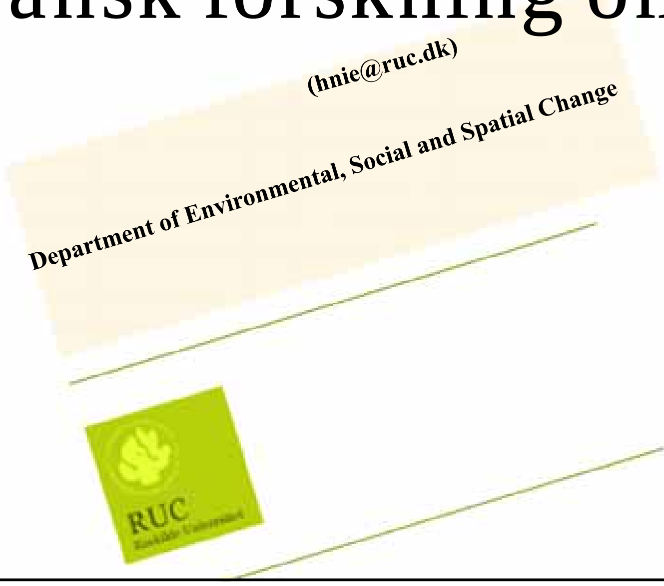
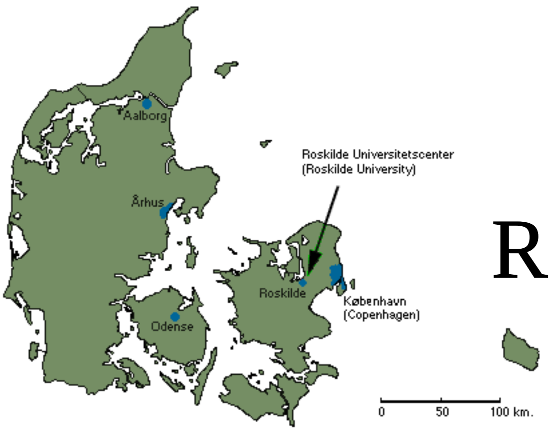
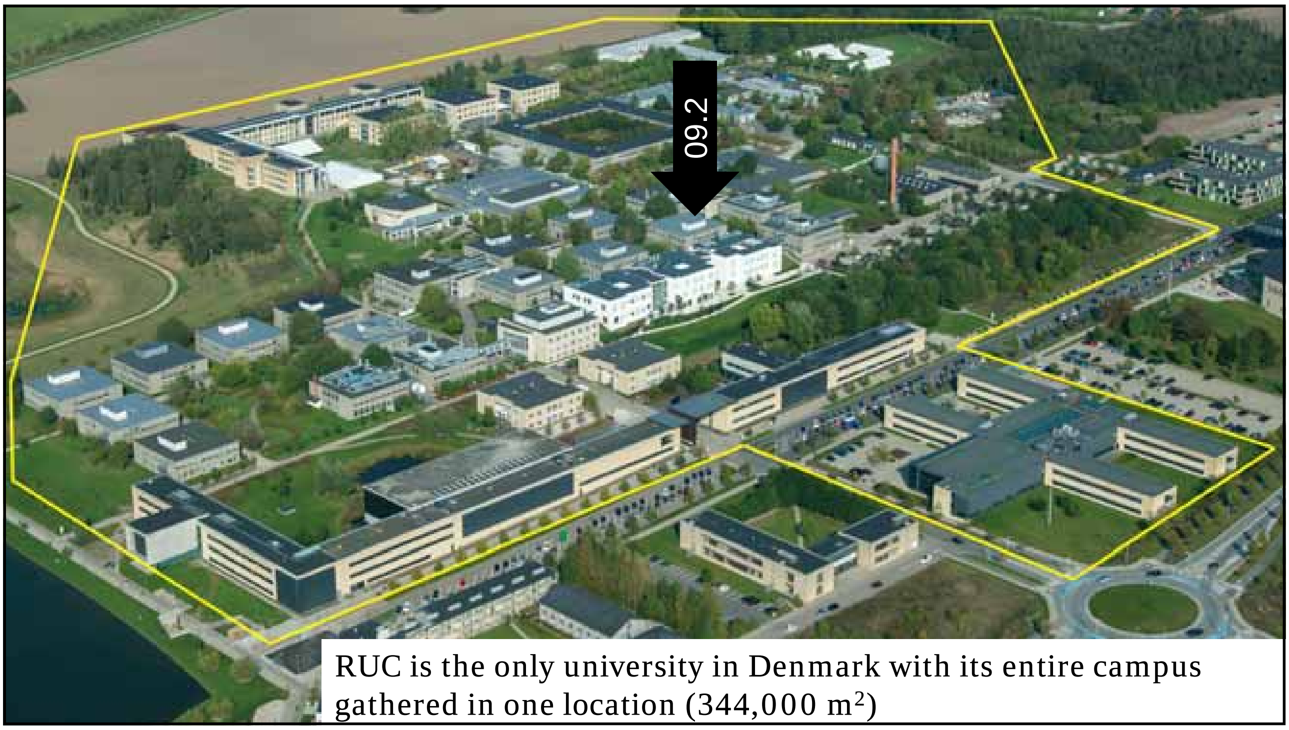
Dansk forskning om biokol





