Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

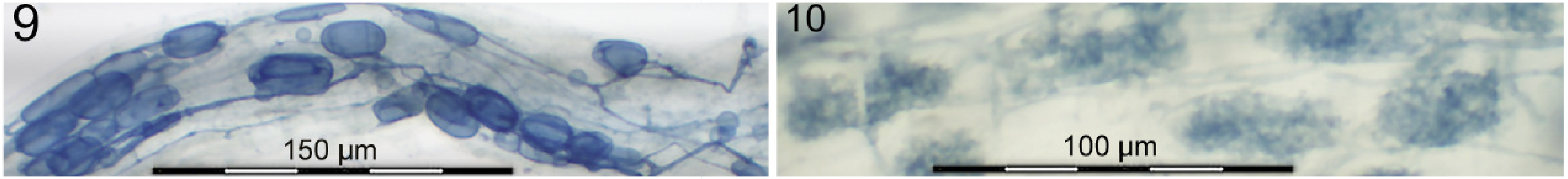
Eidgenössisches Departement für Wirtschaft,
Bildung und Forschung WBF
Agroscope

Diversity of arbuscular mycorrhizal fungi in agricultural systems

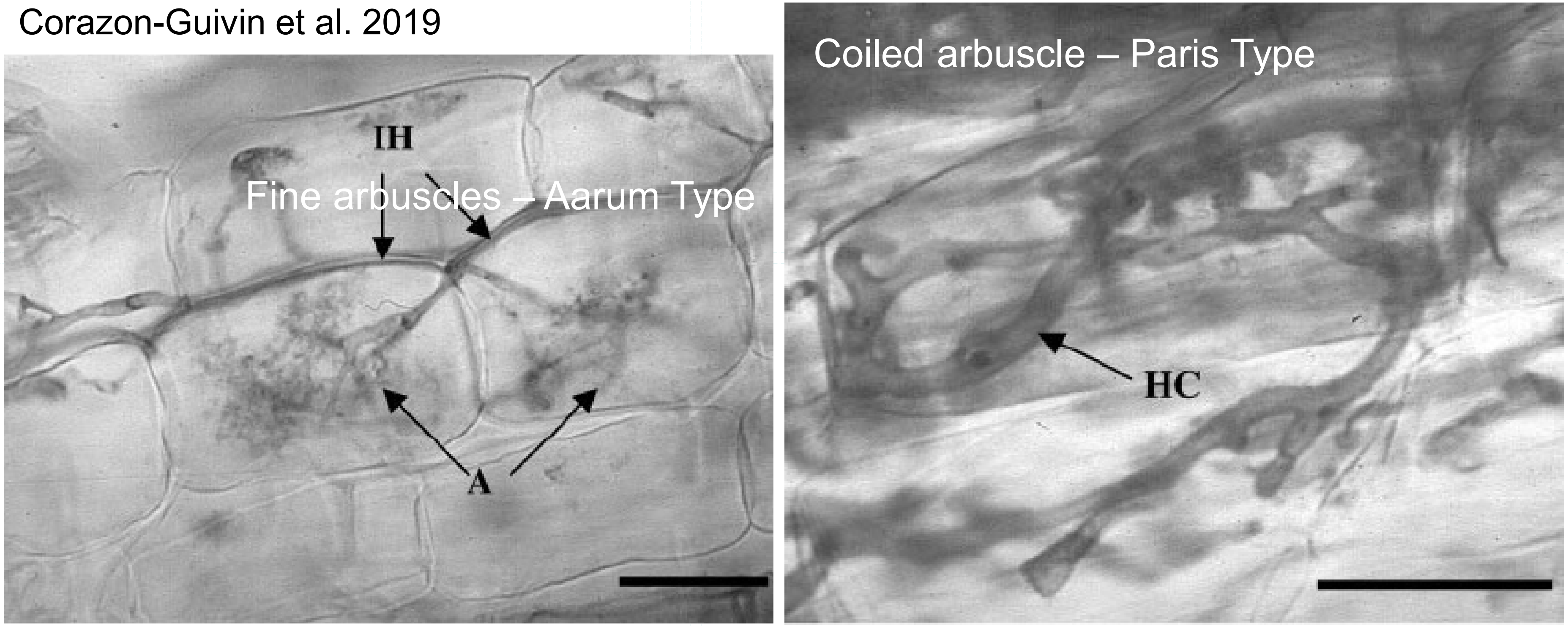
Fritz Oehl

Monte Verità, 8.10.2019

