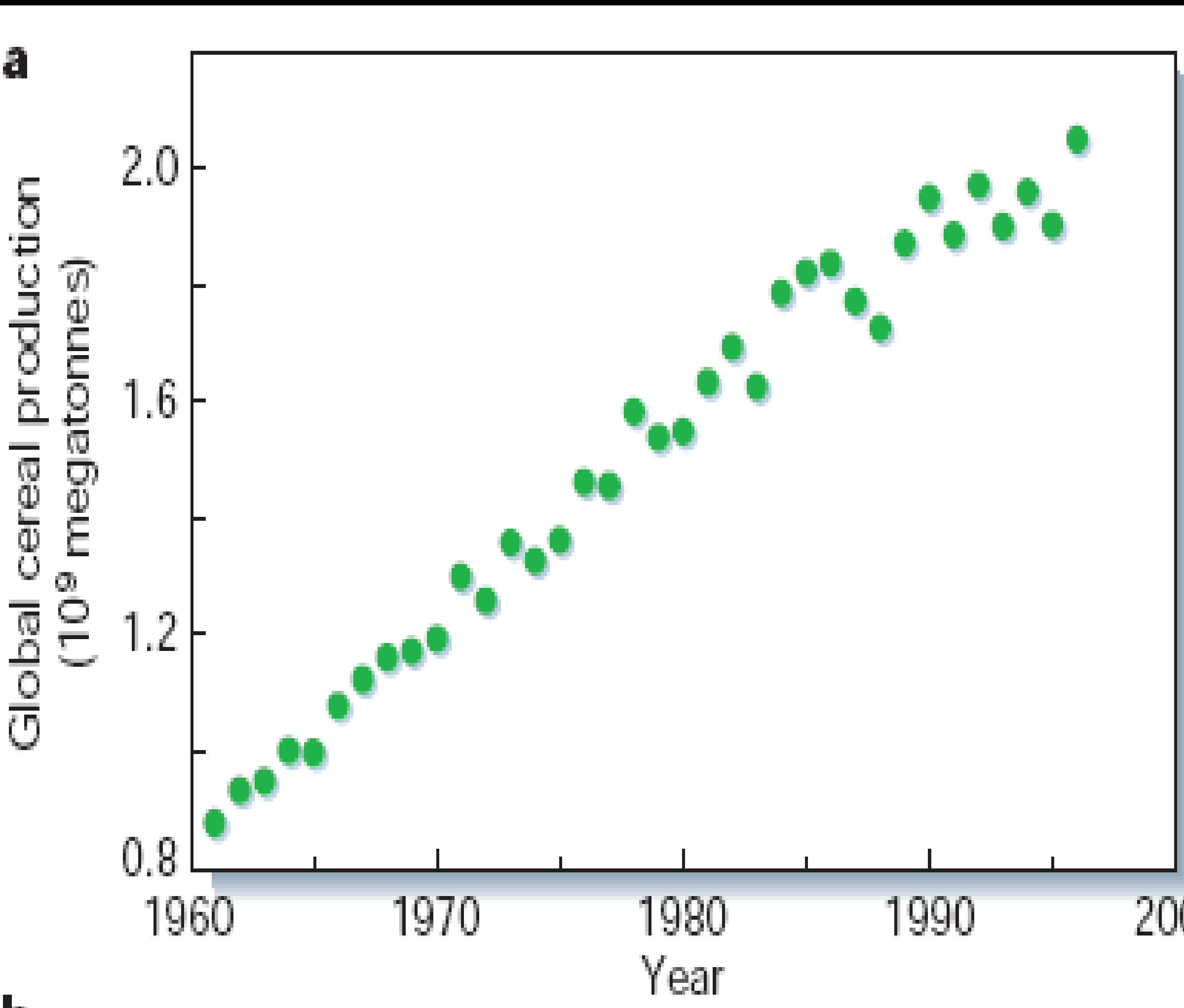
Biochar

Ancient Origins
Modern Solutions

biochar.org
BALANCE CARBON AND RESTORE SOIL FERTILITY

Christoph Steiner

Land-Use Challenges



Tilman et al. 2002, Nature 418

- Humans currently appropriate more than a third of the production of terrestrial ecosystems and about half of usable freshwaters

