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Den agronomiske betydning af forholdet mellem svampe og bakterier i markjorden

-ifølge den videnskabelige litteratur

STØTTET AF
Promilleafgiftsfonden for landbrug

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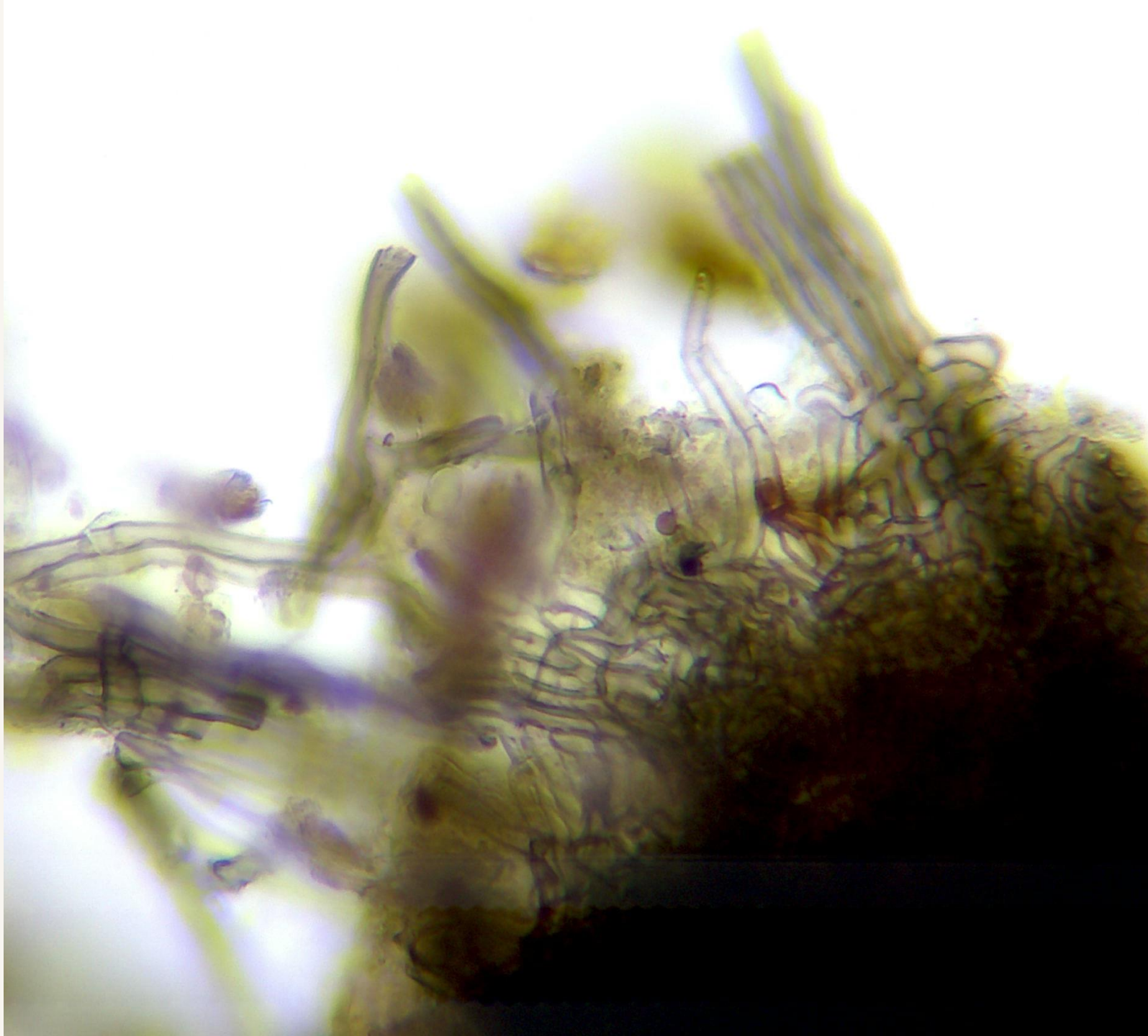
Food & Bio Cluster Denmark,
Netværk for regenerativt landbrug, 10/12 2024

Agenda

- Svampe:bakterie-forhold
- Målemetoder
- Metodernes resultater
- Jordbundens påvirkning
- Betydningen af management
- Er FBR vigtigt i sig selv?



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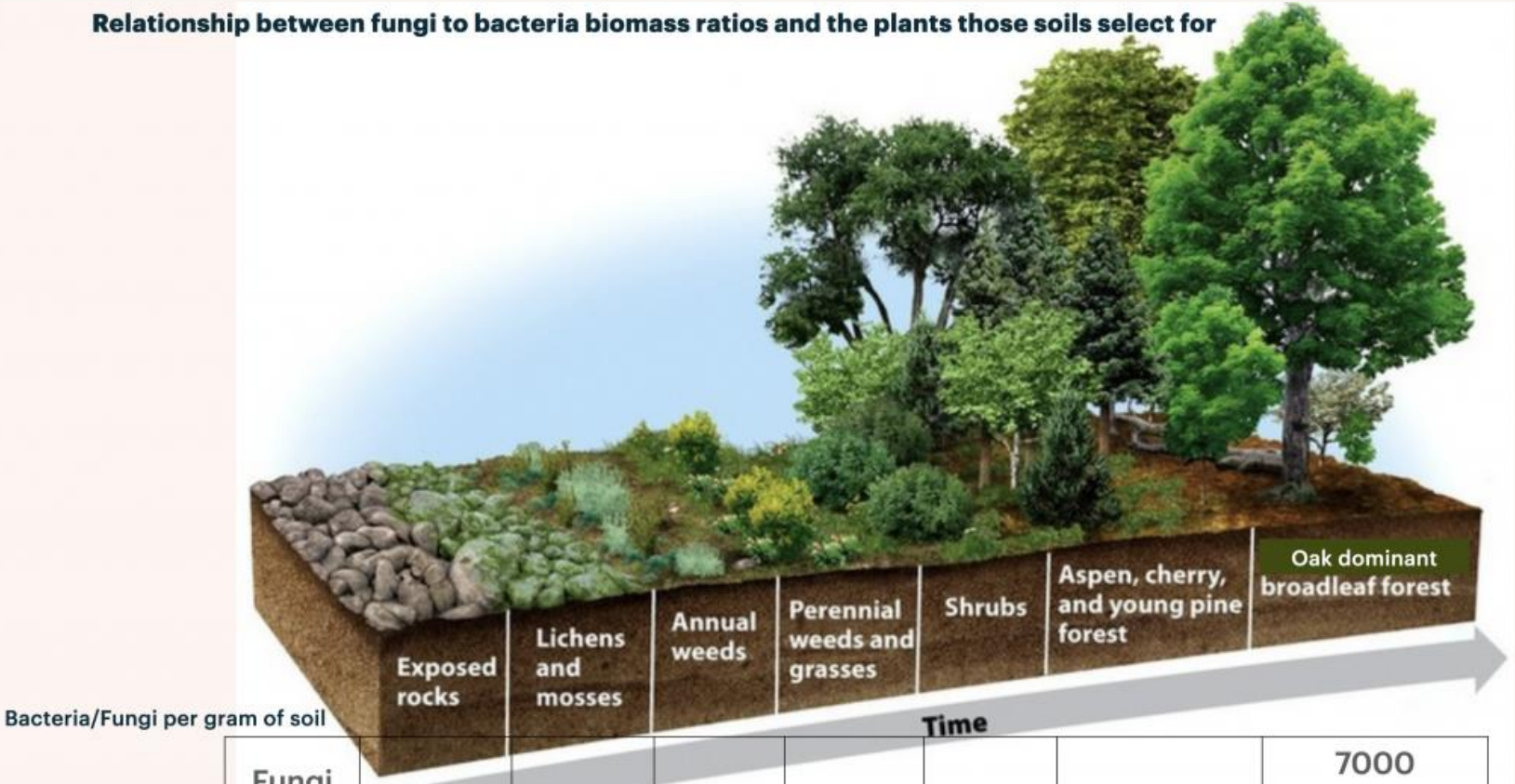
Svampe:bakterie-forhold