(Vesicular-)Arbuscular Mycorrhizal structures



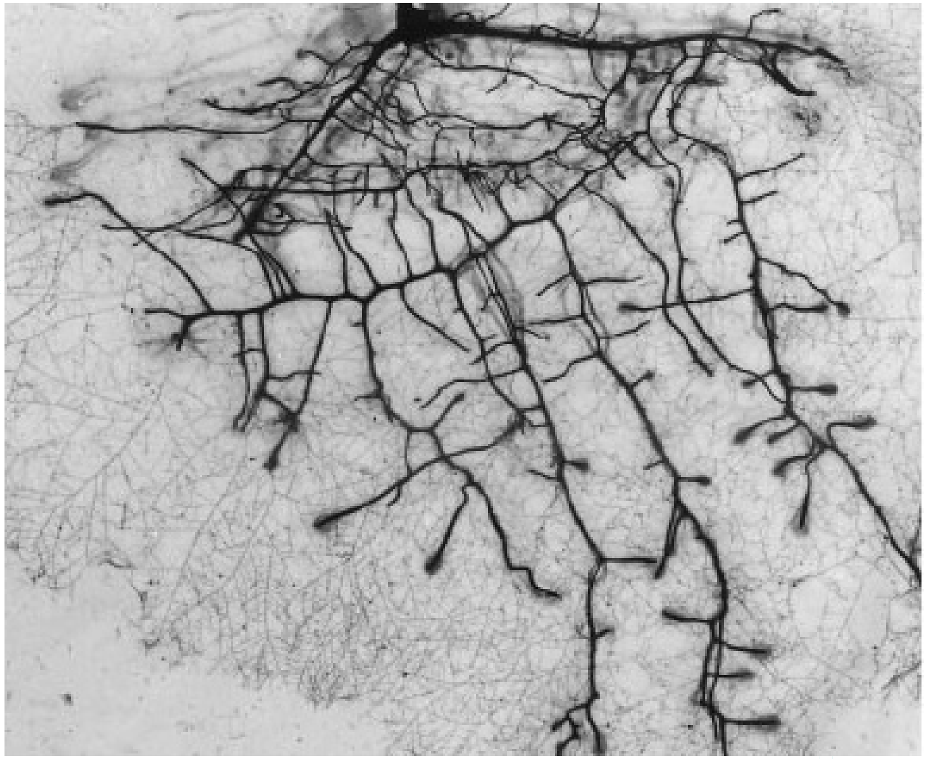
Corazon-Guivin et al. 2019



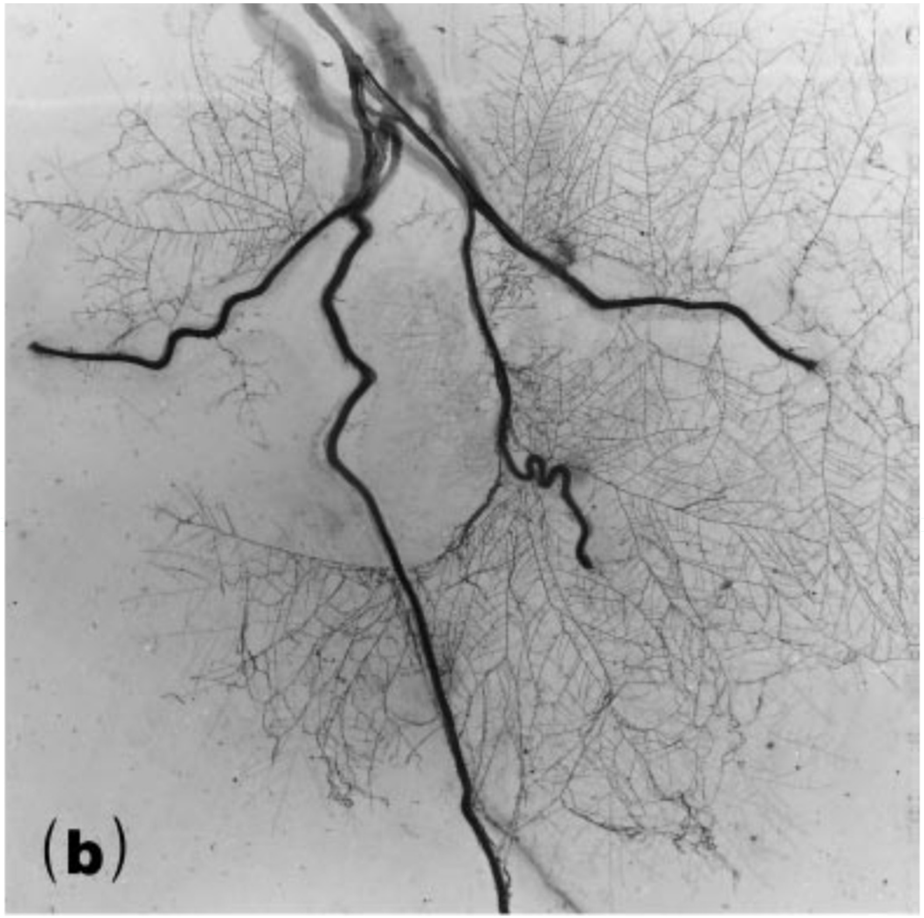
Cavagnaro et al. 2001

Extraradical mycelia

Cherry - *Prunus avium* -roots



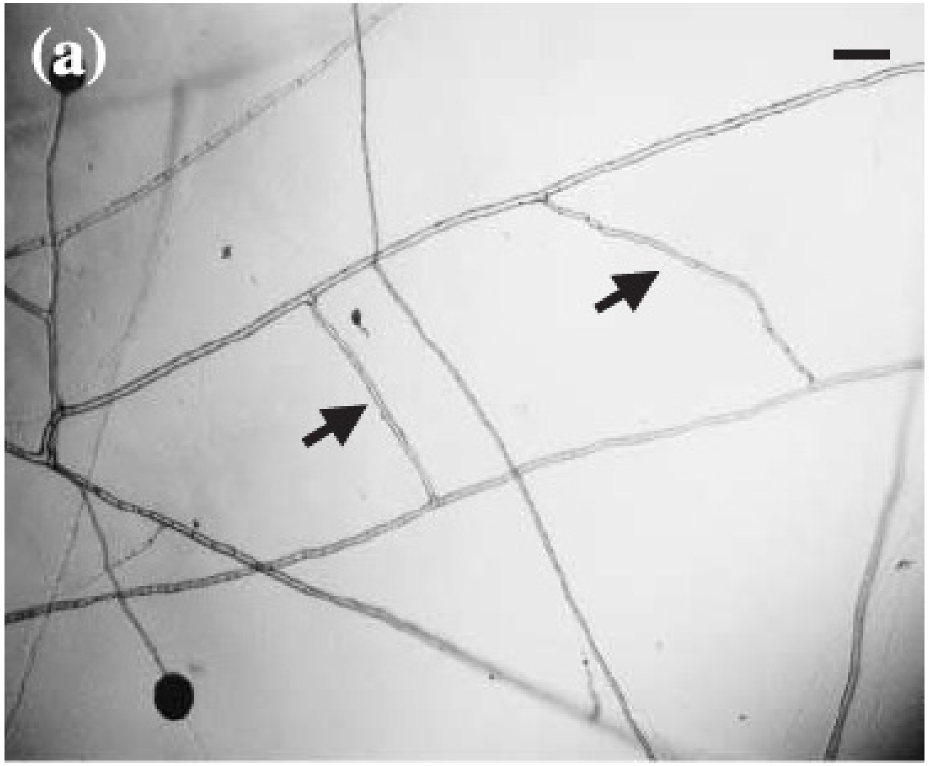
Leek - *Allium porrum* - roots



Giovannetti et al. 2001