Roskilde University

”In tranquillo mors, in fluctu vita”
"In stillness death, in movement life"



RUC is the only university in Denmark with its entire campus gathered in one location (344,000 m^2)

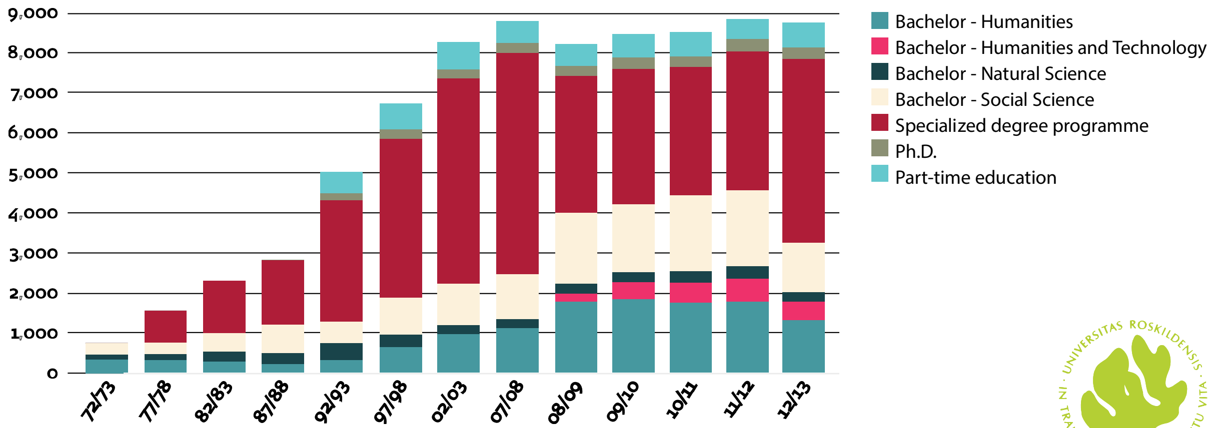
Learning and education

- Interdisciplinarity
- Problem orientation project work in groups
- Close linkage of theory and practice

- Bachelor degree, master degree, doctoral programme
- Continuing education: Master and diploma programme
- Summer school, FabLab and courses

Number of Students

1972 - 2013



Projects

- **2008-2011:** BioChar: Sustainable co-production of pyrolysis bio-oil. DTU Globalisation money
- **2010-2013:** Biochar: climate saving soils. The Interreg IVB North Sea Region Programme
- **2012-2015:** Biochar as option for sustainable resource management. EU COST Action TD1107
- **2012-2016:** Combined soil carbon sequestration and crop nutrient supply. Villum Fonden
- **2012-2016:** Fuel-flexible, efficient and sustainable low temperature biomass gasification. EUDP
- **2014-2017:** Microbial biofertilizers for enhanced crop availability of phosphorus pools in soil and waste. DSF