Fungal to bacterial ratio (FBR)

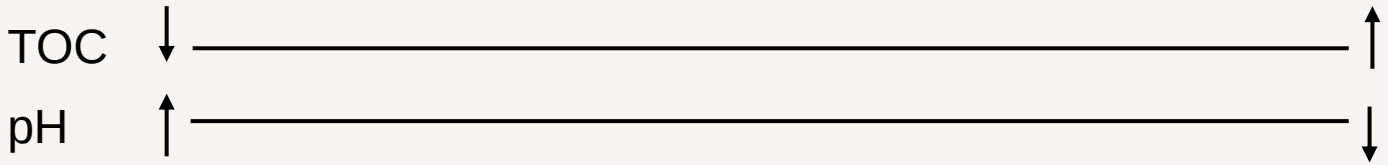
Figurkilde: SoilKind, https://soilkind.co.uk/

Hvorfor FBR?

- Ideen om naturlig succession
- Stigende produktivitet?
- Stigende næringsstofudnyttelses-effektivitet (NUE)?
- Faldende respiration?
- Stigende kulstof?



Bacteria/Fungi per gram of soil							
Fungi biomass	0	1	5	40	100	1000	7000 micrograms of fungi
Bacteria biomass	10	20	50	60	100	500	700 micrograms of bacteria



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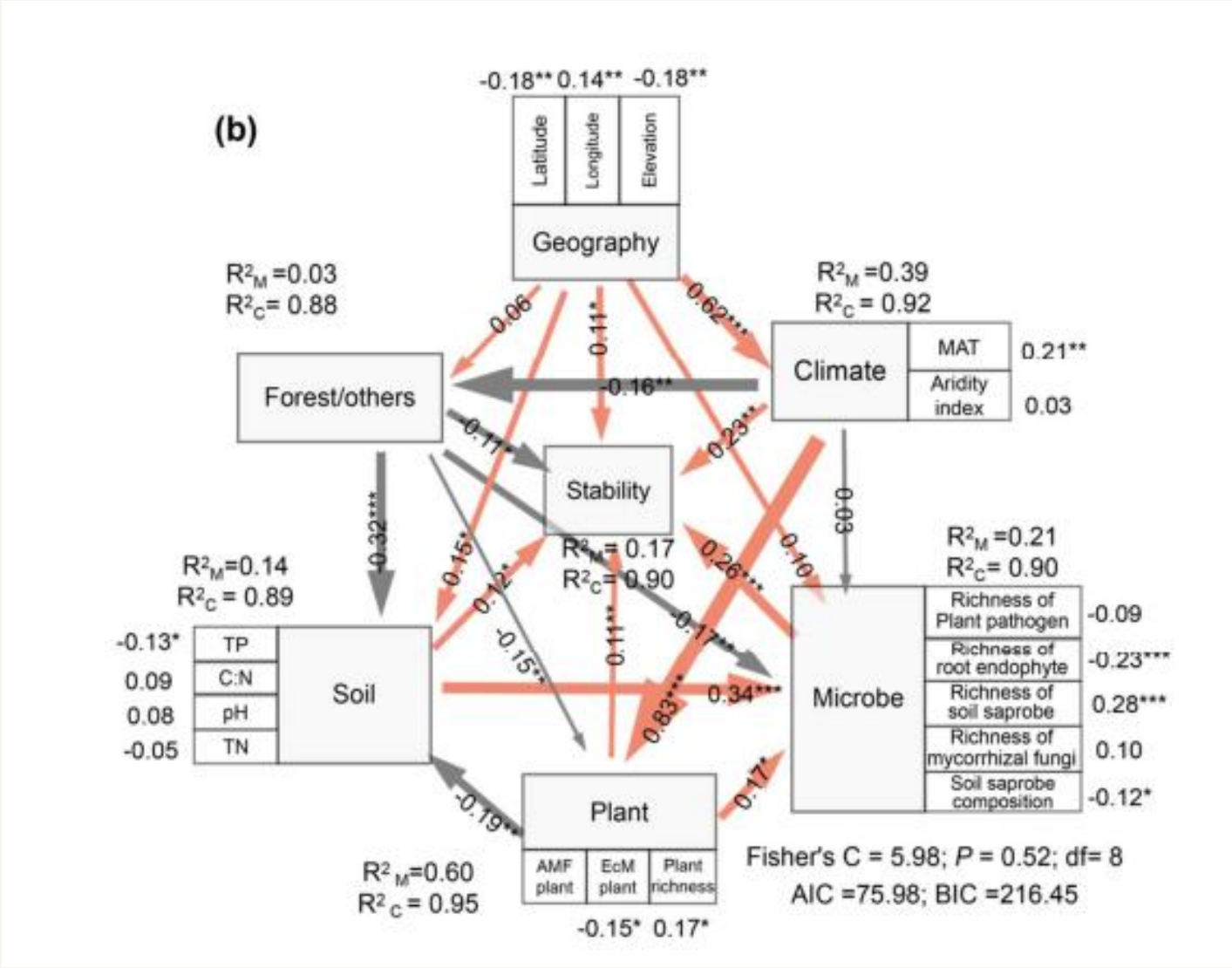
Diversitet af nedbrydere vigtigst for økosystemstabilitet

- 351 økosystemer
- Mikrobielle parametre havde størst indflydelse på stabilitet
- Jord og planter havde størst indflydelse på mikrober
- Nedbrydere > endofytter > mykorrhiza > patogener



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Kilde: Liu, S., García-Palacios, P., Tedersoo, L. *et al.* Phylotype diversity within soil fungal functional groups drives ecosystem stability. *Nat Ecol Evol* **6**, 900–909 (2022). https://doi.org/10.1038/s41559-022-01756-5

Forskellige kategorier af FBR

Table 1
The categories of fungal to bacterial ratios (F: B) in the current studies.