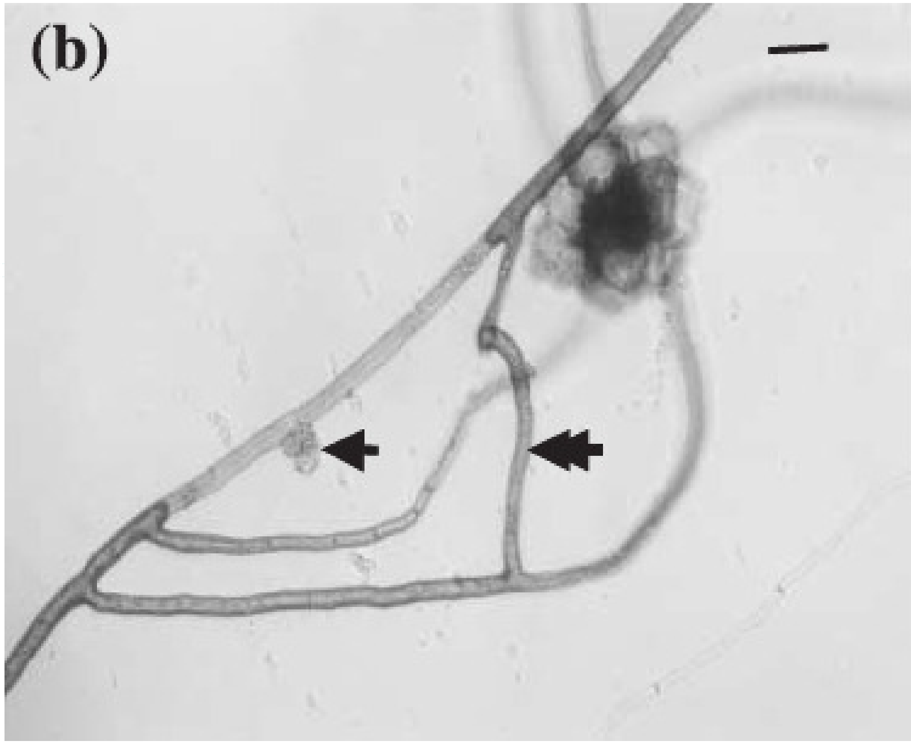
Extraradical mycelia

Glomerales

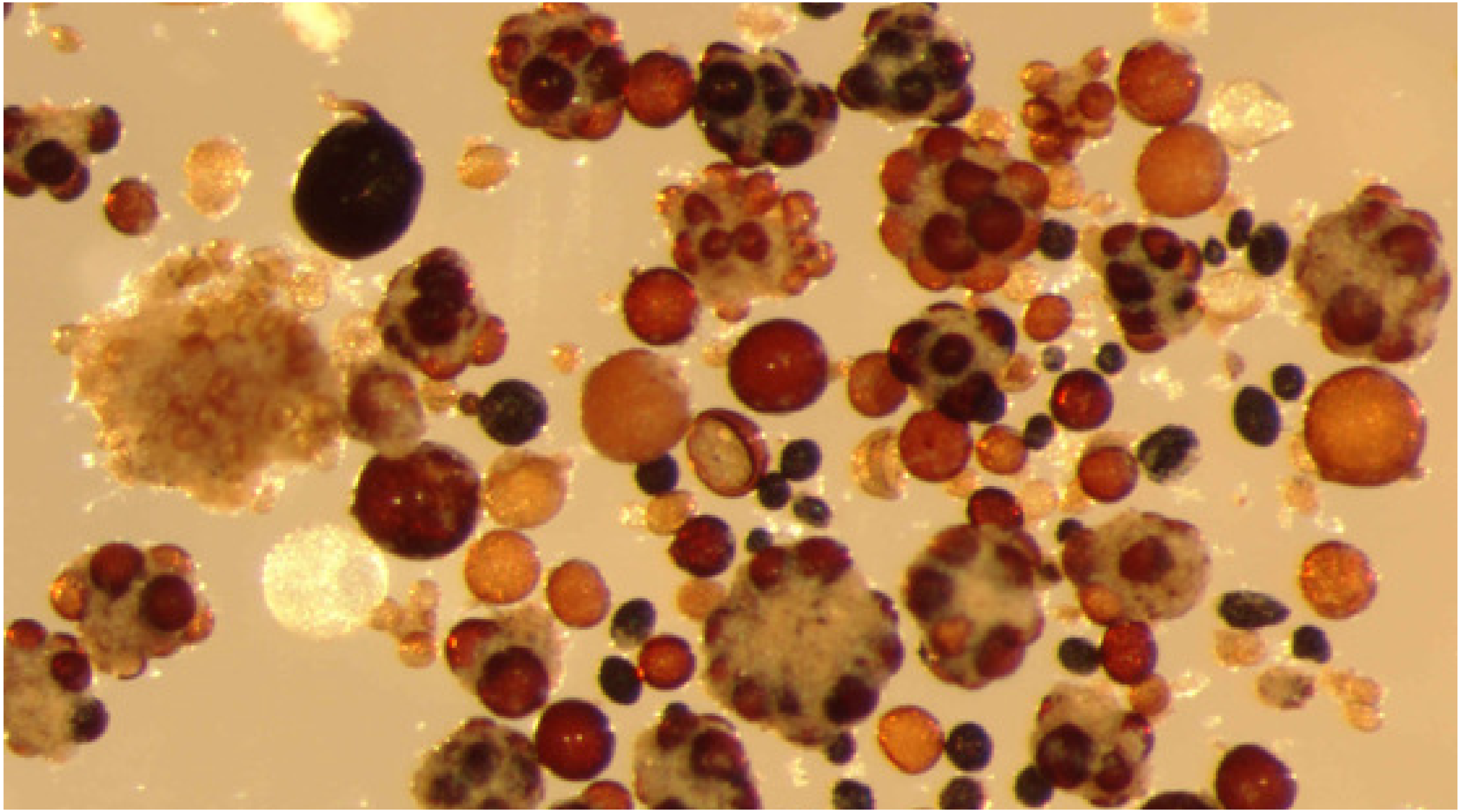


De la Providencia et al. 2005

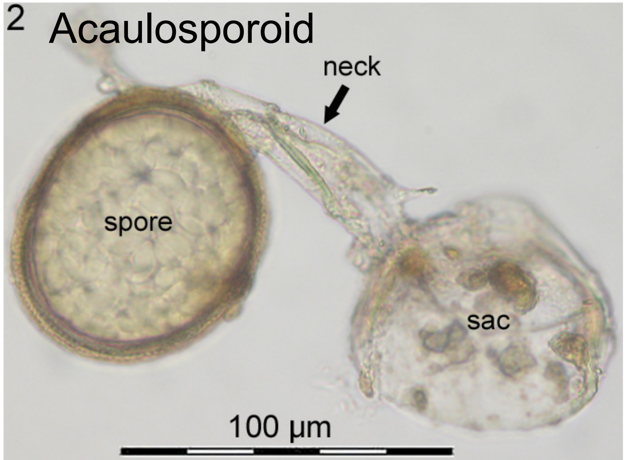
Gigasporales

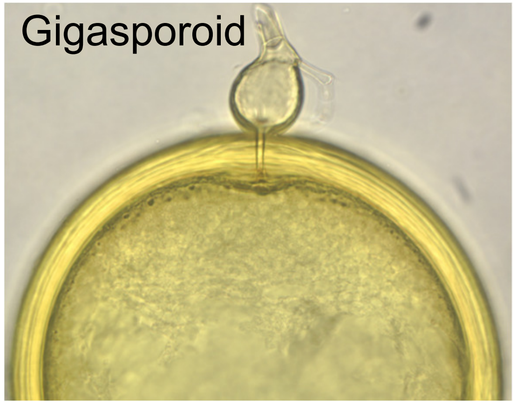


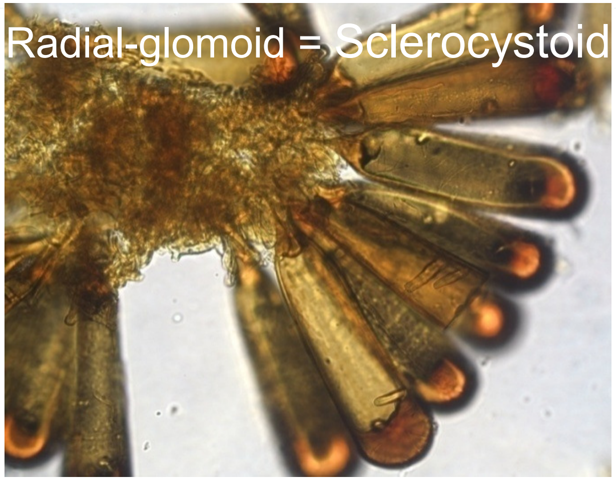
AMF spore population in a natural grassland in Europe