Partnere

SEGES

Danmarks Tekniske Universitet

DTU

WEISS

DONG energy

KØBENHAVNS UNIVERSITET

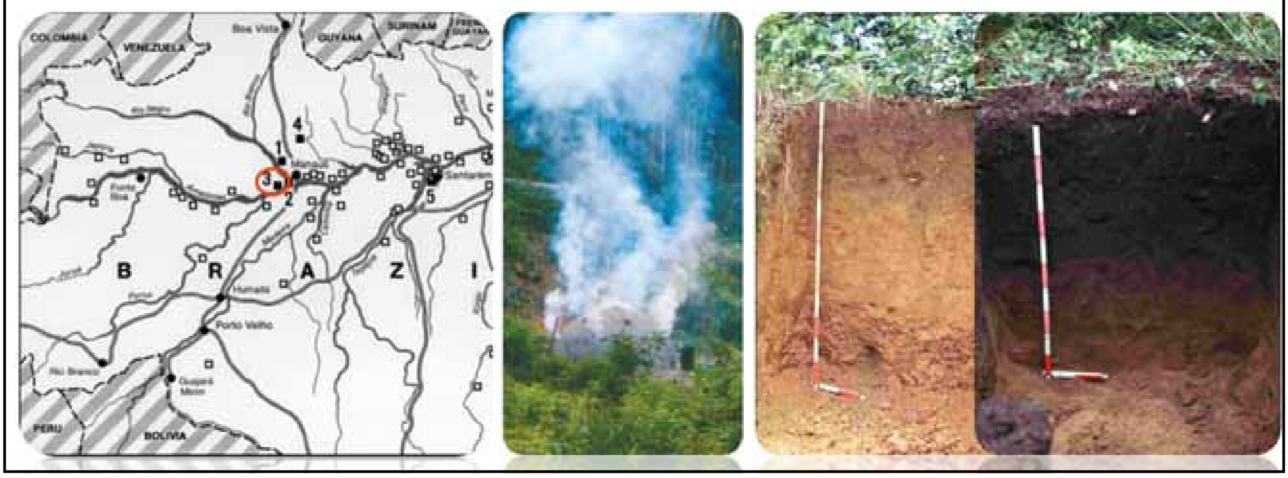
AgroTech
Institut for Jordbrugs- og Fødevareinnovation

novozymes
Rethink Tomorrow

MASSEY FERGUSON

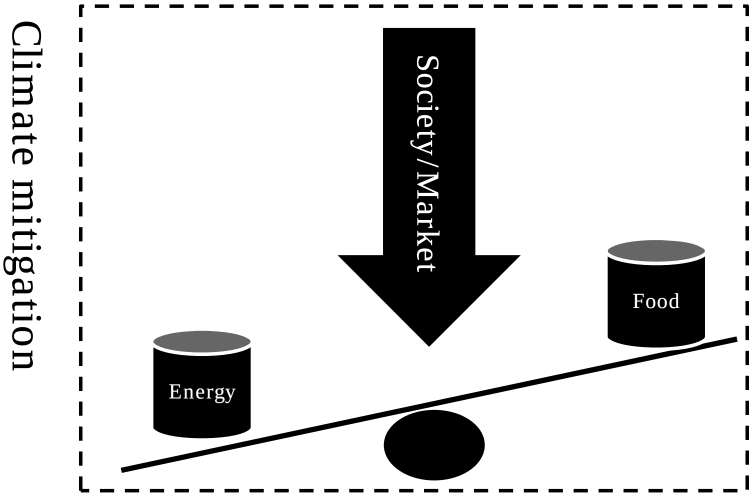
UNIVERSITAS ROSKILDENSIS · IN TRANQUILLO MORS · IN FLUCTU VITA ·

Terra Preta soils of Amazonas

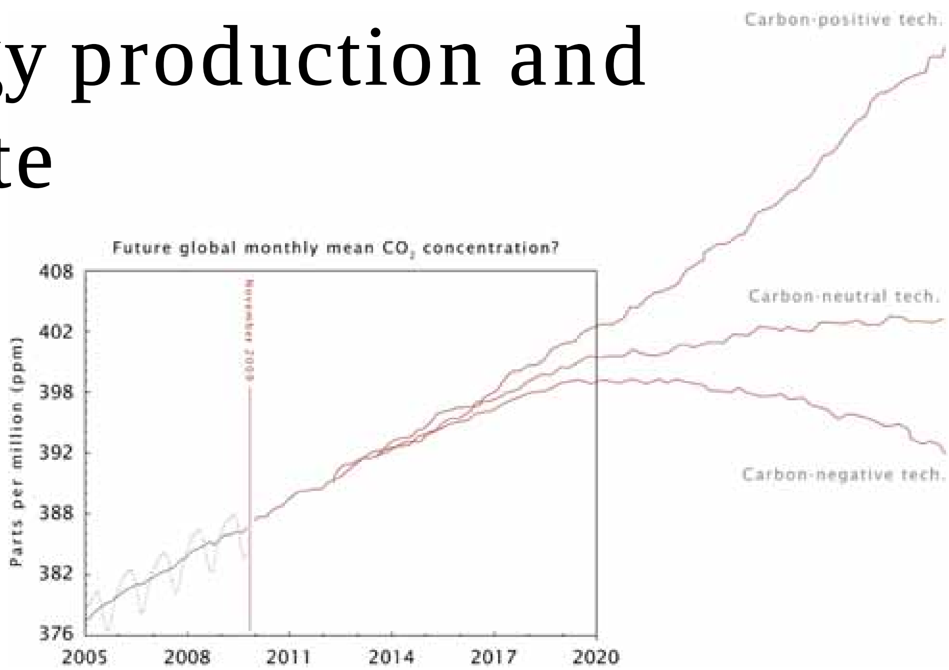



Sequestering 'biochar' in soil, which makes soil
darker in colour, is a robust way to store carbon.