Classify	Characterised	Methods	References
F: B biomass ratio	The ratio of fugal colonies to bacterial colonies	Plate count method	Olsen and Bakken (1987)
F: B biomass ratio	The length and diameter of the fungal hyphae were measured by the membrane filter method, using optical microscopy and phenol aniline blue as a stain.	Direct microscopy method	Shield et al., 1973; Hanssen et al. (1974); Hobbie et al. (1977); Nishio (1983)
F: B biomass ratio	Bacteria and fungi have different fatty acid compositions in their phospholipids. PLFA 18:2ω6, 9 as a measure of fungal biomass and the sum of 13 bacteria-specific PLFAs as a measure of bacterial biomass.	Phospholipid fatty acid (PLFAs)	Frostegård and Bååth (1996)
F: B respiratory ratio	Using the streptomycin and cycloheximide antibiotics were applied alone or in combination to the soil to determine the fungal and bacterial respiration	Substrate-induced respiration (SIR)	Anderson and Domsch (1975); Bailey et al. (2002)
F: B gene ratio	It is based on DNA and estimated using quantitative polymerase chain reaction	qPCR (16S RNA/18S RNA)	Fierer et al. (2005)
F: B growth ratio	Fungi growth was assessed using the Ac-in-erg method. Bacteria growth was assessed using the thymidine and leucine incorporation. That can directly estimate of microbial growth rates under natural soil conditions exist.	Acetate into ergosterol incorporation and the thymidine and leucine incorporation	Rousk and Bååth (2007a); 2007b; Bapiri et al. (2010)
F: B feeder ratio	The relative flow of energy and nutrients through the bacterial and fungal channel can be assessed by the fungal to bacterial feeder ratio (The ratios of fungal to bacterial feeding nematodes)	Microscopic examination	Ruess and Ferris (2004)
F: B channel biomass ratio	fungal-energy channel was fungi and fungal-feeding fauna biomass, and bacterial-energy channel was bacteria and bacterial-feeding fauna biomass (The bacterial-feeding fauna included the enchytraeids, flagellates, amoebae, bacterivorous nematodes, omn. + pred. nematodes, nematophagous mites, pred. mites + collembola. The fungal-feeding fauna included enchytraeids, fungivorous nematodes, microbi-detritivores, omn. + pred. nematodes, nematophagous mites, pred.mites + collembola)	Based on the soil food web and the feeding preference of the predators	Holtkamp et al. (2008); de Vries et al., 2012a

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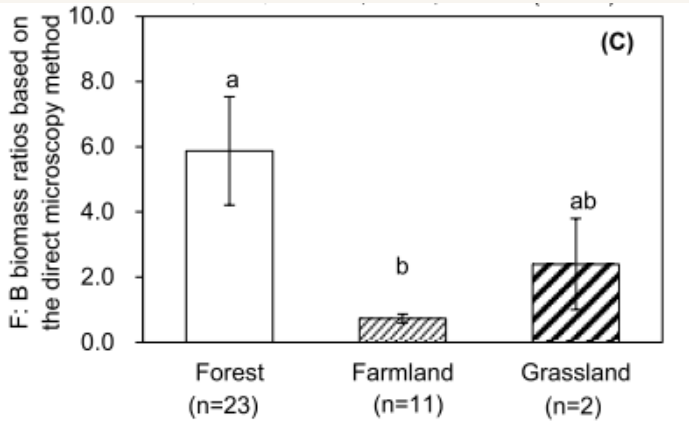
Kilde: Wang et al., 2019, *Fungi to bacteria ratio: Historical misinterpretations and potential implications*, https://doi.org/10.1016/j.actao.2018.10.003

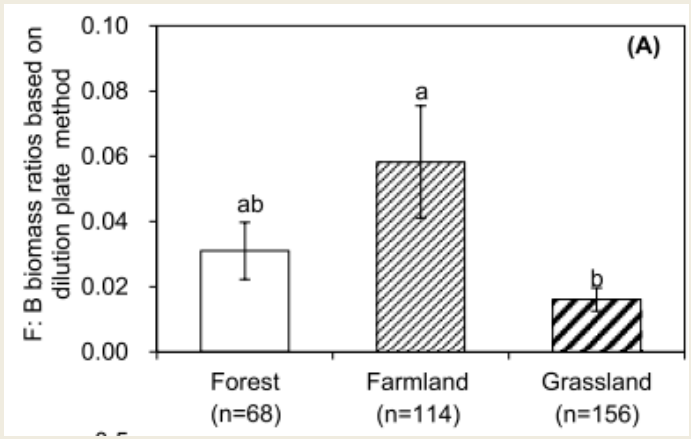
Målemetoder

Forskellige målemetoder giver forskellige resultater



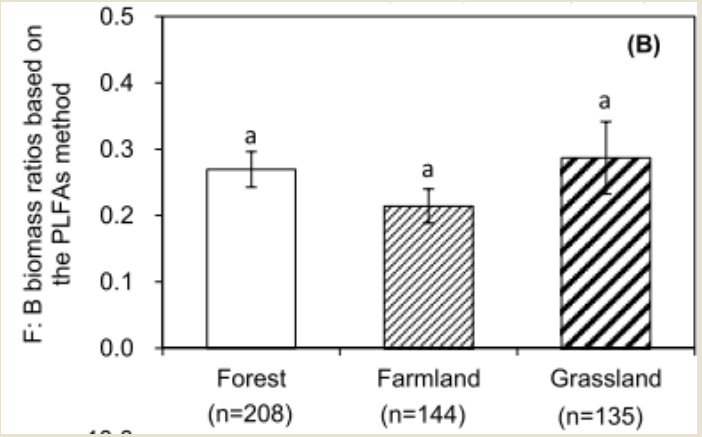
Direkte mikroskopi

- Tendens til overestimering af svampe
- Svampe er større end bakterier
- Omregning fra A til V til TS er usikker



Selektiv inhibition

- Benyttes især til undersøgelse af aktivitet/respiration
- Primær metode til at isolere levende, aktive mikrober
- Anvendte antibiotika ikke 100% selektive



Fedtsyreanalyse

- PLFA'er er letnedbrydelige – godt udtryk for levende mikrober
- Usikkerhed ifm. beregning af (biomasse-) FBR (tykkelse af cellevægge etc.)

