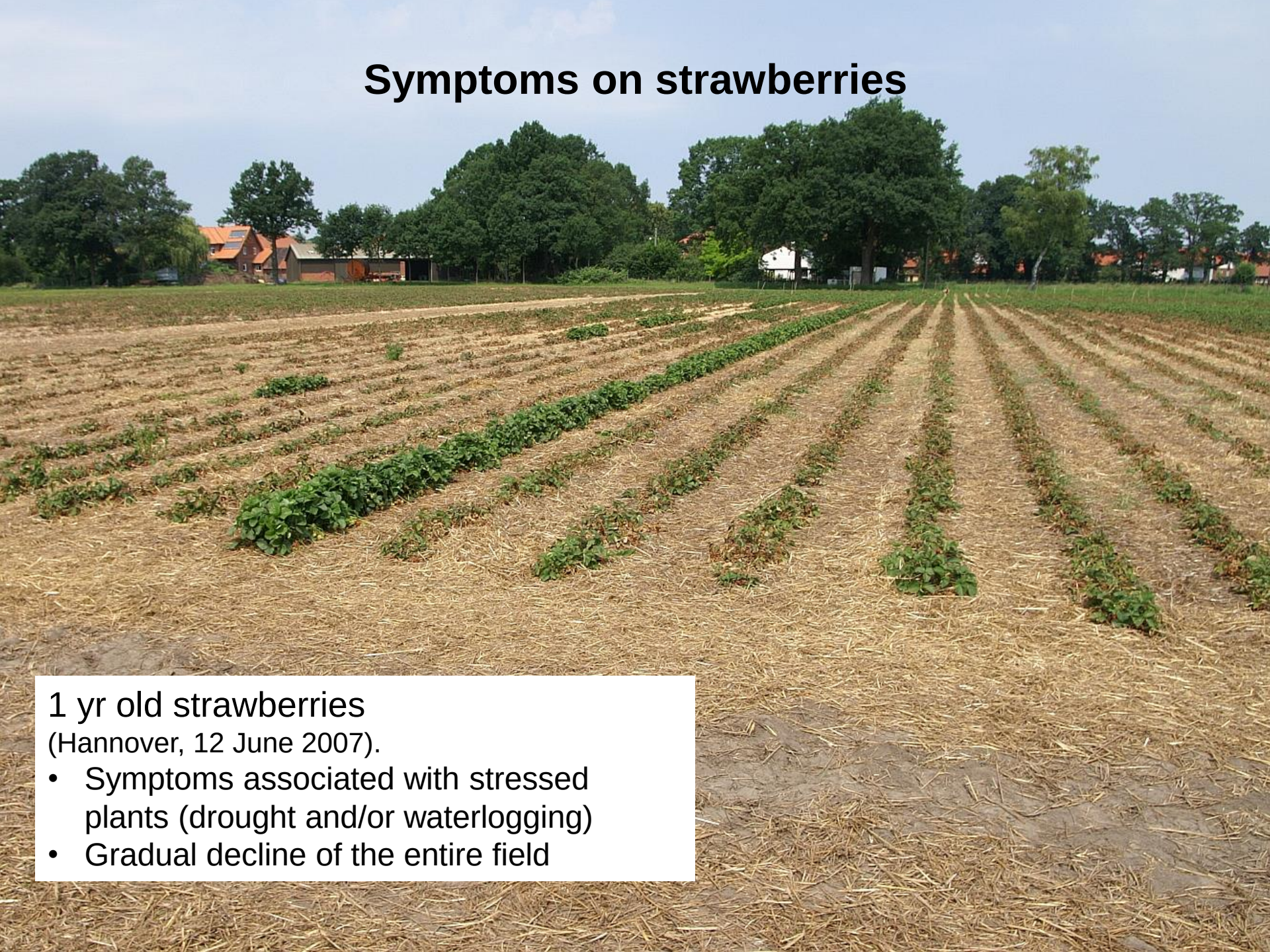
Dactylonectria torresensis as the Main Component of the Black Root Rot Complex of Strawberries and Raspberries in Northern Germany

Roland W. S. Weber[1,2] · Alfred-Peter Entrop[1]