Objective


Climate mitigation
Society/Market
Energy
Food

Energy production and climate



Biochar and crops

Table 1 Relation between charcoal amendments to soil and crop response

Treatment	Amendment (Mg ha⁻¹)	Biomass production (%)	Plant height (%)	Root biomass (%)	Shoot biomass (%)	Plant type	Soil type	Reference
Control	–	100	100	–	–	Bauhinia wood	Alfisol/Ultisol	Chidumayo (1994)
Charcoal	Unknown	113	124	–	–	Bauhinia wood	Alfisol/Ultisol	
Control	–	100	–	–	–	Soybean	Volcanic ash soil, loam	Kishimoto and Sugiura (1985)
Charcoal	0.5	151	–	–	–	Soybean	Volcanic ash soil, loam	Iswaran et al. (1980)
Charcoal	5.0	63	–	–	–	Soybean	Volcanic ash soil, loam	Kishimoto and Sugiura (1985)
Charcoal	15.0	29	–	–	–	Soybean	Volcanic ash soil, loam	
Control	–	100	–	–	–	Pea	Dehli soil	Iswaran et al. (1980)
Charcoal	0.5	160	–	–	–	Pea	Dehli soil	
Control	–	100	–	–	–	Moong	Dehli soil	
Charcoal	0.5	122	–	–	–	Moong	Dehli soil	
Control	–	100	–	100	–	Cowpea	Xanthic Ferralsol	Glaser et al. (2002a, 2002b)
Charcoal	33.6	127	–	–	–	Oats	Sand	
Charcoal	67.2	120	–	–	–	Rice	Xanthic Ferralsol	
Charcoal	67.2	150	–	140	–	Cowpea	Xanthic Ferralsol	
Charcoal	135.2	200	–	190	–	Cowpea	Xanthic Ferralsol	
Control	–	100	100	100	100	Maize	Alfisol	Mbagwu and Piccolo (1997)
Coal humic acid	0.2	118	114	122	114	Maize	Alfisol	
Coal humic acid	2.0	176	145	186	166	Maize	Alfisol	
Coal humic acid	20.0	132	125	144	120	Maize	Alfisol	
Control	–	100	100	100	100	Maize	Inceptisol	
Coal humic acid	0.2	125	119	122	127	Maize	Inceptisol	
Coal humic acid	2.0	186	148	198	173	Maize	Inceptisol	
Coal humic acid	20.0	139	131	147	130	Maize	Inceptisol	
Control	–	100	100	100	–	Sugi trees	Clay loam	Kishimoto and Sugiura (1985)
Wood charcoal	0.5	249	126	130	–	Sugi trees	Clay loam	
Bark charcoal	0.5	324	132	115	–	Sugi trees	Clay loam	
Activated charcoal	0.5	244	135	136	–	Sugi trees	Clay loam	