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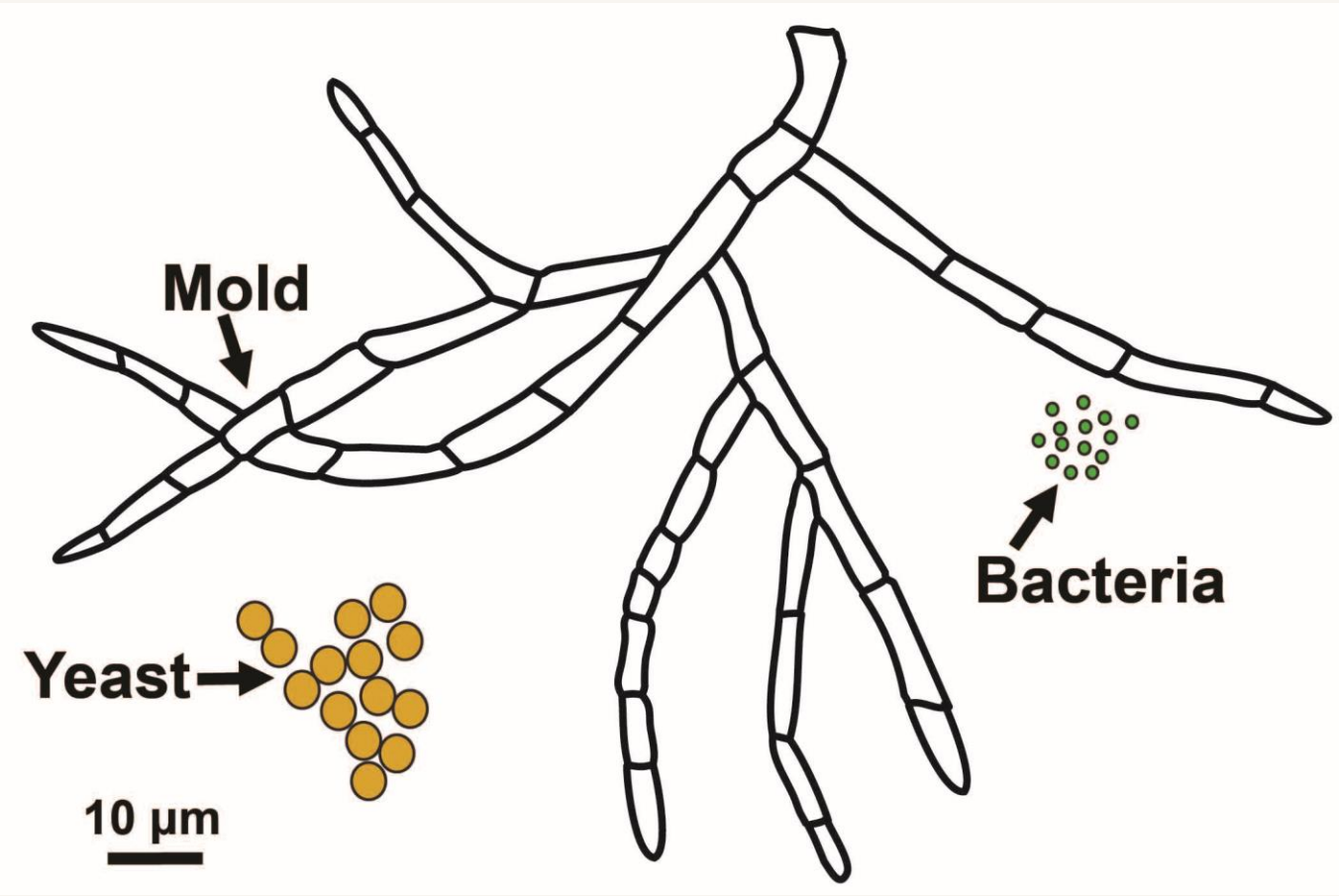

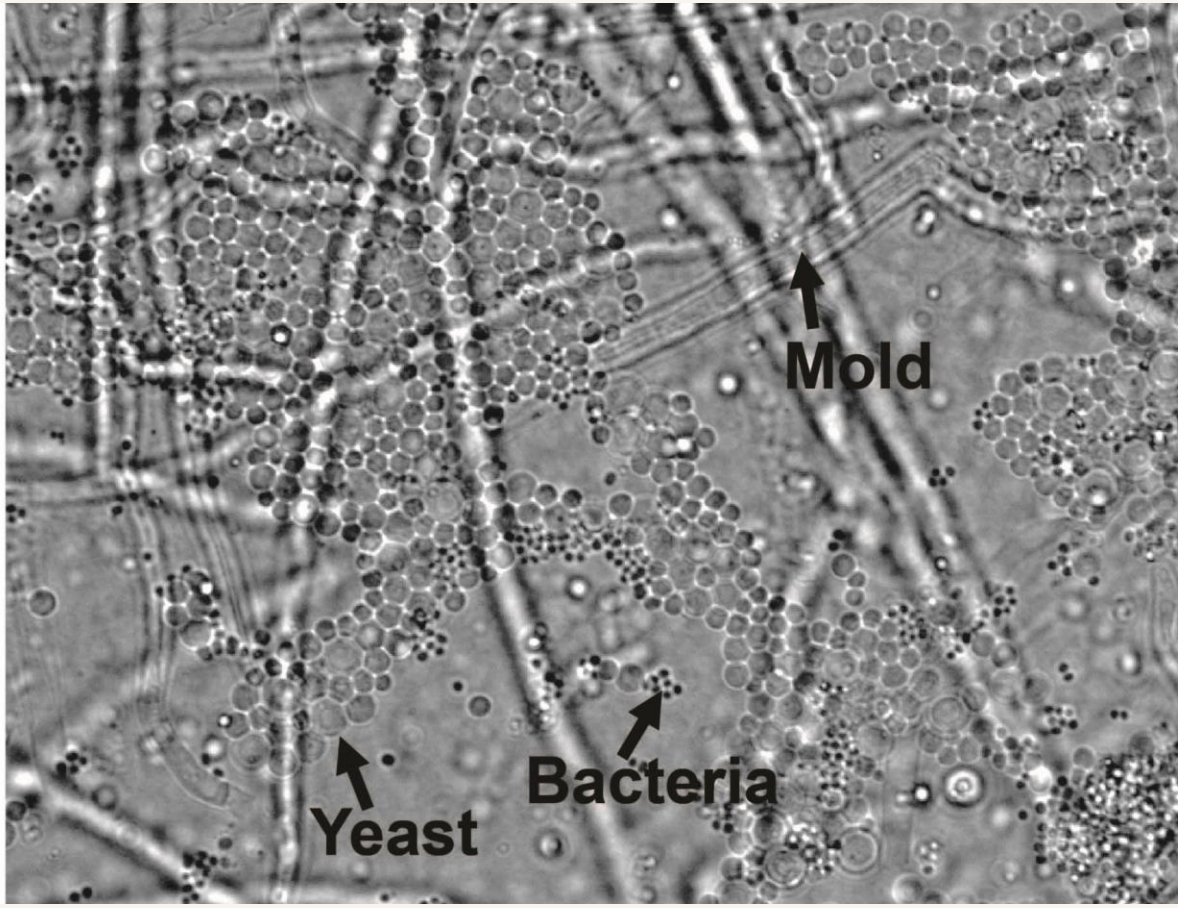

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Kilde: https://microbialfoods.org/wp-content/uploads/2014/07/Mold-yeast-bacteria-01.jpg

Betydningen af management

FBR og mikrobiel biomasse efter 4 år med konventionel, økologisk eller reduceret jordbearbejdning

- Forhistorie: Monokulturel, konventionel majs
- Management meget ulig dansk, fx 278 kg N/ha til øko majs, tre pløjninger i år 1 etc.
- Øko hævede total mikrobiel biomasse mest i rækkeafgrøder – RT mest i lucernegræs (meget lav gødskning i øko)
- **FBR steg (lige meget) i alle behandlinger**
- Hhv. sædskifte, plantedække og evt. vanding form. grunden