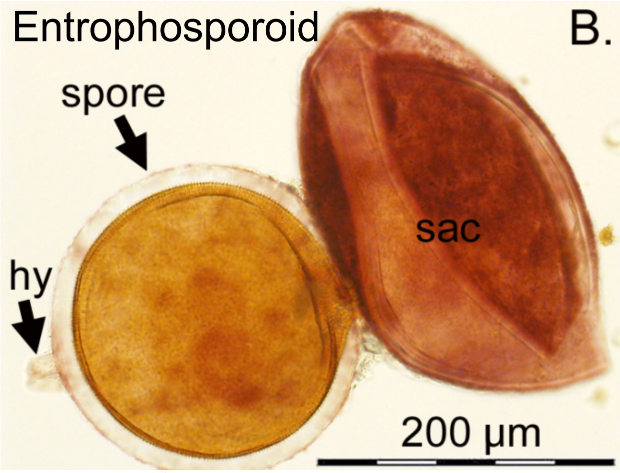


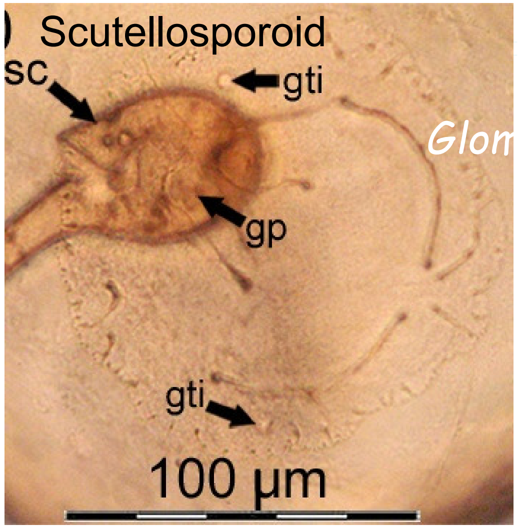
1999: 2x3 Spore formation types = 3 AMF families, 6 genera; ca. 150 species





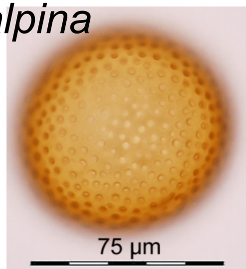




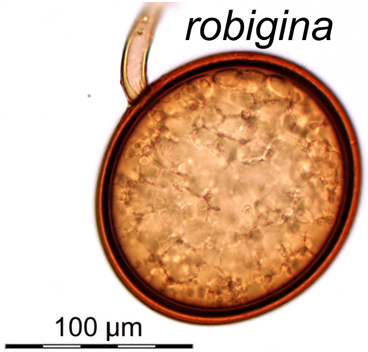


2019: 16 AMF families, 49 genera, ca. 320 species

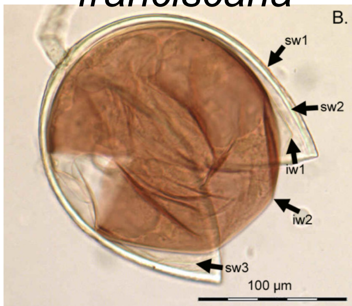
Acaulospora alpina



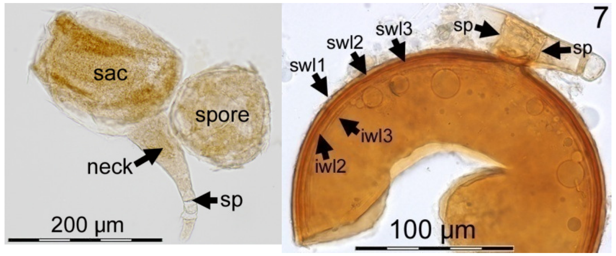
Pacispora robigina



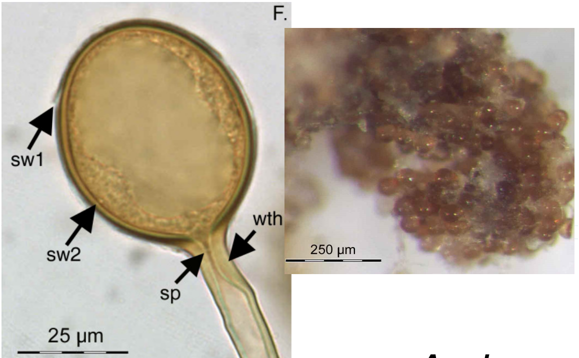
Pacispora franciscana



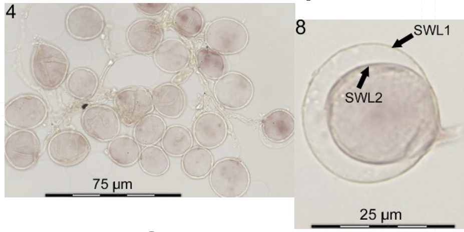
Otospora bareae



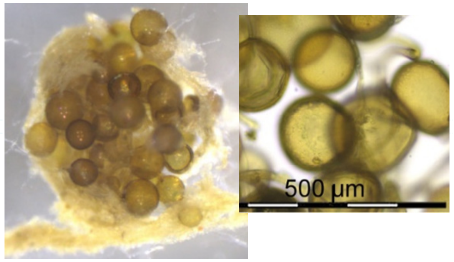
Dominikia aurea



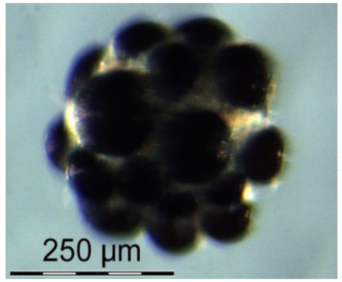
Microkamienskia peruviana



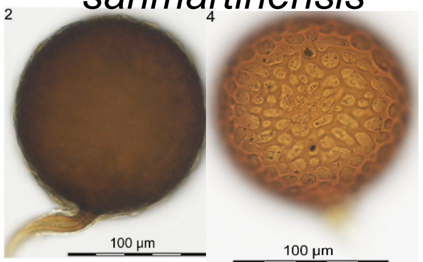
Rhizoglomus venetianum



Glomus badium

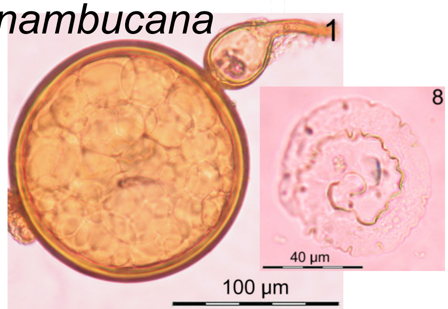


Funneliglomus sanmartinensis

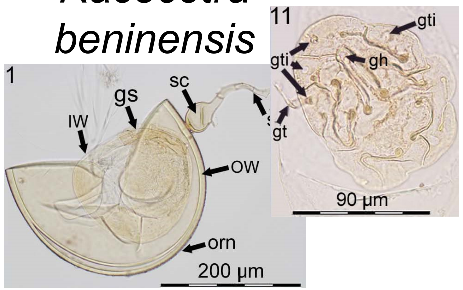


Archaeospora europaea

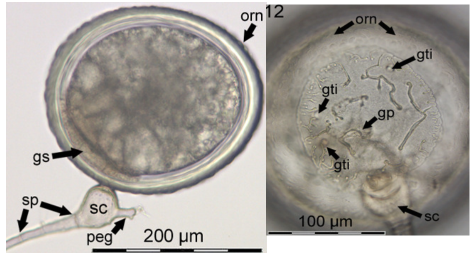
Orbispora pernambucana



Racocetra beninensis

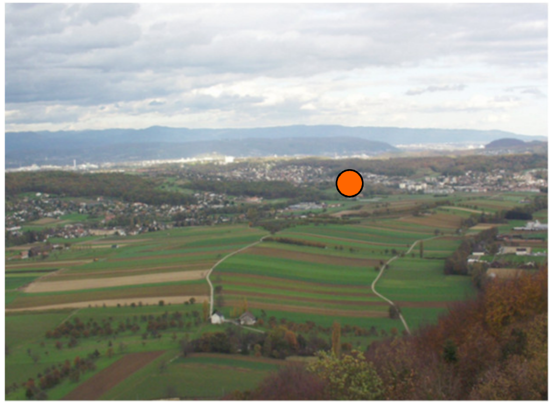


Cetraspora helvetica



Baltruschat et al. 2019

1. DOK Long-term field experiment in Therwil BL
Organic versus **conventional** farming since 1976/78



Geology: periglacial Loess
Soil type: Haplic Luvisol

Site: DOC field trial, Therwil (BL)