Survey area
Schleswig-Holstein
Stader Geest
Esteburg
Lang-förden
Hannover
Nordfriesisches Wattenmeer
Schleswig-Holsteinisches Wattenmeer
Husum
Schleswig
Eckernförde
Kappeln
Fehmarn
Kiel
Rendsburg
St. Peter-Ording
Heide
Itzehoe
Brunsbüttel
Cuxhaven
Otterndorf
Glückstadt
Elmshorn
Drochtersen
Stade
Wedel
Hamburg
Norderstedt
Ahrensburg
Bad Oldesloe
Kaltenkirchen
Lübeck
Neustadt in Holstein
Rostock
Wismar
Schwerin
Ratzeburg
Mölln
Bremerhaven
Wilhelmshaven
Wittmund
Norden
Esens
Wangerland
Borkum
Krummhörn
Aurich
Emden
Leer (Ostfriesland)
Westerstede
Oldenburg
Bad Zwischenahn
Weener
Papenburg
Delfzijl
Großefehn
Wiesmoor
Zetel
Varel
Nordenham
Loxstedt
Beverstedt
Gnarrenburg
Osterholz-Scharmbeck
Ritterhude
Bremen
Ottersberg
Scheeßel
Schneverdingen
Rotenburg (Wümme)
Achim
Delmenhorst
Langwedel
Visselhövede
Verden (Aller)
Walsrode
Soltau
Munster
Bispingen
Lüneburg
Winsen (Luhe)
Seevetal
Hagenow
Parchim
Lübz
Ludwigslust
Dannenberg (Elbe)
Perleberg
Wittenberge
Uelzen
Salzwedel
Osterburg (Altmark)
Celle
Wittingen
Gifhorn
Wolfsburg
Braunschweig
Helmstedt
Gardelegen
Stendal
Tangermünde
Haldensleben
Burg (bei Magdeburg)
Wolmirstedt
Möckern
Hildesheim
Salzgitter
Springe
Laatzen
Neustadt am Rübenberge
Wunstorf
Minden
Lübbecke
Espelkamp
Bramsche
Damme
Nordhorn
Lingen (Ems)
Haselünne
Meppen
Löningen
Cloppenburg
Bassum
Sulingen
Twistringen
Emmen
Haren (Ems)
Klazienaveen
Coevorden
Stadskanaal
Veendam
Friesoythe
Wardenburg
Großenkneten
Samtgemeinde Dörpen
Rheine
Osnabrück
Ibbenbüren
Hengelo
Enschede
Steinfurt
Lengerich
Melle
Bünde
Bad Oeynhausen
Bruchhausen-Vilsen
Recke
Almelo
Barsinghausen
Uetze
Eine
Cremlingen
Wolfenbüttel
Verbandsgemeinde Beetzendorf-Diesdorf
Verbandsgemeinde Arneburg-Goldb
Pritzwalk
Mecklenburgisches Elbetal
Elbe
Bützow
Güstrow
Satow
Bad Doberan
Kühlungsborn
Neustadt in Holstein
Eutin
Preetz
Amt Nortorfer Land
Schwentinental
Schönberg
Altenholz
Nossen
Schwinze
Ribr

1. **Symptoms on strawberries**
2. Isolation of pathogenic fungi
3. Occurrence of *Cylindrocarpon* spp.
4. Identification of relevant species
5. Perspective

Symptoms on strawberries



1 yr old strawberries
(Hannover, 12 June 2007).

- Symptoms associated with stressed plants (drought and/or waterlogging)
- Gradual decline of the entire field



Above-ground symptoms:
Red leaves and small fruit
→ stunted growth
→ necrosis

Late appearance
of above-ground symptoms



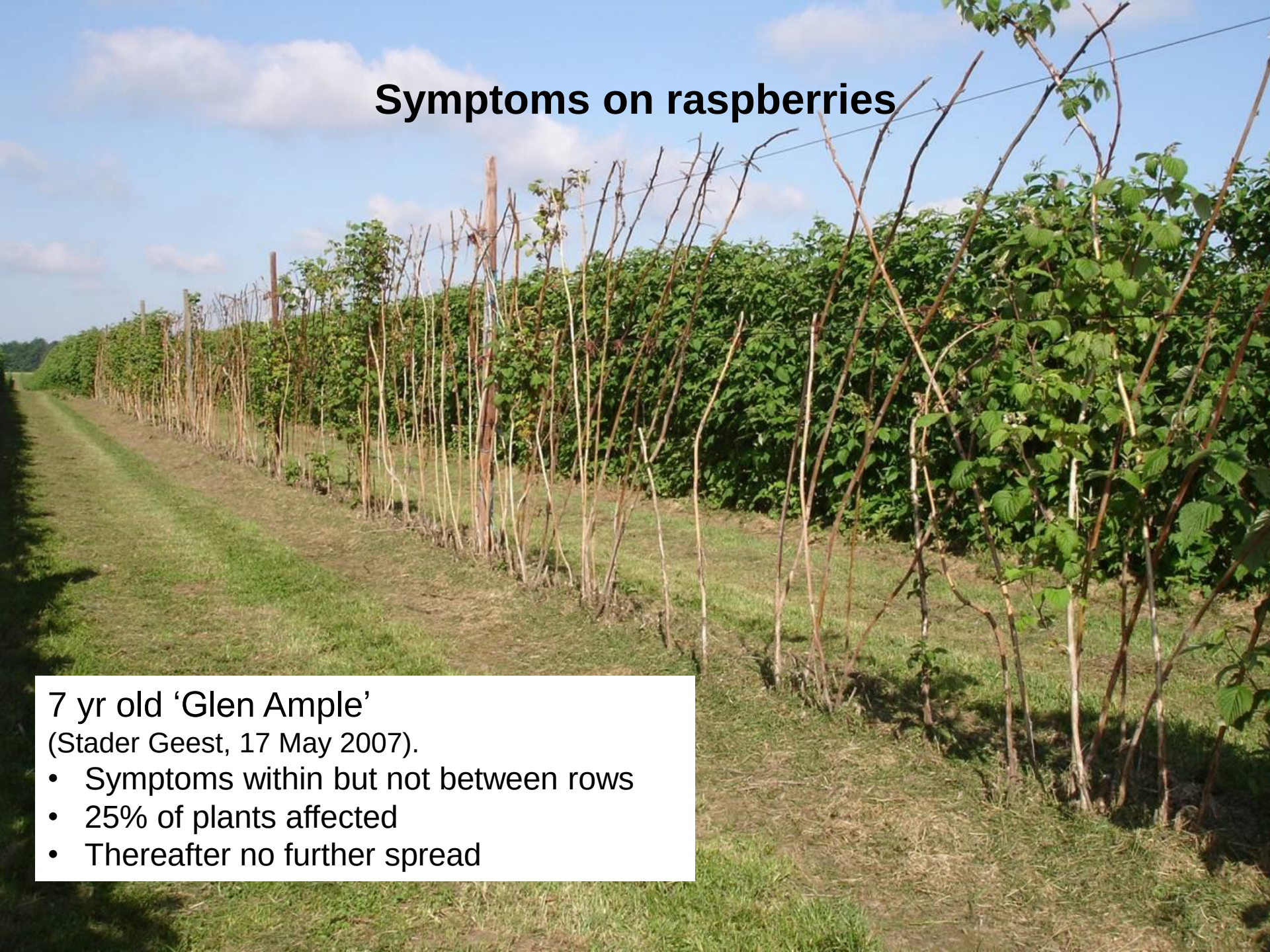


Symptoms on strawberries



- Black rot: no red colouration of stele
- Decomposition of cortex with intact stele underneath
- New root growth only at the top of rhizome
- No growth of sucker roots
- Rhizome remains intact

Symptoms on raspberries



7 yr old ‘Glen Ample’
(Stader Geest, 17 May 2007).