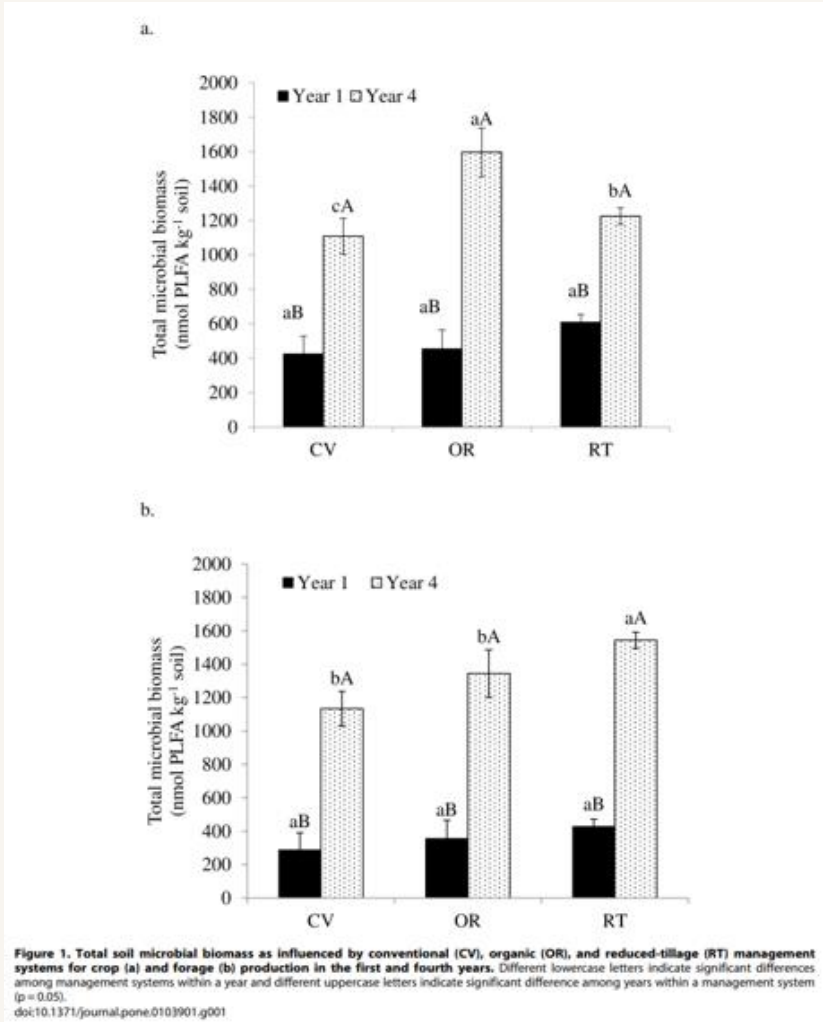

Figure 1. Total soil microbial biomass as influenced by conventional (CV), organic (OR), and reduced-tillage (RT) management systems for crop (a) and forage (b) production in the first and fourth years. Different lowercase letters indicate significant differences among management systems within a year and different uppercase letters indicate significant difference among years within a management system ($p = 0.05$).
doi:10.1371/journal.pone.0103901.g001

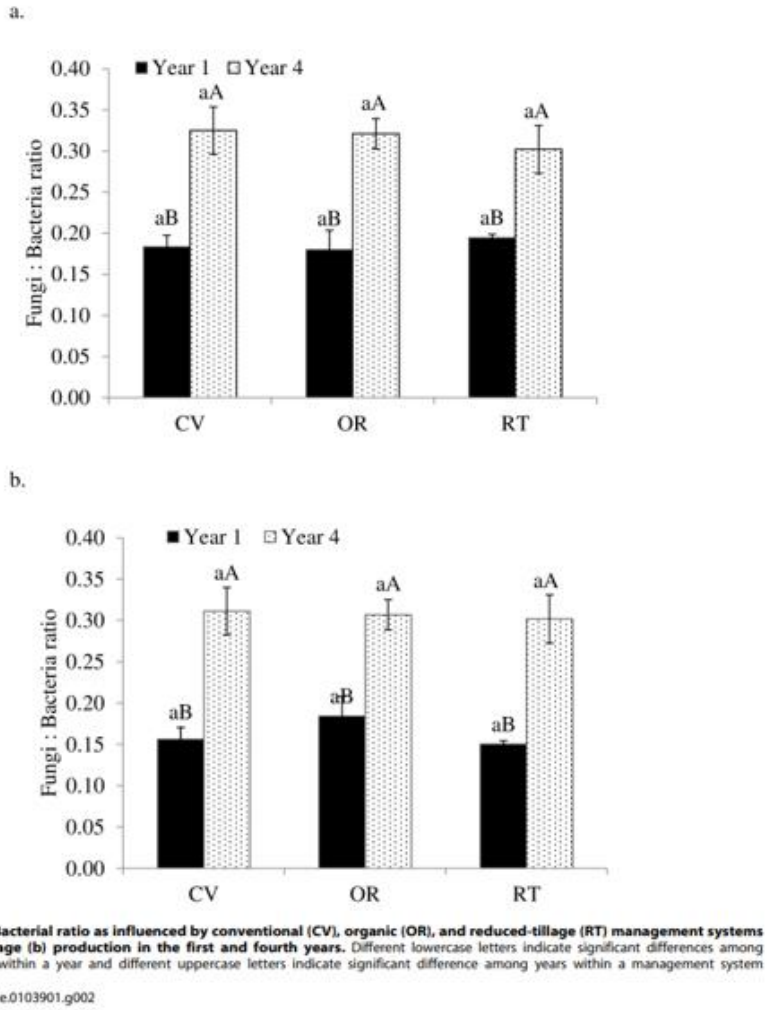

Figure 2. Fungal-to-Bacterial ratio as influenced by conventional (CV), organic (OR), and reduced-tillage (RT) management systems for crop (a) and forage (b) production in the first and fourth years. Different lowercase letters indicate significant differences among management systems within a year and different uppercase letters indicate significant difference among years within a management system ($p = 0.05$).
doi:10.1371/journal.pone.0103901.g002

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Kilde: Ghimire et al., 2014, Soil Microbial Substrate Properties and Microbial Community Responses under Irrigated Organic and Reduced-Tillage Crop and Forage Production Systems. https://doi.org/10.1371/journal.pone.0103901