Land use intensity

←

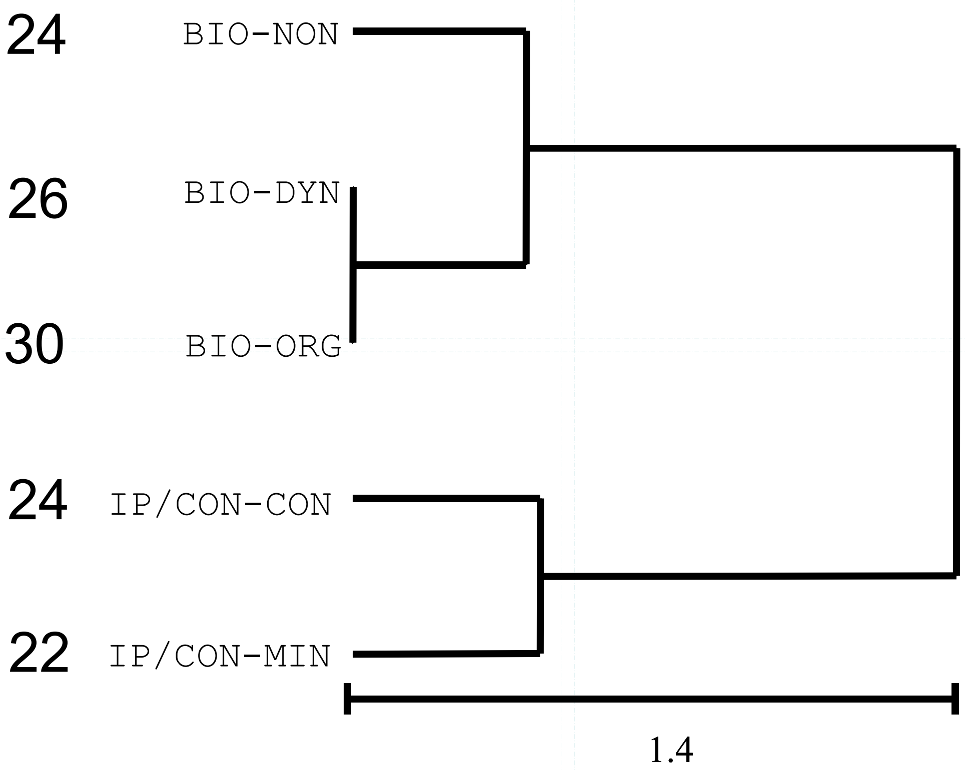
Conventional | **Integrated Production** | **Organic Farming**

Manure-Conventional | **Mineral-Conventional** | **BIO-Dynamic** | **BIO-Organic**

Hierachical cluster analysis on AMF spore populations in conventional and organic farming systems

Σ: 32 species

AMF species richness



Oehl et al. 2004

Agroscope

Impact of chemical soil parameters on spore density of different AMF species

AMF orders / *AMF species*	r (linear regression)				
Glomerales/Paraglomerales	**pH (H_2O)**	**Organic carbon**	**Available P (E_1)**	**Available K**	**Weed species**
Oehlia diaphana	-0.26	**-0.48***	**0.51***	0.42	0.26
Funneliformis caledonius	-0.36	-0.21	**0.56***	**0.63***	-0.36
Claroideoglomus etunicatum	0.19	0.09	-0.33	-0.36	0.34
Rhizoglomus fasciculatum	0.06	0.09	-0.16	-0.14	0.19
Fu. mosseae	0.28	0.08	-0.05	-0.10	0.06
Dominikia compressa	0.10	0.26	-0.14	-0.09	0.20
Fu. geosporus	0.00	0.08	-0.09	0.16	-0.40
Paraglomus laccatum, albidum & occultum	0.29	-0.19	-0.27	0.46	-0.25
Septoglomus constrictum	0.37	0.31	0.08	0.03	-0.03
Rh. invermaium	0.19	-0.03	-0.20	-0.3	-0.37
Diversisporales/Gigasporales					
Pacispora dominikii	**0.62***	0.21	**-0.51***	-0.20	**0.61***
Scutellospora calospora	0.10	0.24	**-0.48***	**-0.55***	0.32
Cetraspora pellucida	-0.27	-0.28	**-0.48***	**-0.58***	**0.48***
Acaulospora paulinae & sieverdingii	0.09	-0.14	**-0.62***	**-0.67***	0.40
Ac. thomii	0.13	-0.24	**-0.49***	**-0.55***	0.43
Ac. laevis	0.04	-0.15	**-0.53***	**-0.57***	0.38
Ac. longula	0.23	0.26	**-0.70***	**-0.58***	**0.56***
Ac. scrobiculata	0.21	-0.42	**-0.66***	**- 0.57 ***	0.39

Oehl et al. 2011

2. 'Oberacker' Long-term field experiment in Rütti BE Tillage versus No-tillage, ÖLN/PEP conventional

- Since 1994

- Soil type: Sandy-loamy Luvisol/Cambisol, sandig-lehmige Parabraun-/Braunerde
- pH 5.7-6.2 in topsoil, pH 6.3-6.5 in subsoil

- 6y crop rotation:
- Sugar beet, winter wheat, winter protein peas, corn, broad bean, winter barley

- In collaboration with Wolfgang Sturny, Claudia Maurer, Andreas Chervet, Murielle Rüdy, Urs Zihlmann