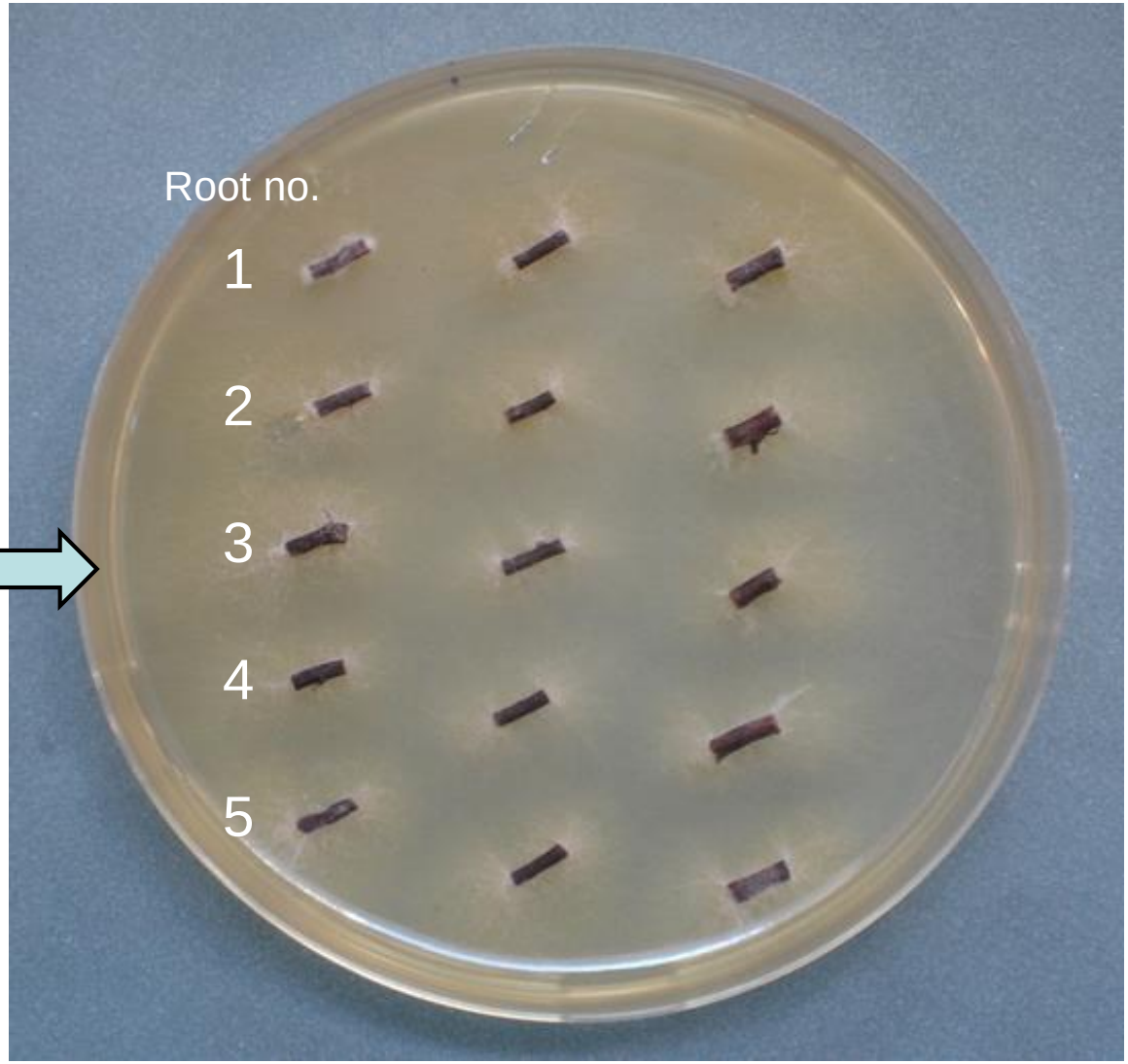
- Symptoms within but not between rows
- 25% of plants affected
- Thereafter no further spread