- Have doubled terrestrial nitrogen supply and phosphorus liberation

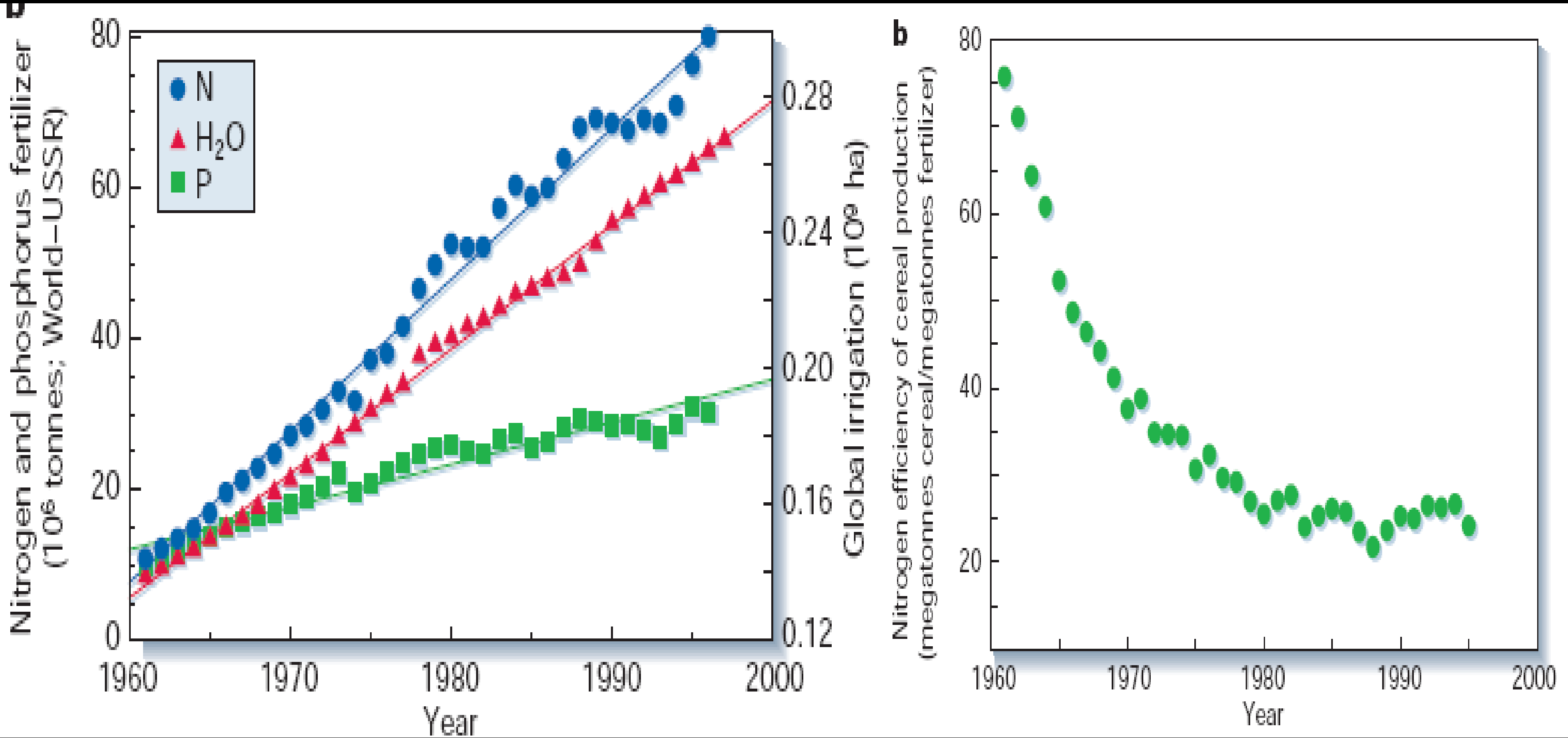
- Have manufactured and released globally significant quantities of pesticides

- and have initiated a major extinction event.

Tilman at al. 2001, Science 292

Land-Use Challenges

Fertilizers



Tilman et al. 2002, Nature 418

Land-Use Challenges

During the next 50 years the global population will grow by 50% and the population is more demanding
→ doubling food production

Predictions:

• A further conversion of 10^9 hectares of natural ecosystems (loss of natural ecosystems larger than the United States)

• 2.4 to 2.7-fold increases in nitrogen and phosphorus-driven eutrophication of water.



Land-Use Challenges/Limitations

How can agricultural productivity doubled?

- Without increasing the environmental impact
  - Considering climate change
  - Considering peak oil

In developed countries 4kcal of energy is invested to produce 1kcal of food (Pimentel 2009)
One barrel of oil per hectare (Hall and Hall, 1993)