Maurer et al. 2014

AM fungal species richness in 'Oberacker' long-term field experiment

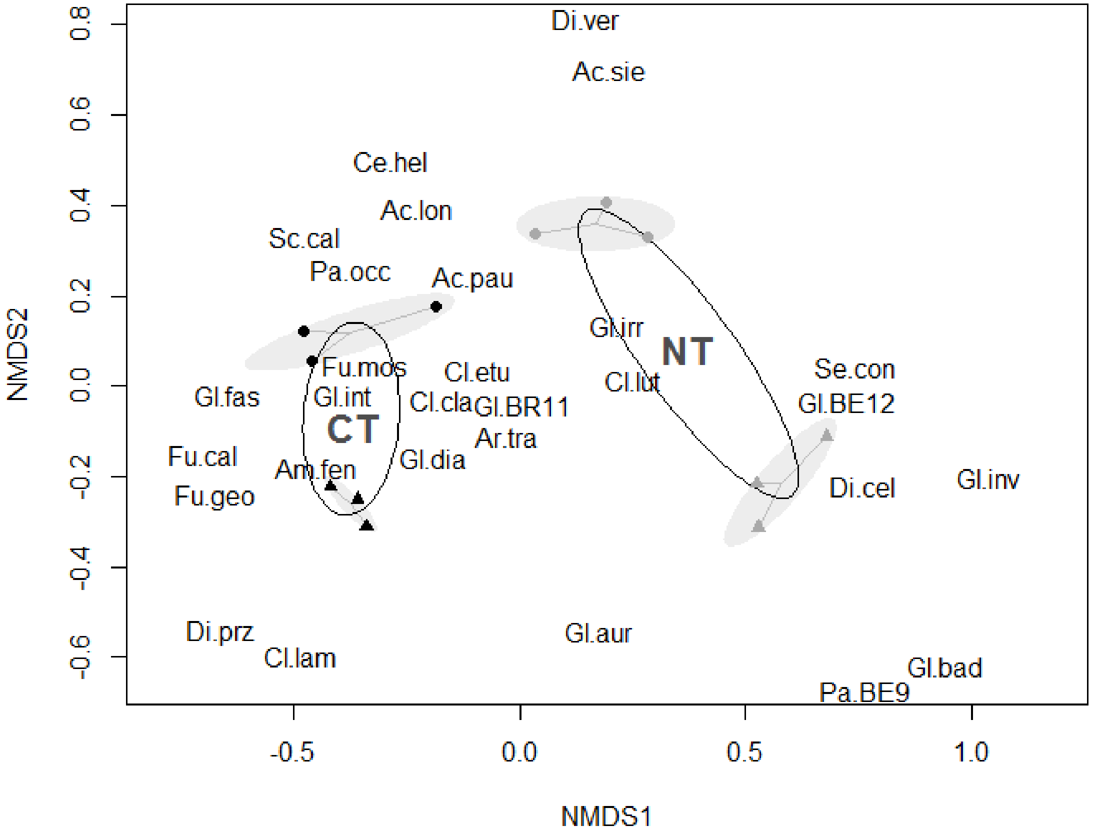
	Species richness no-till	Stdev	Species richness tillage	Stdev
Winter protein peas	21		17	
Winter wheat	17		15	
Interim crops after wheat	17		14	
Winter barley	15		11	
Interim crops after barley	21		12	
Broad bean	20		10	
Mean species richness	18.5	2.5	13.2	2.6
Total species richness	33		21	

Maurer et al. 2014

After 20 months culturing in the greenhouse on grass/clover from winter barley field	23		24	

Köhl et al. 2014

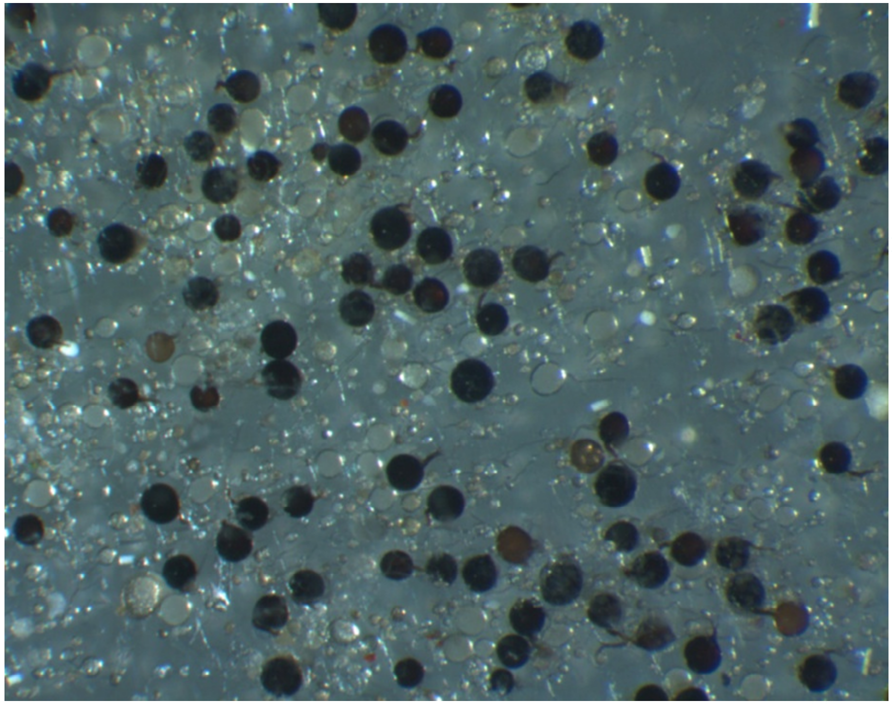
Multidimensional scaling of AM fungal communities from Oberacker, in microcosms after 20 months