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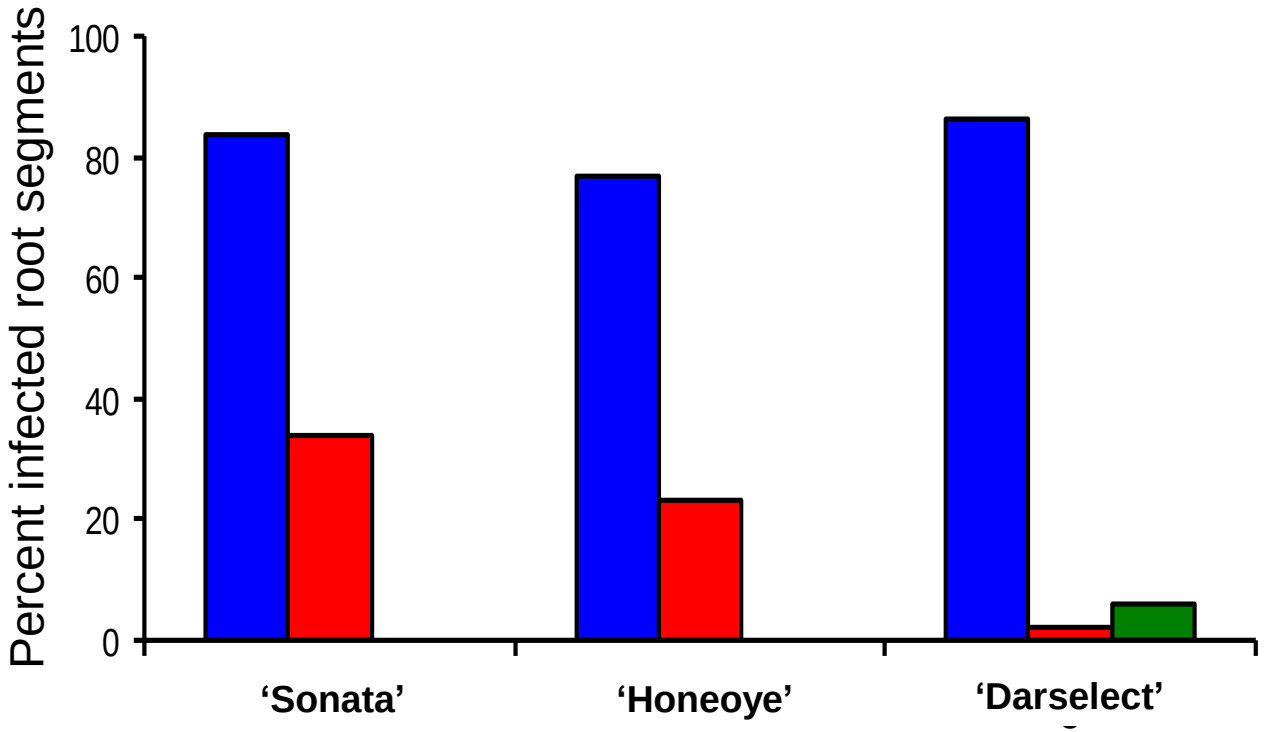


Diversity of isolated fungi

Species	Medium	Frequency
Coniothyrium fuckelii	MEA	+
Cylindrocarpon sp.I	MEA	+++
Cylindrocarpon sp.II	MEA	++
Cylindrocarpon sp.III	MEA	+
Fusarium oxysporum	MEA	++
Fusarium (various spp.)	MEA	+
Hainesia lythri	MEA	+
Phytophthora spp.	CMA	+
Pythium sylvaticum	CMA	+
Rhizoctonia AG-I	MEA	+
Verticillium dahliae	MEA	+

Example: strawberry plantation (2 yr old)

For each variety 6 plants, 6 roots per plant, 5 segments per root (*n* = 180).



Occurrence of *Cylindrocarpon*, *Rhizoctonia* and *Verticillium* in the roots of heavily symptomatic strawberry plants in one field. Field had been tested positive for microsclerotia of *Verticillium* prior to planting.

Are *Cylindrocarpon* species pathogens?

Difficulty with soilborne fungi: Roots often strongly decayed when first above-ground symptoms become visible.

1. *Cylindrocarpon* spp. always associated with black root rot symptoms of strawberries and raspberries
2. Pathogens isolated from every batch of diseased plants
3. Koch's Postulates fulfilled…