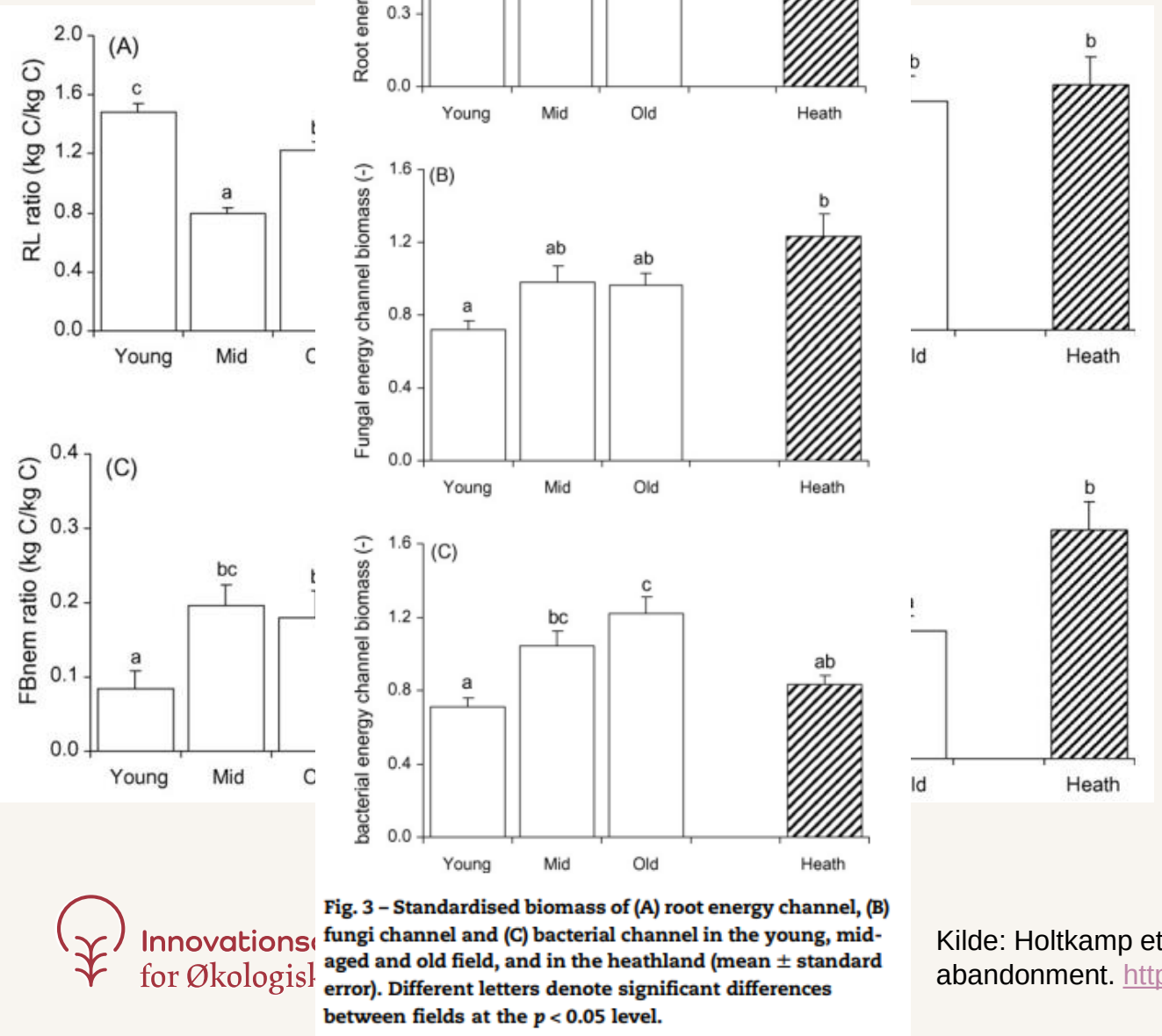

Fig. 3 – Standardised biomass of (A) root energy channel, (B) fungi channel and (C) bacterial channel in the young, mid-aged and old field, and in the heathland (mean ± standard error). Different letters denote significant differences between fields at the $p < 0.05$ level.

Målt succession i FBR

- Tre jorde taget ud af produktion hhv. 2, 9, og 22 år tidligere – og en hede som reference
- FBR bestemt ved direkte mikroskopi
- F:B channel ratio **faldt**, selvom svampebiomasse **steg**
- Bakteriel biomasse steg mere end svampenes biomasse

Kilde: Holtkamp et al., 2008 - Soil food web structure during ecosystem development after land abandonment. https://doi.org/10.1016/j.apsoil.2007.11.002

Betydning af jordbundsforhold

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Korrelationer mellem jordbundsforhold og mikrobielle samfund

Table 4
Land-use effects on edaphic properties and correlations between microbial communities and edaphic properties

	Land-use	Correlation coefficients	
	Main effect	Bacteria	Fungi
pH	2.2	**0.47**	0.15
%Silt + clay	**8.2**	**0.42**	0.00
%Soil moisture	6.9	0.18	0.00
Bulk density, g cm^{-3}	6.7	0.00	0.00
C:N	6.9	0.16	**0.73**
C, kg^{-1}	**8.2**	0.00	0.07
N, g kg^{-1}	**8.1**	0.13	**0.39**
P, mg kg^{-1}	**7.7**	0.33	**0.54**

Significant effects of land-use on soil properties were determined using the Mann–Whitney *U* test for non-parametric data with land-use as the main factor. The Mann–Whitney *U* test statistic is reported. Pearson correlation coefficients relate the calculated UniFrac community distance between each pair of bacterial and fungal communities to the measured soil properties. Significant land-use effects and correlation coefficients are noted as bold text where $P < 0.05$.

- Fire arealanvendelser: Markafgrøder, afgræsning, fyrreplantage, blandet løvskov (Eg/Hickory)
- **pH** betød mest for bakterier, dernæst bonitet og P
- **C:N** betød mest for svampe, dernæst tilgængelighed af P og N
- Massefylde viste **ingen** korrelation. Iltforhold måske af mindre betydning?
- Jordfugt kun (svagt) korreleret til bakterier – ingen sammenhæng med svampe

Kilde: Lauber et al., 2008, *The influence of soil properties on the structure of bacterial and fungal communities across land-use types.* https://doi.org/10.1016/j.soilbio.2008.05.021

pH

- Mark som har fået en kæmpe mængde kalk (150-250 t/ha) i slutningen af 1800-tallet
- Ingen andre input siden
- Kalk udvasket i den ene ende af marken – ikke i den anden
- pH-gradient fra 4-8+
- Ingen forskel i udbytte fra pH 4,5-8

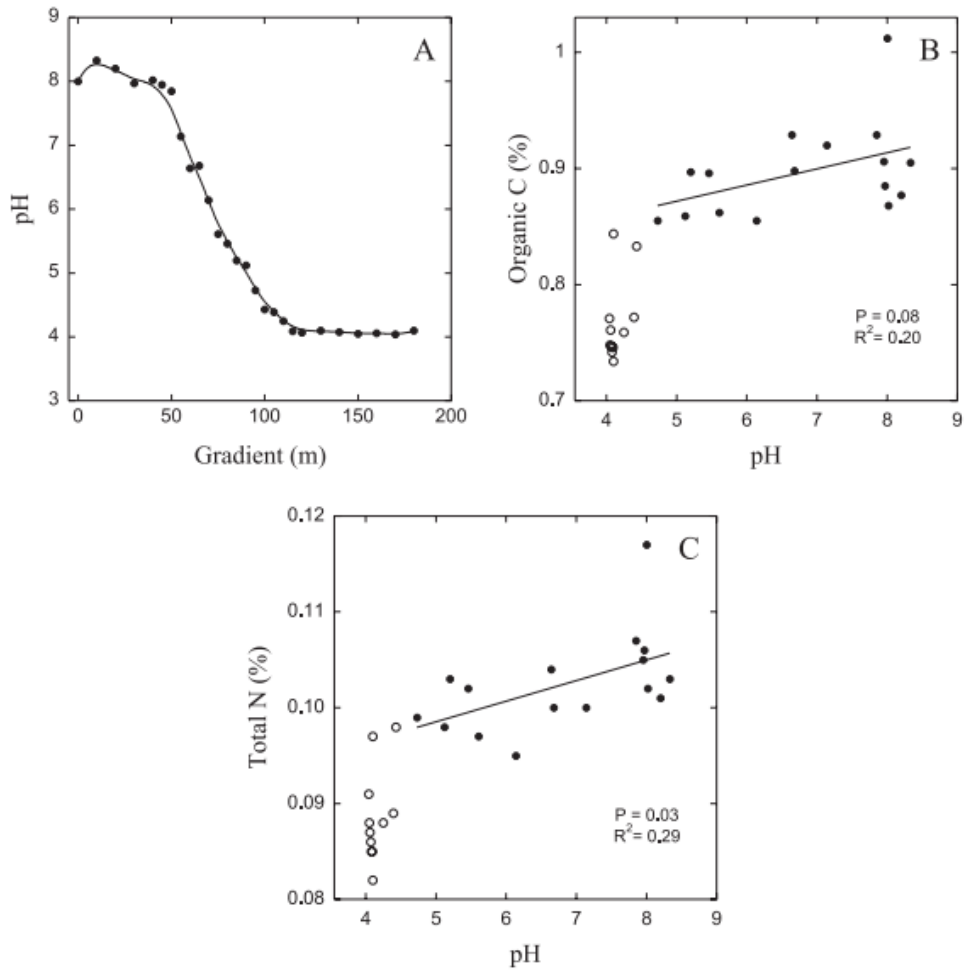

FIG. 1. Soil pH along the Hoosfield acid strip (A) and the effect of pH on organic C (B) and total N (C). Data for pHs less than pH 4.5 (open circles) were not used in the regression analyses (see Discussion).