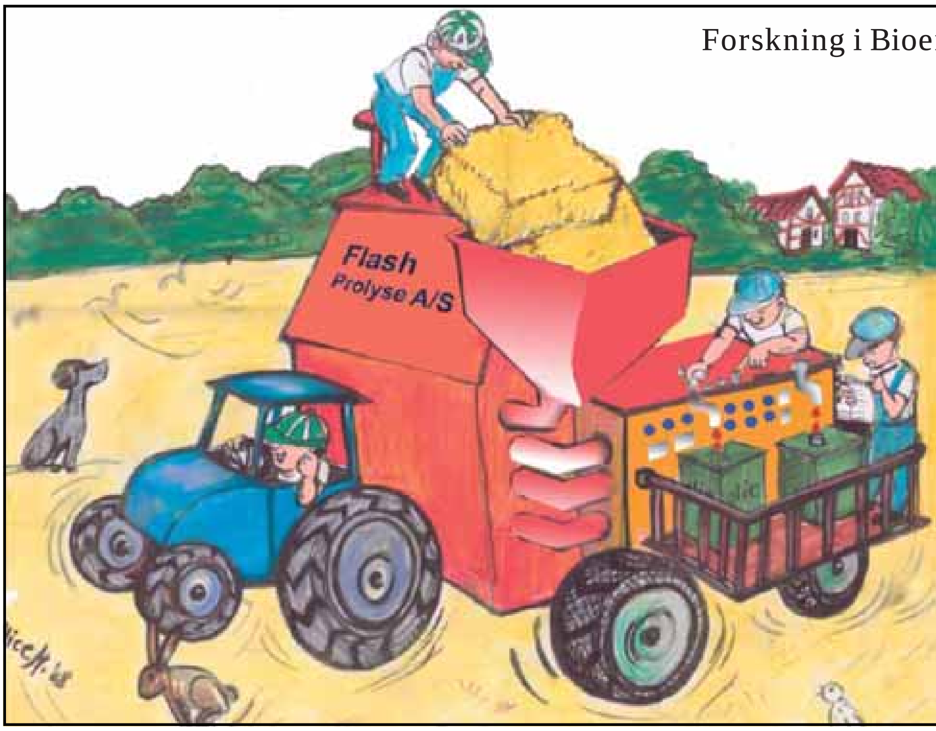
From Zweiten et al. 2010

Clear advantages!?😐

"I believe **biochar** helps protect and build the structure of my soil especially when you water as much as I do."

Jeff Joliet, Illinois, 2010

Forskning i Bioenergi nr. 24 • juni 2008

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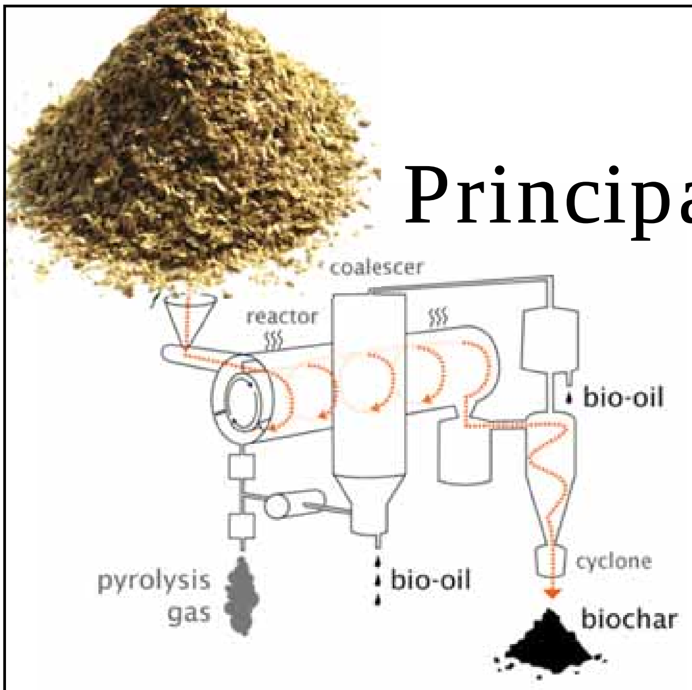
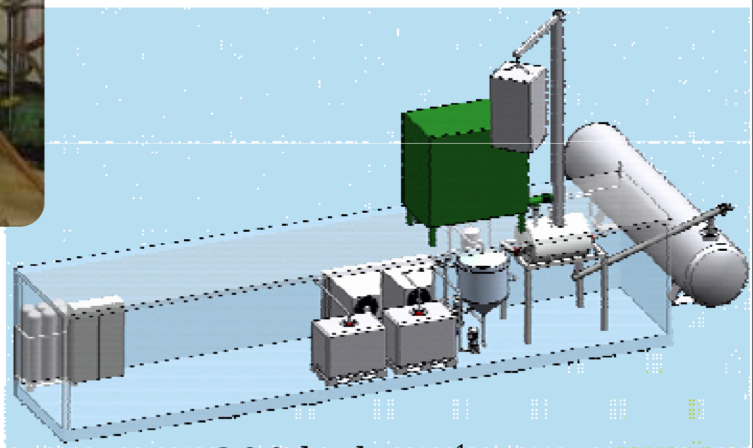
Principal technology



© Fast pyrolysis

- Heating (300-600°C) without oxygen.
- Fast heating rate.

Source: Arendt, Unpubl.