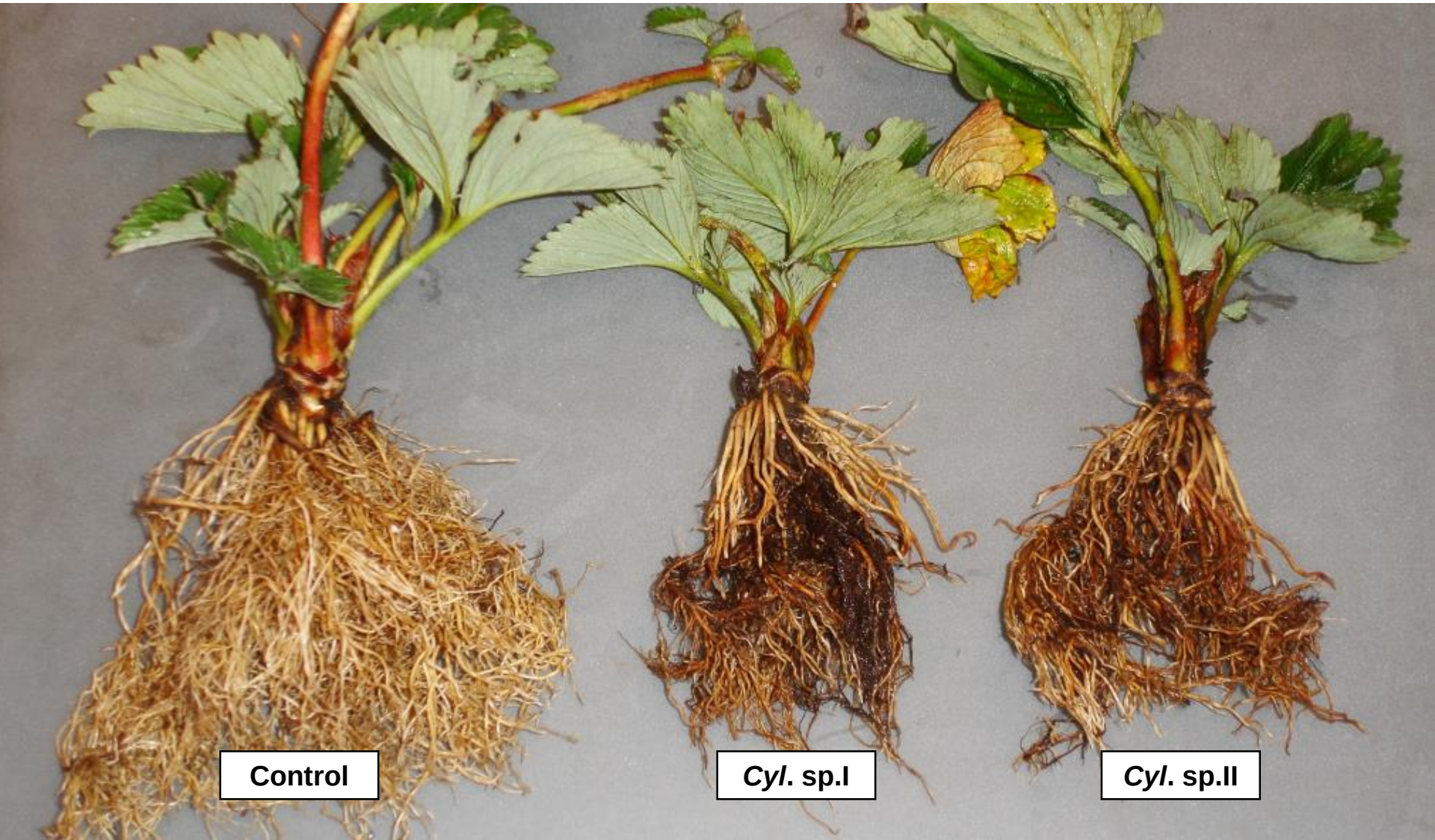


***Cylindrocarpon* spores**

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Confirmation of pathogenicity on strawberries



Results of inoculation trials

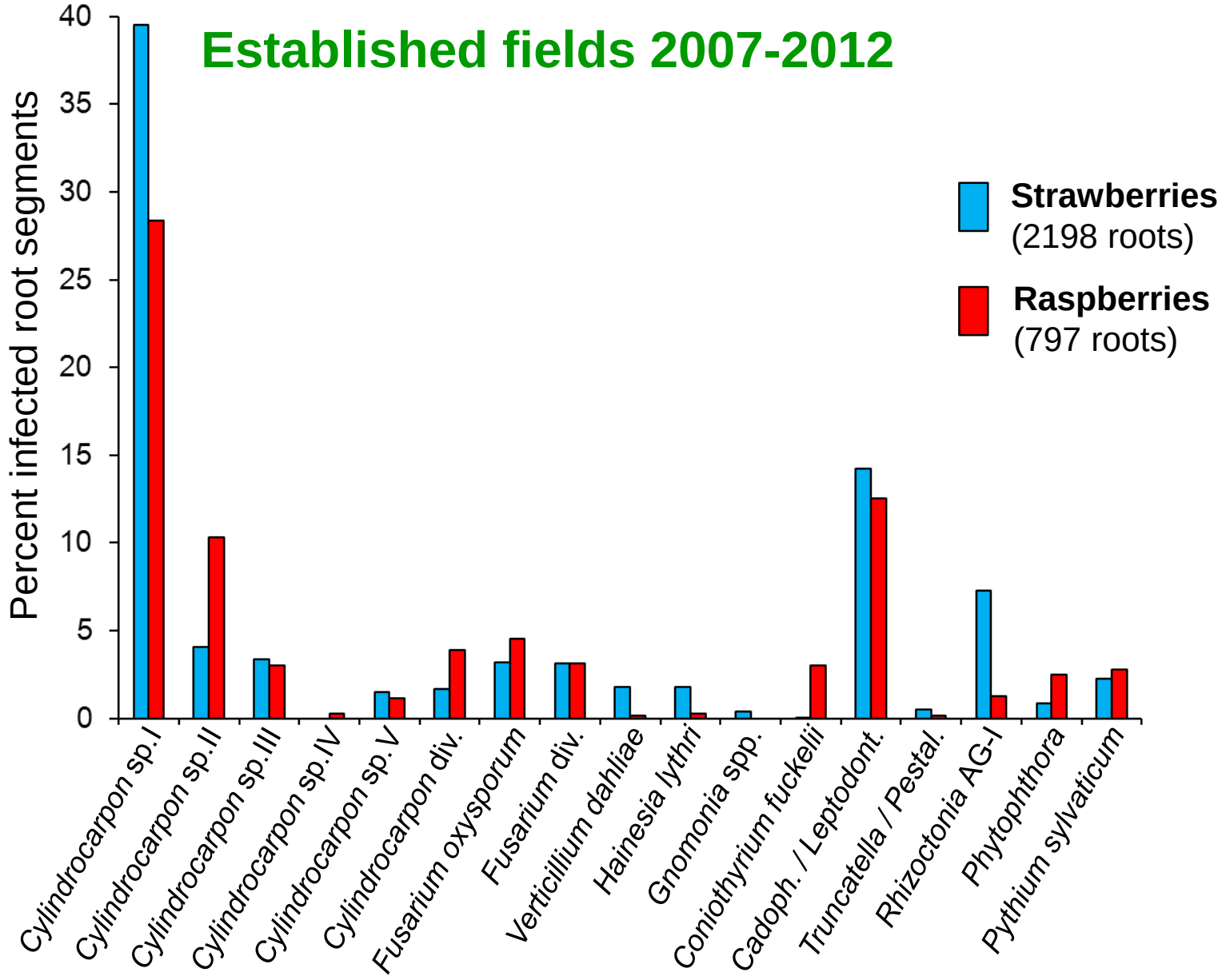
Isolate	**Symptoms** (after 8 weeks)	**Re-isolation from 15 roots** sp. I	sp. II	sp. IV
Unbeimpft	Keine	0	0	0
Cyl003 (sp.I)	+++	15	0	0
Cyl020 (sp.I)	+++	14	0	0
Cyl021 (sp.II)	++	0	13	0
Cyl012 (sp.II)	++	0	15	0
Cyl024 (sp.IV)	+	1	0	14