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Kilde: Rousk et al., 2009, Contrasting Soil pH Effects on Fungal and Bacterial Growth Suggest Functional Redundancy in Carbon Mineralization. https://doi.org/10.1128/AEM.02775-08

pH

- Bakteriel vækst **steg** med stigende pH
- Svampevækst **faldt** med stigende pH

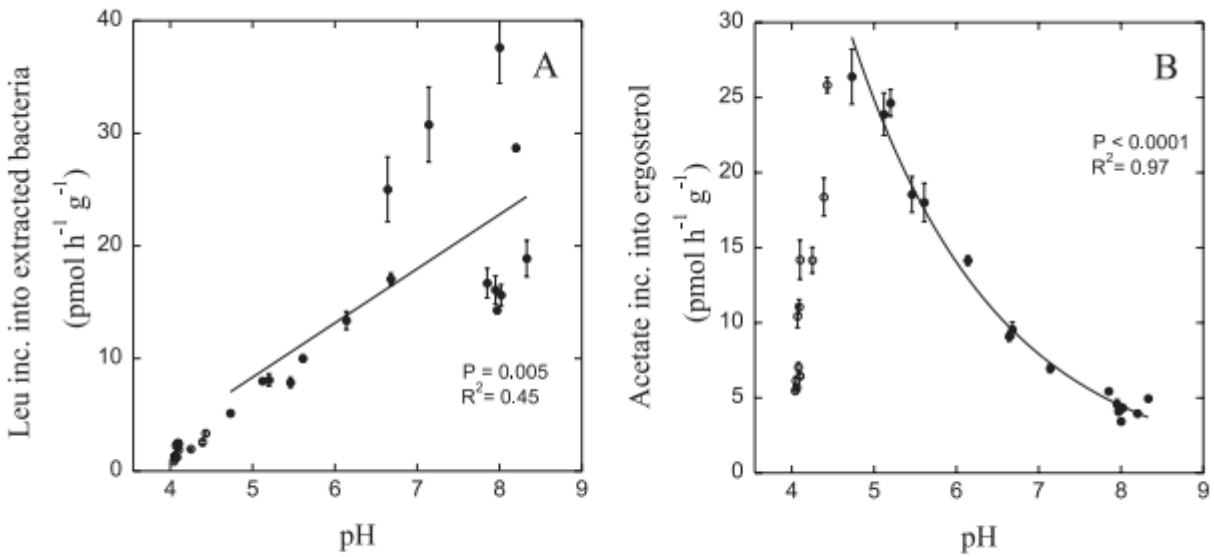

FIG. 2. Effect of pH on bacterial growth as measured by leucine incorporation (A) and on fungal growth as measured by acetate incorporation into ergosterol (B). Data for pHs less than pH 4.5 (open circles) were not used in the regression analyses (see Discussion). The error bars indicate ±1 standard error (n = 3). inc., incorporation.

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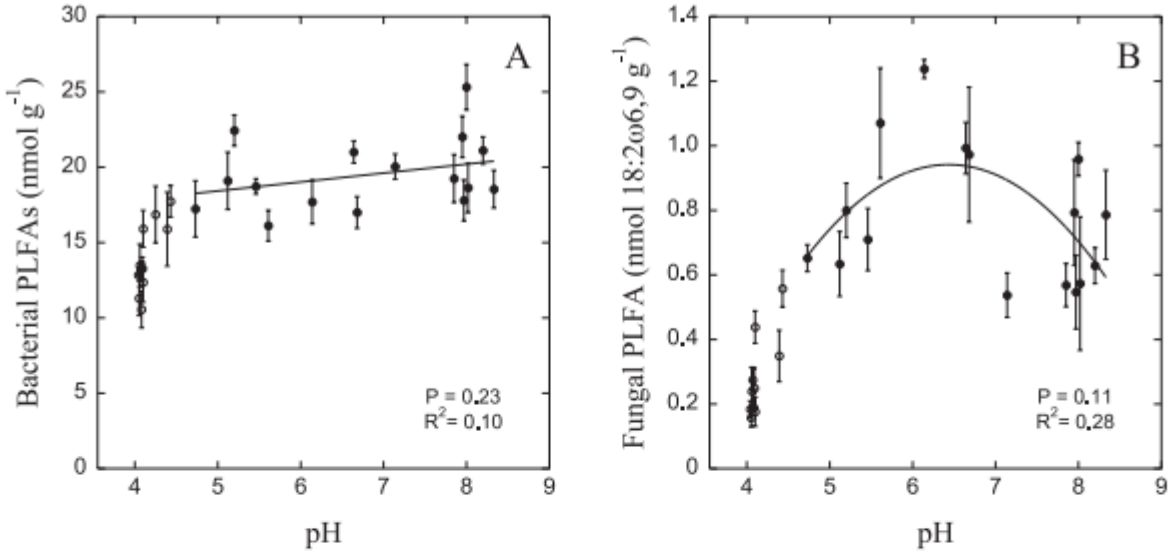
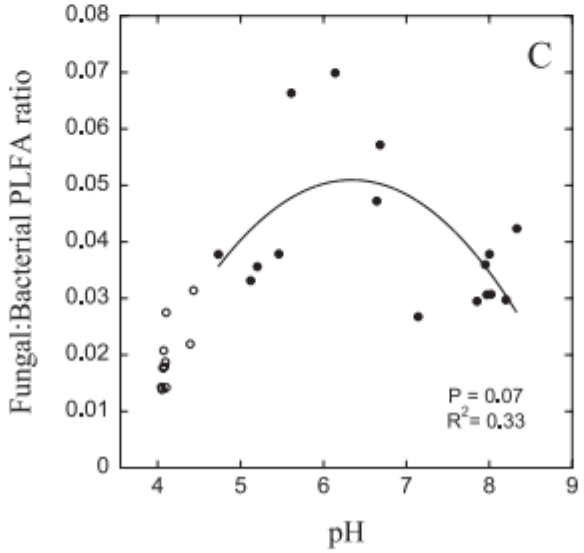
pH

- Forekomst af bakteriel PLFA næsten konstant – svagt stigende med pH
- Forekomst af svampe-PLFA højest mellem pH 5,5 og pH 6,5 (ca.)
- FBR højest omkring pH 6
- God sammenhæng mellem PLFA og biomasse for svampe