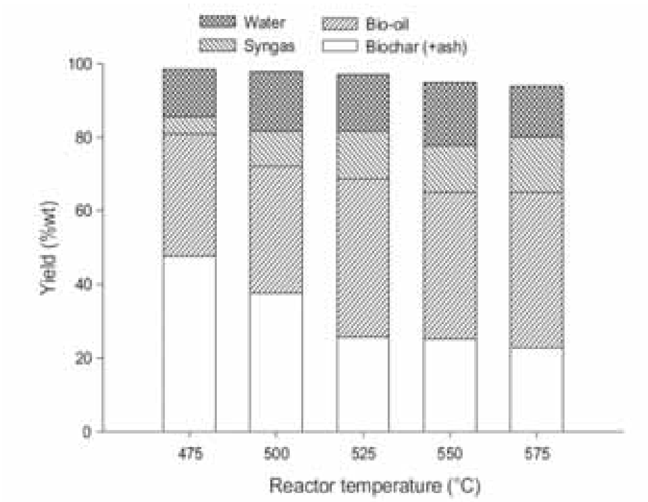


200 kg hour^{-1}

Lab and semi-field experiments

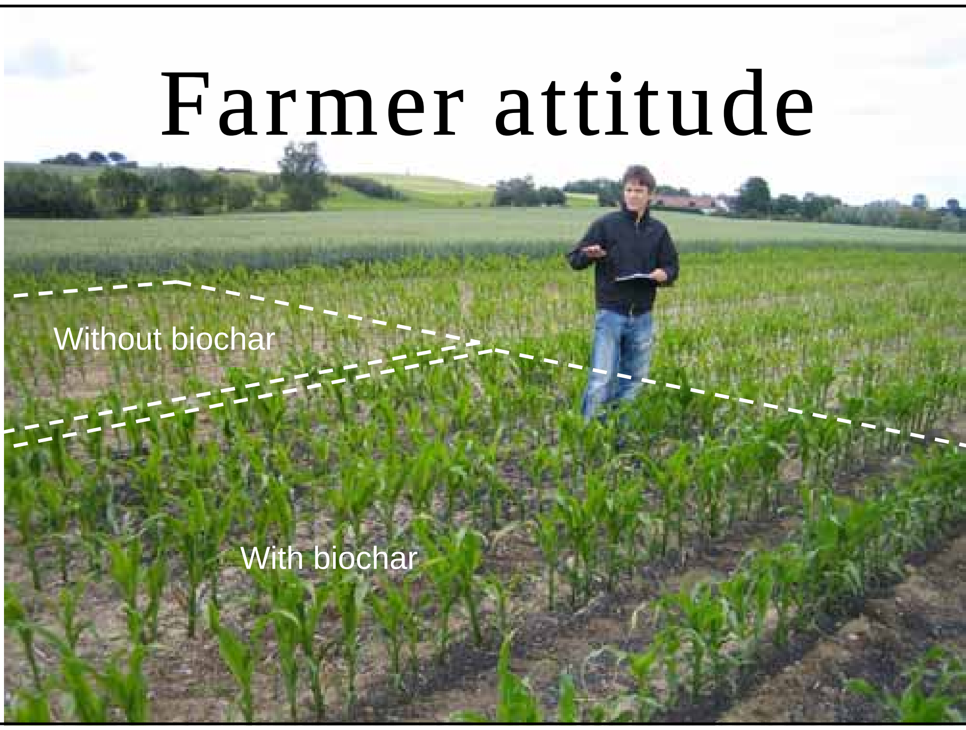
Source: Bruun et al. 2011, 2012a; 2012b

Biochar is not just biochar



PCR	Biochar	
Temp °C	Yield[a] g C kg^{-1} C	Stability[b] % of wt
475	550	65.6
500	464	82.7
525	329	92.4
550	316	95
575	291	97

Farmer attitude



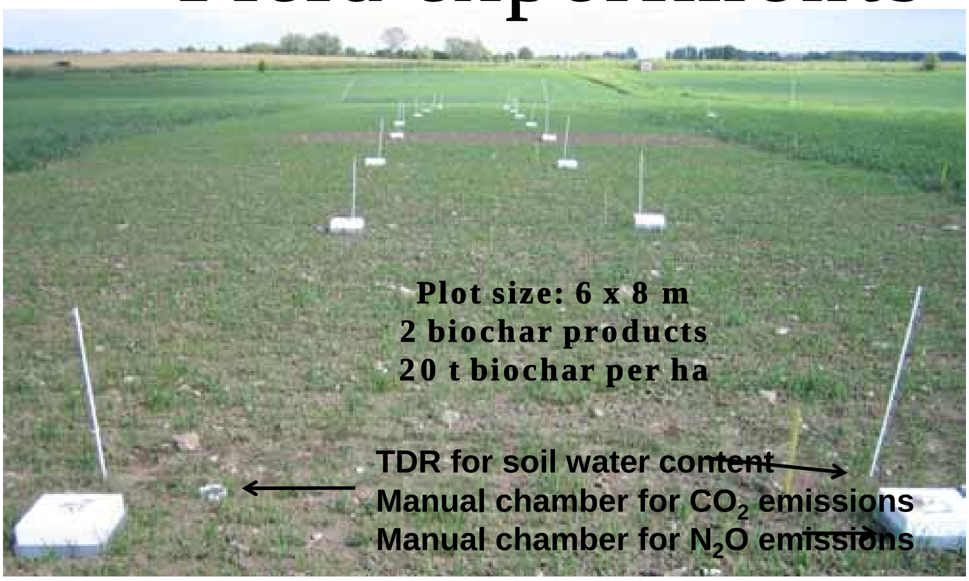
Farmer cooperation

Treatments:

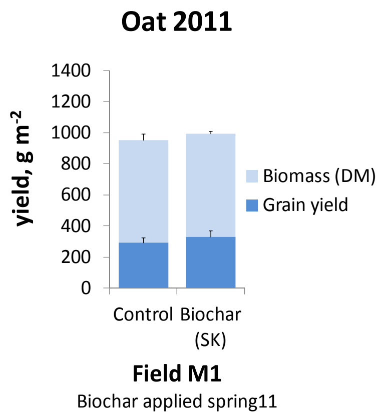
Biochar : 0, 10, 20, 50 t/ha

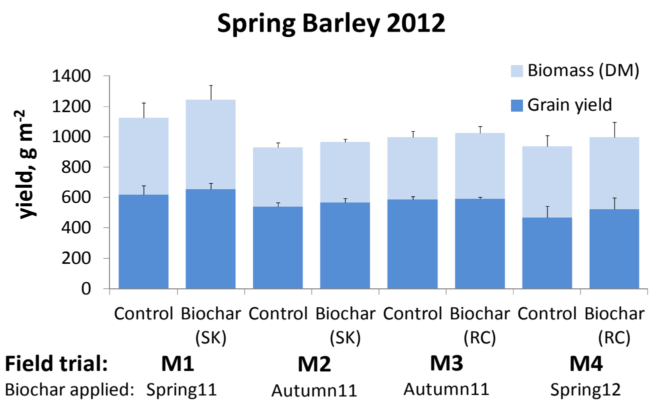
Field application

Field experiments



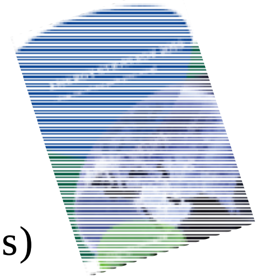
Crop yields





Source: Bruun, unpubl.

Set the scene – *in Denmark*

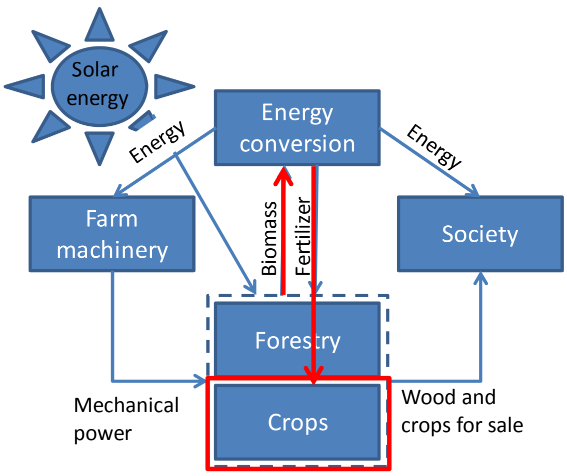


A. 1.2 - 1.7 mill. tons straw year^{-1} used for energy
B. Recycling of phosphorus (80% 2018)

- Energy companies; waste material (not resources)
- Farmers; new markets

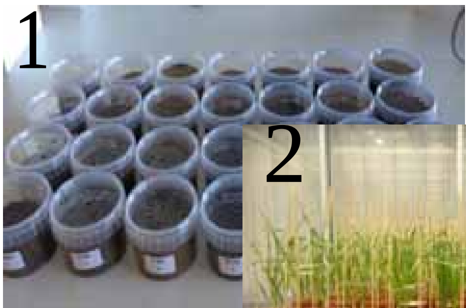
a) Price of straw does not cover the cost of handling
b) Concerns about sewage sludge soil application

Across sector integration



“We are not going to give away our straw for bioenergy – it is too valuable for the cropping system”

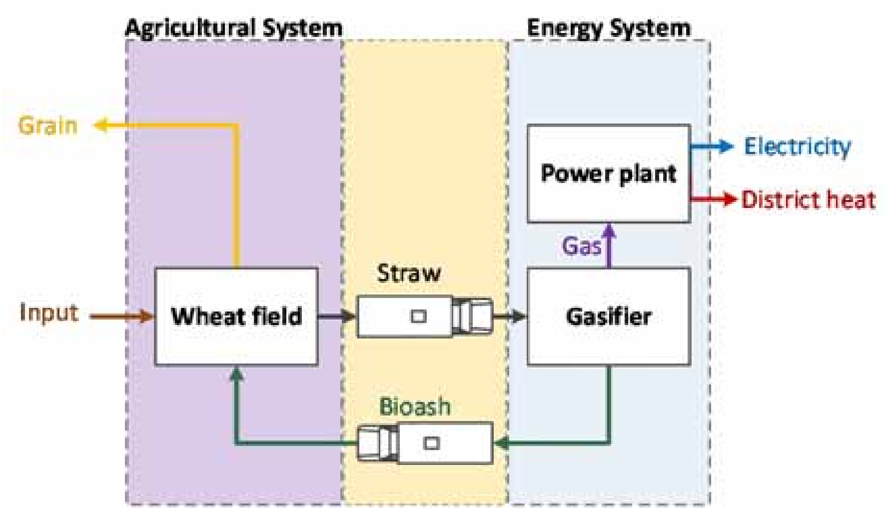
Mechanistic understanding and recommendations