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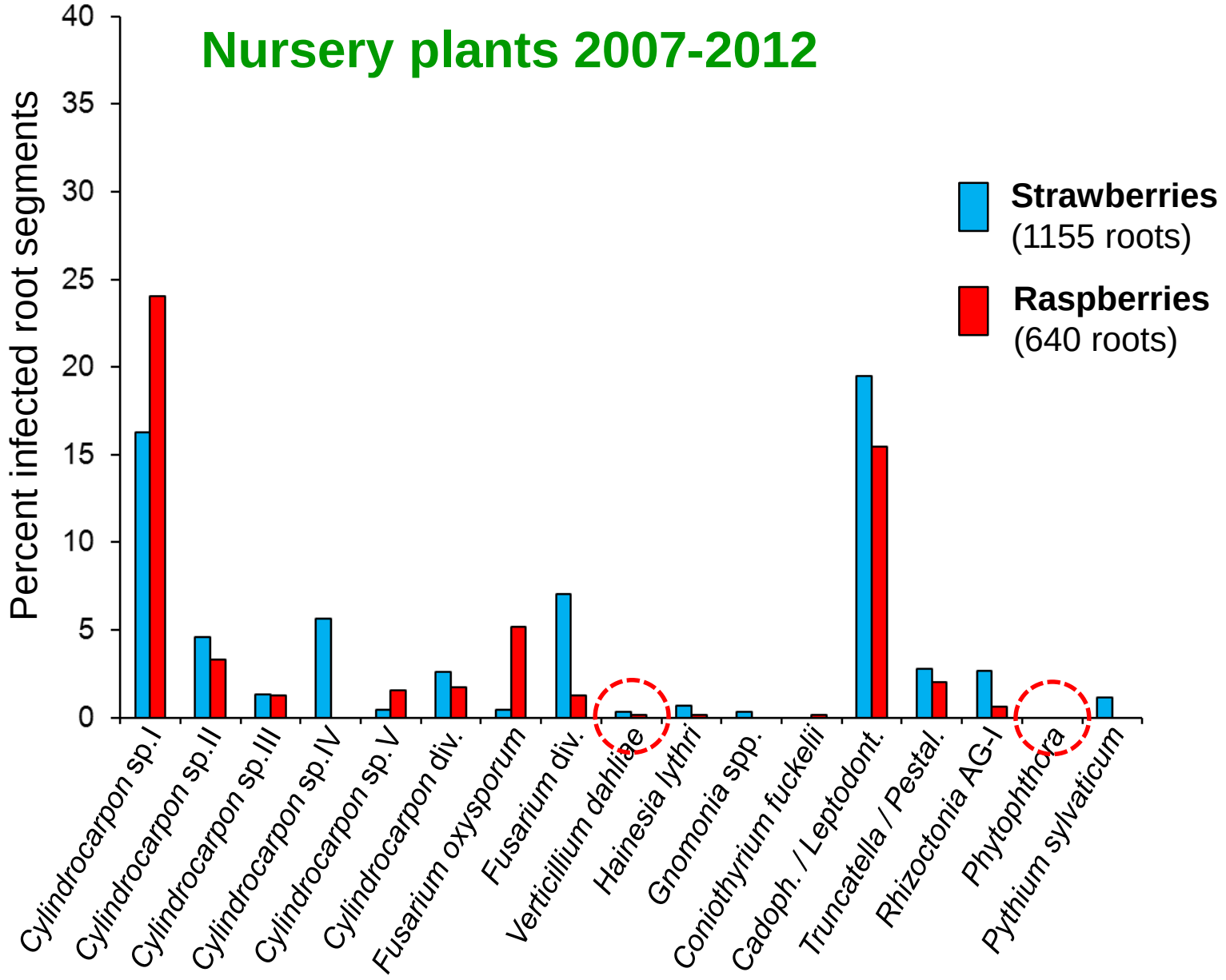
Established fields 2007-2012