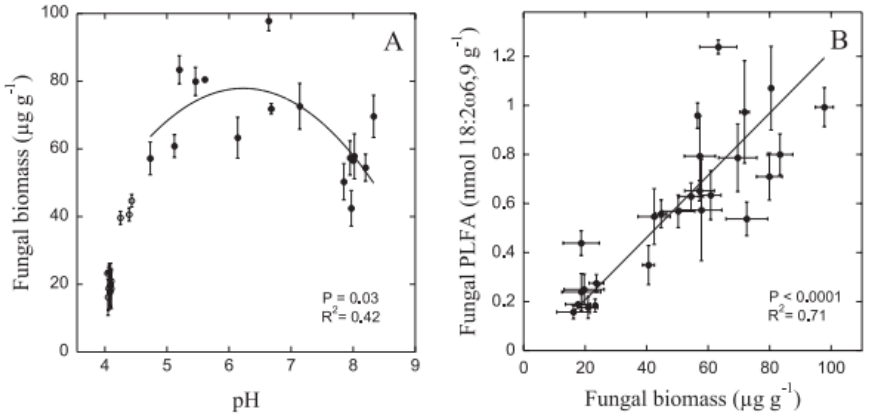


FIG. 5. Effect of pH on the fungal biomass estimated using ergosterol (A) and the relationship between fungal PLFA and ergosterol (B) analyzed using type II major axis linear regression analysis. The error bars indicate ±1 standard error (n = 3).

s (A), fungal PLFA (B), and the fungal PLFA/bacterial PLFA ratio (C). Data for pHs less than pH 4.5 ion analyses (see Discussion). The error bars indicate ±1 standard error (n = 3).

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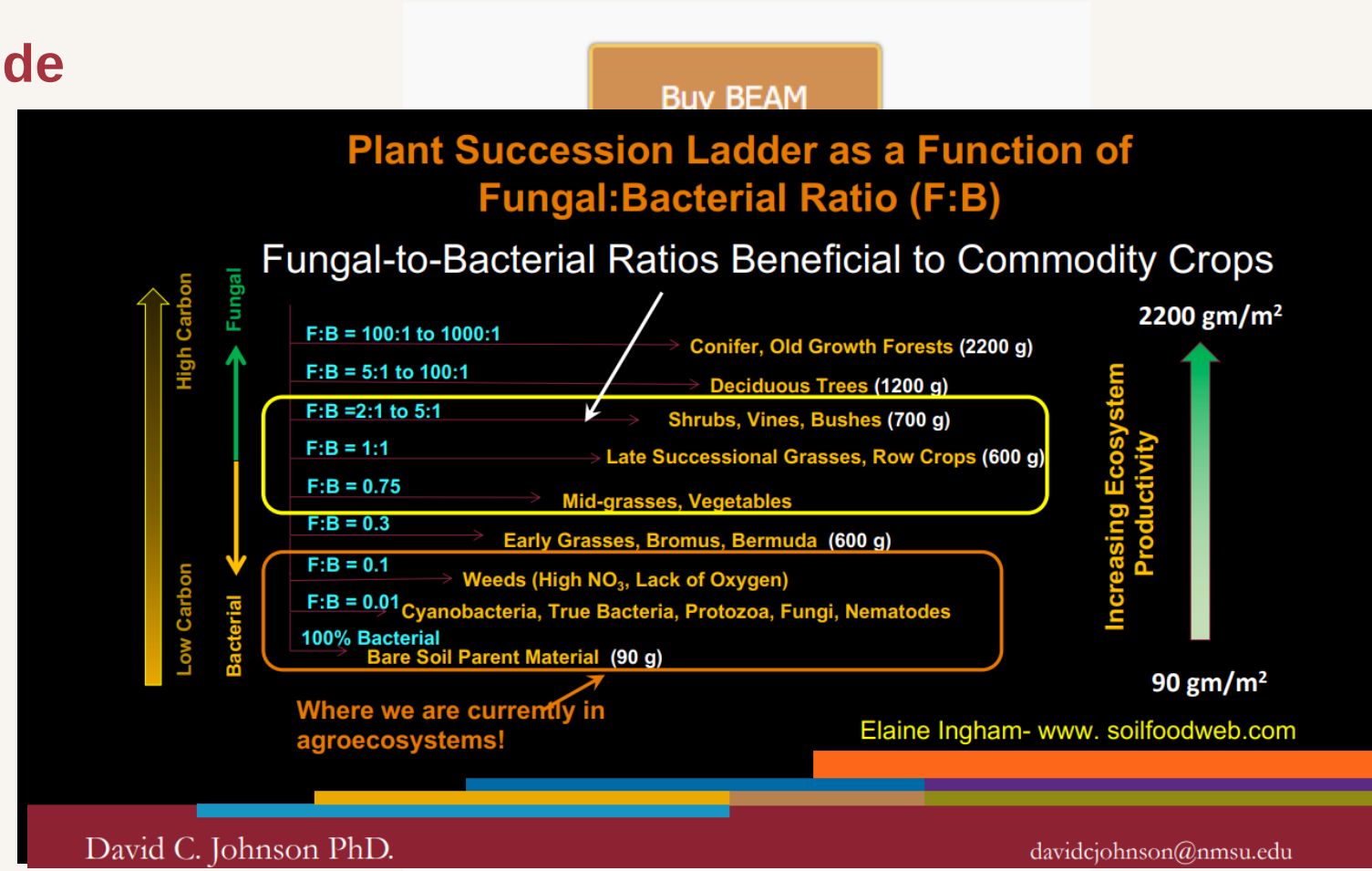
Er FBR vigtigt i sig selv?

Case: David Johnsons påstande

- BEAM: Biologically Enhanced Agricultural management
- Efterafgrøder, reduceret jordbearbejdning og kompost
- Johnson Su Bioreactor
- Påståede effekter: Bedre spiring, højere udbytter, bedre vandinfiltration, næringsstoftilgængelighed, kulstofopbygning, vandhusholdning mm.



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Kilde: Johnson, (N/A), https://landstewardshipproject.org/wp-content/uploads/Beam-Presentation-David
https://beamcompost.com/

Case: David Johnsons påstande

- Artiklen fra 2015 er stadig i pre-print
- FBR undersøgt ved direkte mikroskopi
- FBR og C_{ini} (R^2 >0,99) – ikke muligt at skille effekterne ad
- Jordprøver i 10”-12” (25-30 cm) dybde
- Ingen korrektion for massefylde
- Ingen egentlig kontrol
- Sammenligning af kontinuerlig nedmuldning af efterafgrøder (ingen høst) med konventionel bomuldsdyrkning
- Jordbearbejdning varierer også mellem behandling og kontrol
- Imponerende resultater, men ingen direkte bevisførelse for betydning af FBR

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Development of soil microbial communities for promoting sustainability in agriculture and a global carbon fix

Agricultural Science | Environmental Sciences | Soil Science

David Johnson [1], Joe Ellington [2], Wesley Eaton [3]

January 13, 2015

Author and article information

Abstract

The goals of this research were to explore alternative agriculture management practices in both greenhouse and field trials that do not require the use of synthetic and/or

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Kilde: https://peerj.com/preprints/789v1/

Tak for jeres tid!

Følg podcasten ØKO-LYD

for mere nørderi om jord, biologi og regenerativt landbrug