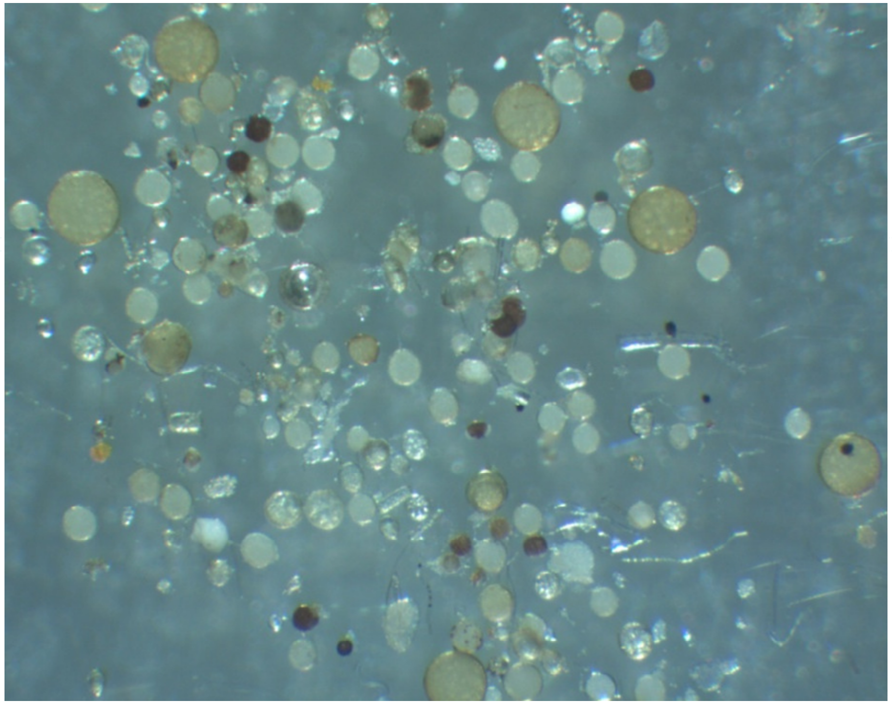
Köhl et al. 2014

AM fungal spore communities from ‚Oberacker' experiment

Conservation tillage



Tillage

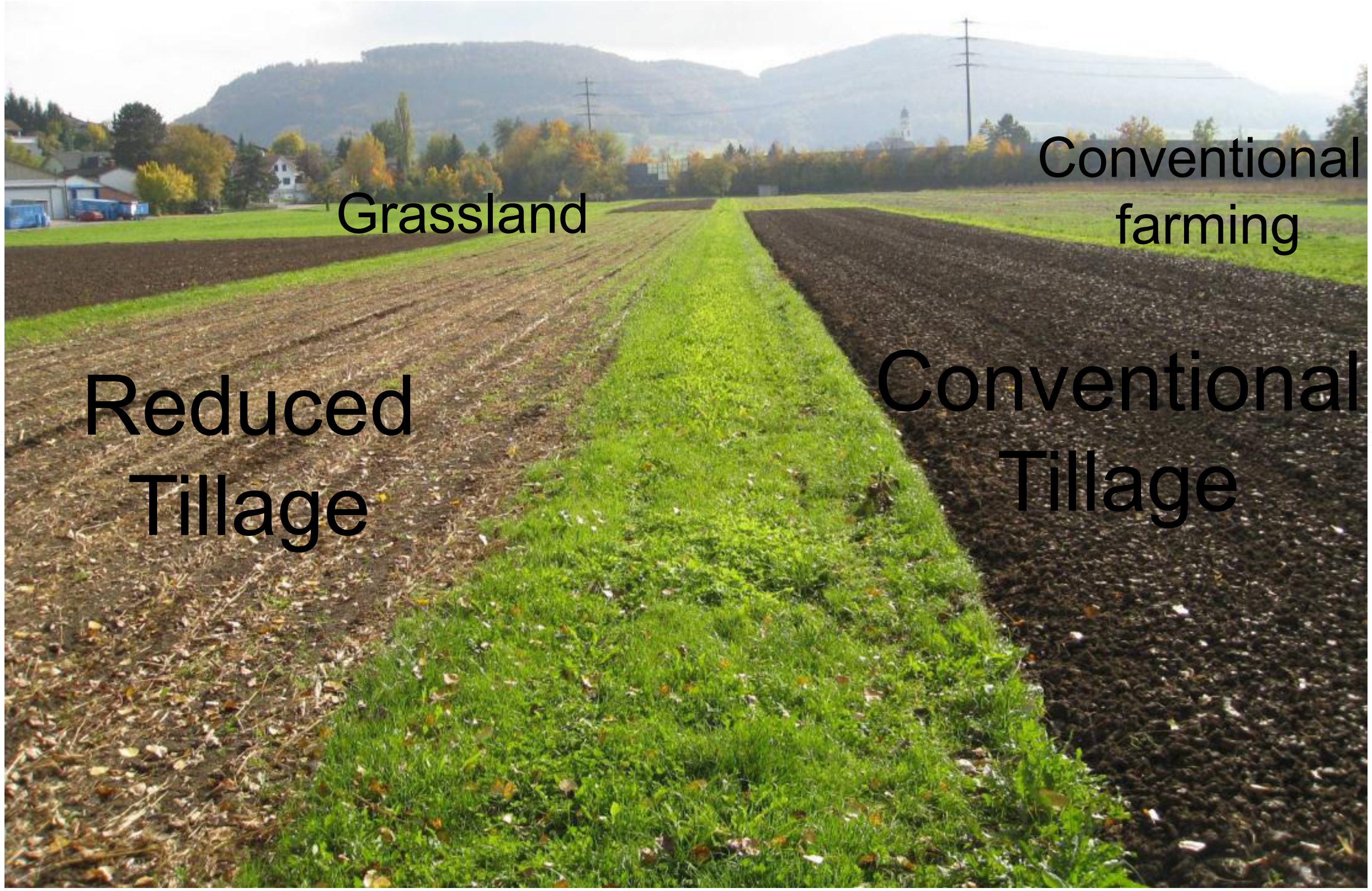


3. Pinot Gris - On farm 'experiment' in Hainfeld DE Tillage versus No-tillage after 38 years, conventional

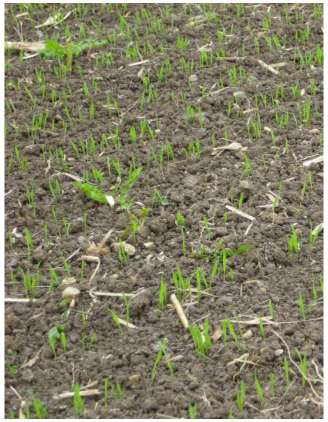
No-till		Tillage
27.2 (1.5)	Mean species richness	17.8 (1.5)
34	Total species richness	24

Oehl & Koch 2018

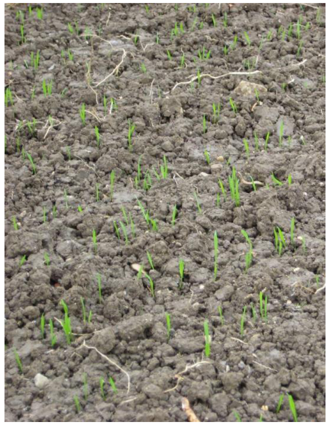
4. FiBL long-term field experiment in Frick AG Tillage versus Reduced-tillage, Bio-systems



4. FiBL soil tillage experiment



Reduced Tillage RT



Convent Tillage CT

- Since 2002

- In our study, conventional IP systems in the neighbourhood of the experiment were included, and a adjacent grassland from FiBL

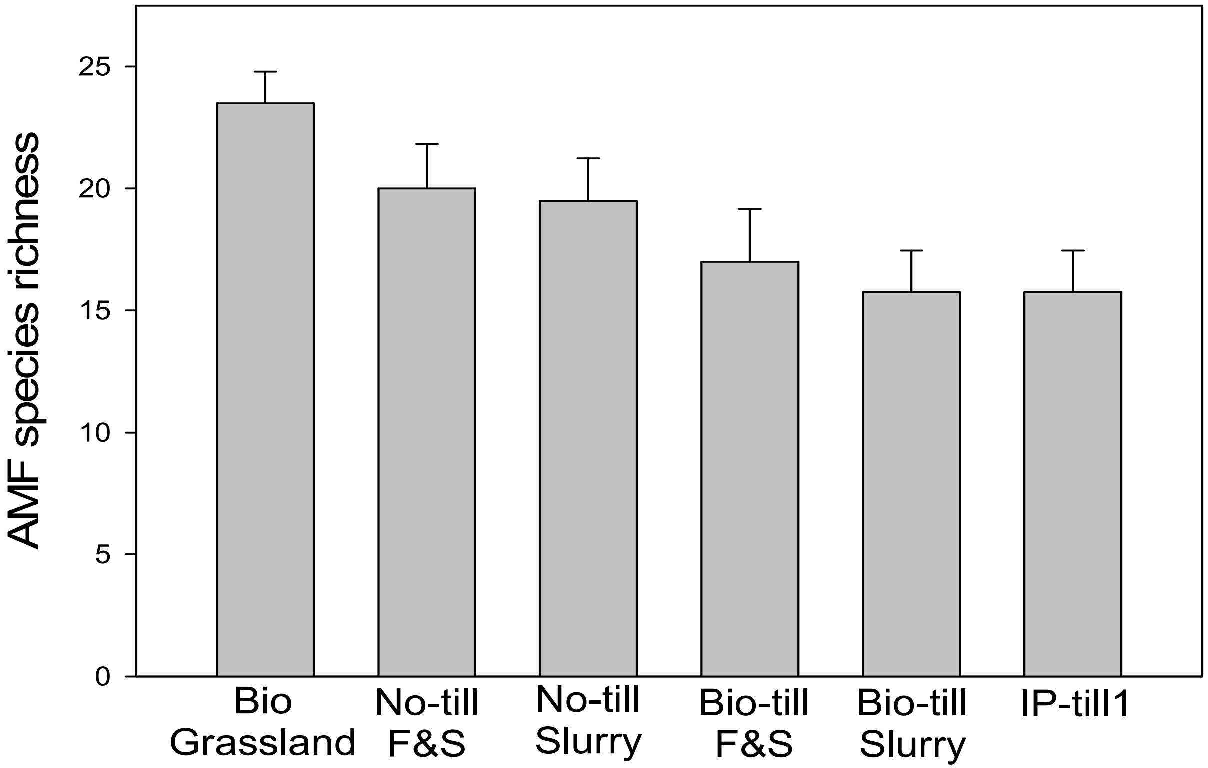
- Soil type: clayey Cambisol, tonige Braunerde;
pH 7.5-7.7 in topsoil, pH 7.8-8.2 in subsoil