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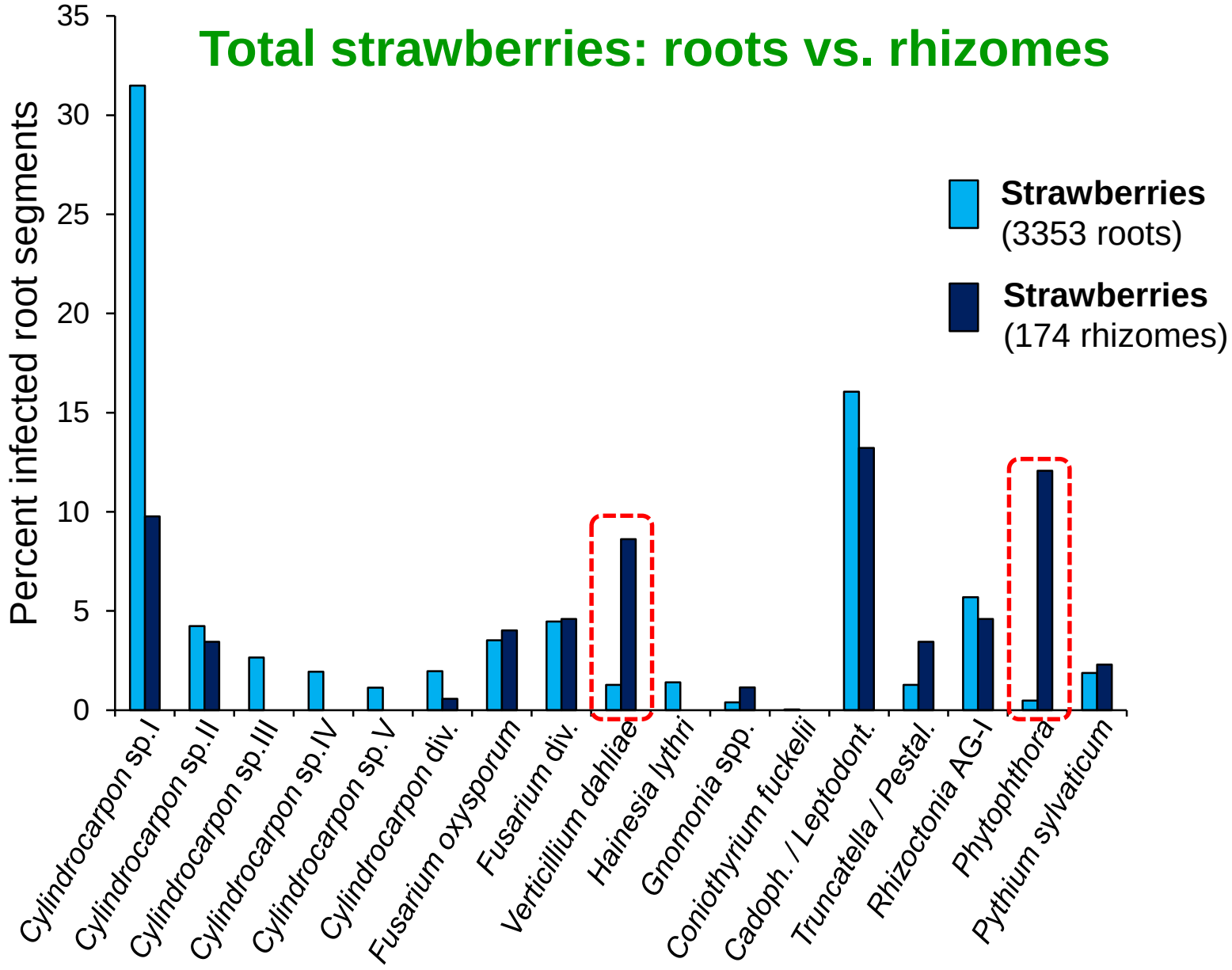
Nursery plants 2007-2012



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Total strawberries: roots vs. rhizomes



Cylindrocarpon – Summary of data

1. The most important current root rot pathogen in Northern Germany: *Cylindrocarpon* sp.I
2. Occurrence on strawberry and raspberry roots equally high
3. DNA analysis, artificial infection experiments and 10 yr observations indicate high pathogenicity of this species
4. At least 4 additional *Cylindrocarpon* spp. contribute to black root rot
5. *Rhizoctonia*, *Verticillium dahliae*, *Phytophthora* and other fungi have minor roles
6. On strawberry rhizomes: *Phytophthora*, *Cylindrocarpon* and *Verticillium* are important

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Infection (% roots) of different nursery plant batches

Propagator / Species	A Strawb.	B Strawb.	C Strawb.	D Strawb.	C Raspb.	D Raspb.	E Raspb.
Cyl. sp.I	2.6	**27.1**	**23.9**	**21.6**	**31.5**	**24.6**	**16.7**
Cyl. sp.II	**13.9**	-	0.6	0.8	4.0	4.0	-
Cyl. sp.III	-	-	1.3	-	-	-	-
Cyl. sp.IV	-	-	2.8	**27.2**	-	-	-
Cyl. sp.V	-	-	-	-	5,0	-	-
F. oxysporum	**15.7**	-	6.3	-	4.5	2.3	-
Rhizoctonia AG-I	-	-	2.5	0.8	0.5	1.7	-
Pythium sylvaticum	-	0.4	0.6	-	4.0	4.0	-

Infection of nursery material

1. All *Cylindrocarpon* spp. as well as additional root-rot pathogens can be introduced with nursery plants
2. Especially *Cylindrocarpon* sp. I also common on nursery material
3. Other pathogens (*Phytophthora*, *Rhizoctonia* and *Verticillium dahliae*) hardly present on nursery plants → soilborne in production fields?

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Analysis of DNA sequences (ITS und HIS H3)