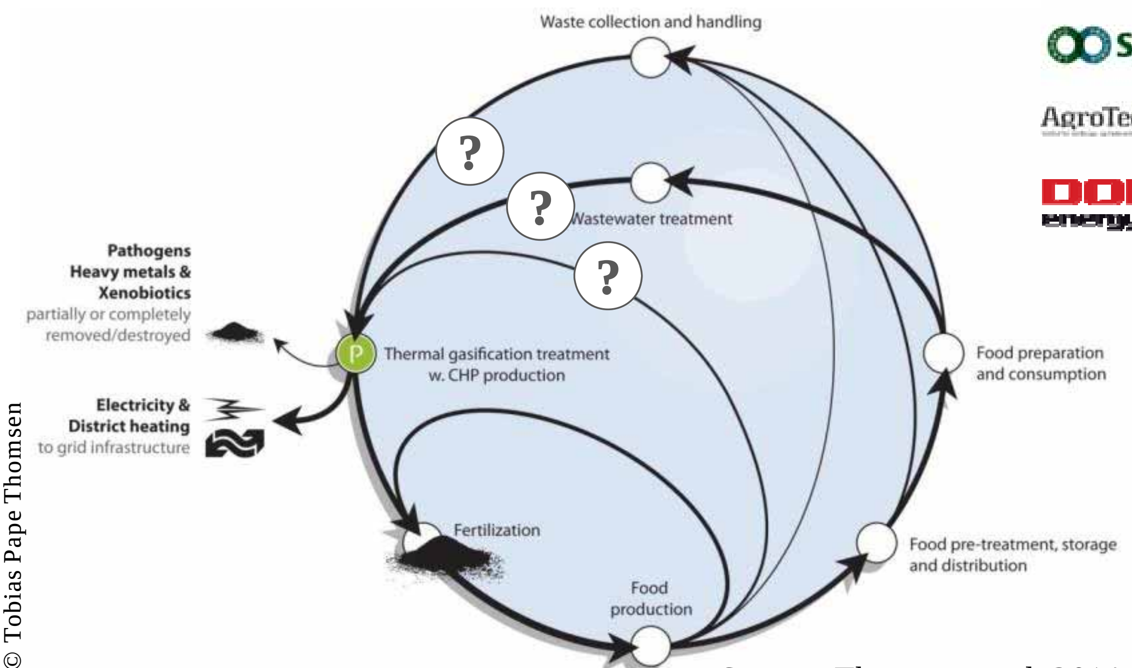


Source: Hansen et al. 2014, 2015

Source: Sigurjonsson et al. Unpubl.

Whole system analyses (LCA)

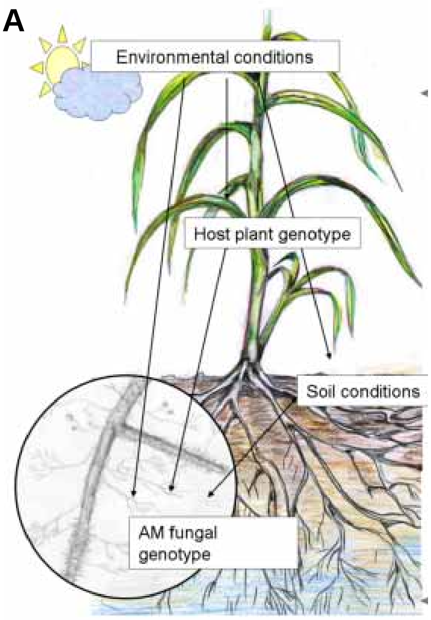




Source: Thomsen et al. 2014, unpubl.

Phosphorous Solubilizing Microorganisms (PSM)

A



Source: Raymond et al. unpubl.

B

C

Promising but maybe not convincing

- Renewable fertilizer
- Straw K; sewage sludge P (KPC)
- Liming agent
- No harmful soil effects (living soils)
- Soil carbon benefits difficult to show – longer term
- Demand-driven farmer involvement required