- 6y crop rotation in FiBL experiment:
> maize, winterwheat, sunflower, spelt, 2y grass-clover

- Part of PhD thesis of Verena Säle,
collaboration with Alfred Berner & Paul Mäder

AMF species richness in the FiBL tillage experiment

AMF species richness: 38 33 33 33 28 28 Σ: 53 species



Säle et al. 2015

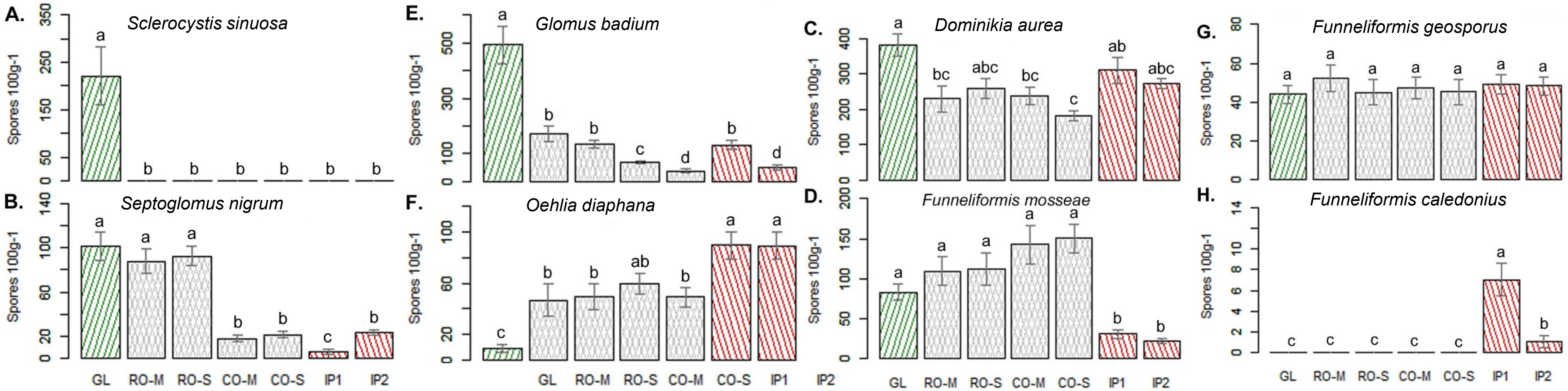
Agroscope

AMF species at study sites in Frick

60-80% of AMF species and > 90% of spores from **Glomerales & Paraglomerales:**
> typical for calcareous sites in Europe

3 Classes	5 Orders	8 Families	17 Genera	53 Species
Glomeromycetes	Glomerales	Glomeraceae	*Glomus & Rhizoglomus & Oehlia*	12
			Funneliformis & Septoglomus	11
			Dominikia	2
			Sclerocystis	3
		Entrophosporaceae	*Claroideoglomus*	3
			Entrophospora	1
	Diversisporales	Diversisporaceae	*Diversispora*	2
			Pacispora	1
		Acaulosporaceae	*Acaulospora*	4
	Gigasporales	Scutellosporaceae	*Scutellospora*	1
Archaeosporomycetes	Archaeosporales	Ambisporaceae	*Ambispora*	2
		Archaeosporaeae	*Archaeospora*	4
			Palaeospora	1
Paraglomeromycetes	Paraglomerales	Paraglomeraceae	*Paraglomus*	5

Selected AMF species in the FiBL tillage experiment - with or without indicator potential



AMF species richness in different soil types, climates & land use intensities

Soil type	Natural ecosystem type	Natural systems	Organic farming/ Low input	Reduced tillage systems	High-input systems
Calcaric Leptosol Oehl et al. 2010	Grasslands	27-33	20-25		21-23
Calcaric Regosol Oehl et al. 2003	Grasslands	24-31			22-24/13
Calcaric Chernosem Baltruschat et al.			26-33	23-27	16-19
Haplic Luvisol Wetzel et al. 2014 Oehl et al. 2003, 2004, 2005, 2009	Grasslands	26-32	25-31	25-33*	22-24 (IP Suisse) 16-19 (Conv.)
Humic Cambisol Oehl et al. 2010	Grasslands	32-39			21-25
Vertic Cambisol Säle et al. 2015	Grasslands	38	33-33	28-32	
Cambisol/Luvisols Maurer et al. 2018, *	Grasslands	33-35	26-30	25-27	20
Ferralsol (semi-humid to semi-arid) Tschabi et al. 2008	Sudan and Guyana savanna (forests)	28-38	15-19 (Yam fields)		5-10 (Cotton fields)
Ferralsol (semi-humid) Pontes et al. 2017a	Cerrado savanna forest	26-33		24-26	15-21 (-28)
Ferralsol (semi-arid) Pontes et al. 2017b	Caatinga dry savanna (forest)	44	29-36		
Ferralsol (semi-arid) Marinho et al. 2019	Caatinga dry savanna (forest)	51-56	25-42		

Summary and Conclusions

- **Land use intensity, soil type and climate strongly affect** AMF communities
- **Low input systems** generally **have high AMF species richness and diversity**, comparable with those of natural systems
- **AMF indicator species can be named** for different land use intensities, soils and climates
- In Central Europe, ***Funneliformis caledonius*** and ***Oehlia diaphana*** are representative AMF species for **intensively managed agricultural systems**
- Several AMF species are indicators for **low-input** agricultural systems, such as ***Cetraspora helvetica*** and ***Gigaspora margarita***
- Others, such as ***Glomus badium*** and ***Septoglomus nigrum***, are indicators for no- or reduced tillage systems
- It is **still difficult to predict the beneficial potential of single AMF species** in respect to their different ecosystem services and their environments
- A **higher diversity of AMF fungi** in soils usually is accompanied by a higher general soil biodiversity
- Both should lead to **more active and biologically more buffered soils**, and thus to a **higher biological soil fertility and stability**, and to enhanced **plant growth and health**

Agroscope

Danke für Ihre Aufmerksamkeit
Thank you for your attention!

Agroscope gutes Essen, gesunde Umwelt
Agroscope – Research for Agriculture and Nature