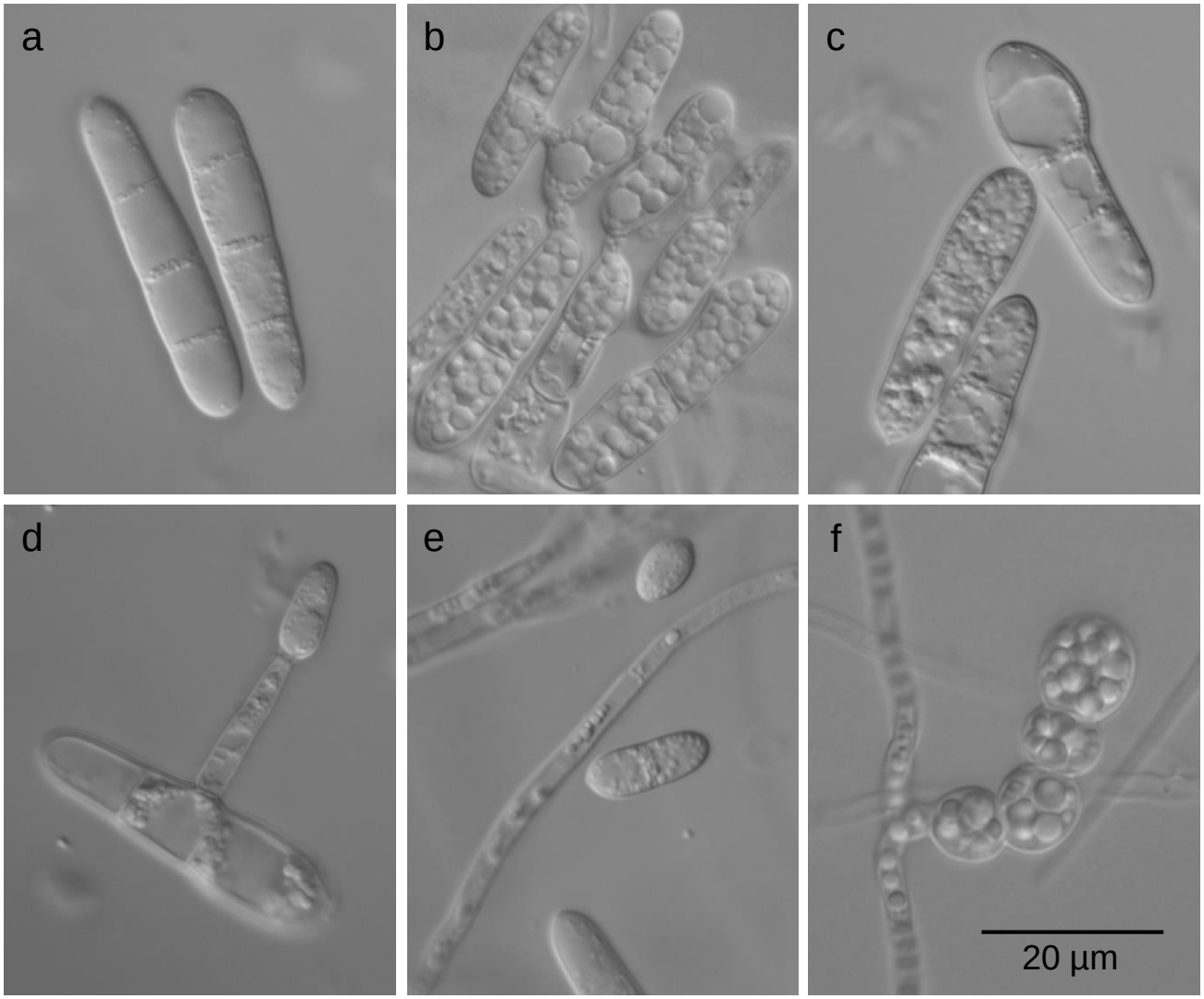
Preliminary numbering	Probable identity	Strains (∑ = 79 seq.)
sp. I	*Dactylonectria torresensis*	24
sp. II	a. *Ilyonectria crassa* b. *Ilyonectria* sp.	18 10
sp. III	*Ilyonectria robusta*	10
sp. IV	*Cylindrocarpon obtusisporium*	2
sp. V	*Ilyonectria* sp.	10
various	*Ilyonectria europaea* *Ilyonectria liriodendri*	3 2

Reference sequences available in 2013
(Cabral *et al*., 2012)

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Microscopic features of *D. torresensis*



What do we know about *Cylindrocarpon* sp. I ?

Cylindrocarpon sp. I (*Dactylonectria torresensis*)

- common root rot of grapevine in Europe, North America, Australia, South Africa (Cabral *et al*., 2012)
- sporadic occurrence on strawberry roots (NL)
- found in N. Germany on *A. nordmanniana*
- highly destructive in grapevine nurseries in Portugal
  → introduction into vineyards with nursery material

Additional potential pathogens

Preliminary identity	Formal identity	Sequences (∑ = 16 Seq.)
Fusarium (resembling *Cylindrocarpon*)	*Fusarium oxysporum*	2
Phialophora (sterile green mycelium)	a. *Cadophora luteo-olivacea* b. *Leptodontidium orchidicola*	3 2
Verticillium dahliae	*Verticillium dahliae*	2
Pythium spp.	a. *Pythium sylvaticum* b. *Pythium irregulare*	4 1
Rhizoctonia	*Ceratobasidium* AG-I (*R. fragariae*)	2

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Black root rot is a replant disease:
new plants inserted into holes in
established rows will fail

Possible control options

1. Healthy planting material: Black root rot can be recognised visually
2. Avoid replanting: New plantings into established infection courts will lead to rapid death of plants
3. Check soil for nematodes prior to planting: Nematodes are vectors for root diseases
4. Control of nematodes by sowing *Tagetes* between two strawberry cultures: No trial results as yet for black root rot





Possible control options

1. Healthy planting material: Black root rot can be recognised visually
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4. Control of nematodes by sowing *Tagetes* between two strawberry cultures: No trial results as yet for black root rot
5. Avoid stress (drought, waterlogging): Infected plants may recover to a certain extent



Literature

Weber, R.W.S. & Entrop, A.-P. (2017). *Dactylonectria torresensis* as the main component of the black root rot complex of strawberries and raspberries in Northern Germany. *Erwerbs-Obstbau* **59**: 157-169.

Weber, R.W.S. (2019). Sorte rødder i jordbær. *Gartner Tidende* **7/2019**: 46-47.

Weber, R.W.S. (2019). Sort rodråd – et kompleks af svampe. *Gartner Tidende* **10/2019**: 32-33.



Thank you