  - Considering peak phosphorus
  - Considering soil degradation

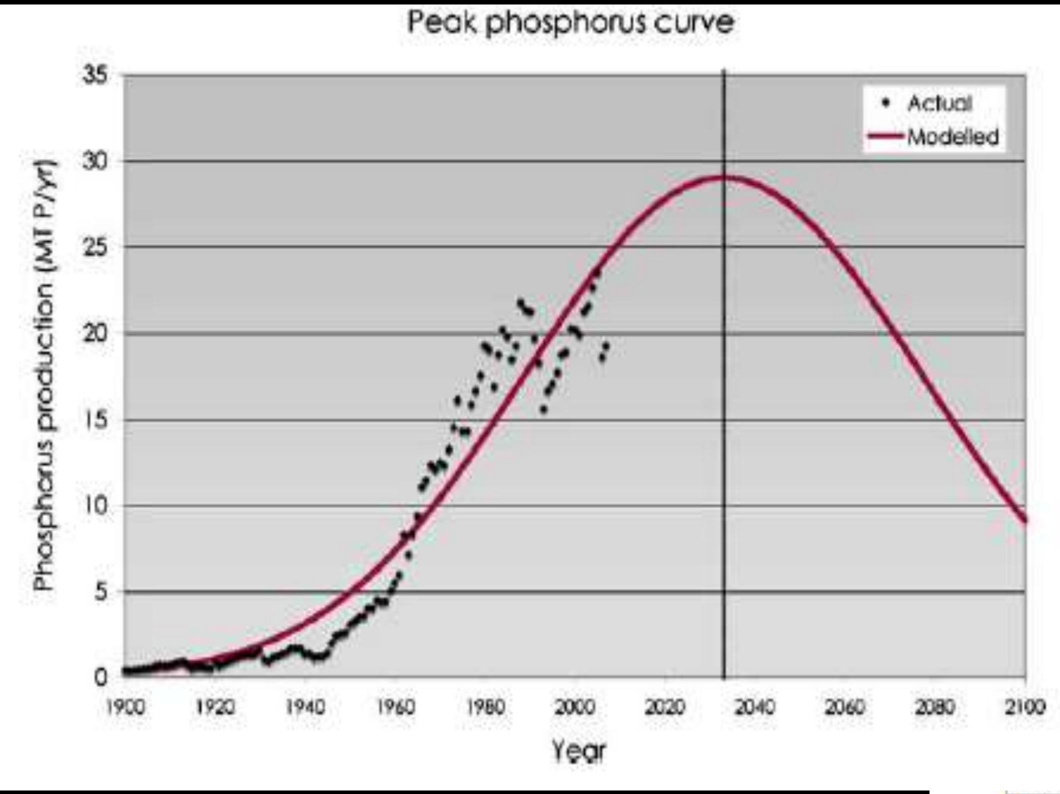
Average soil loss in the US is 5 tons per ha per year (Horrigan et al. 2002)

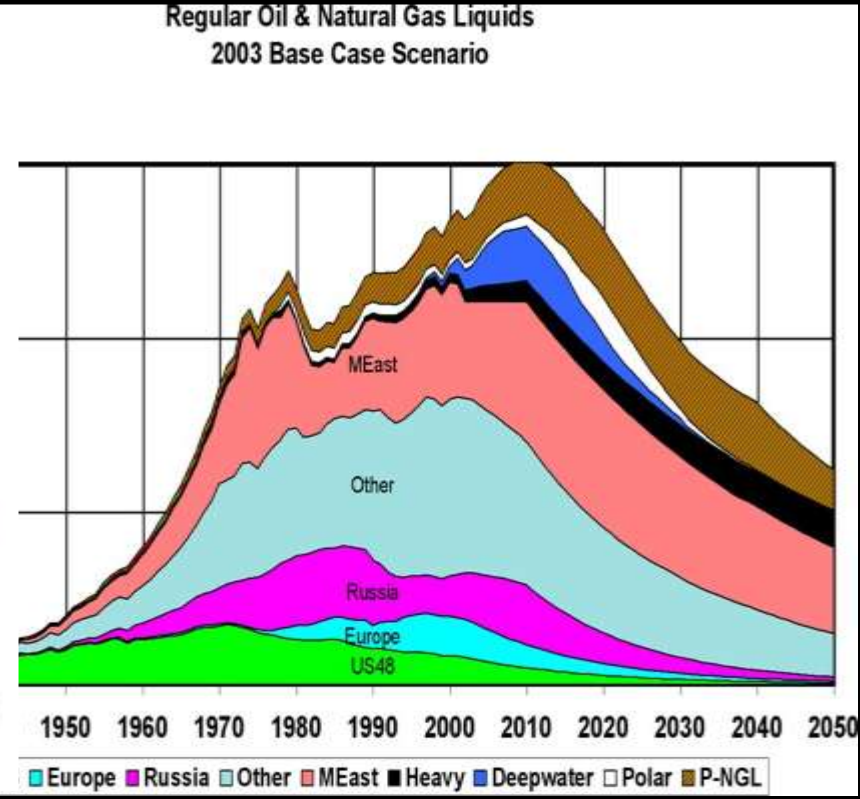
  - Considering water shortages
  - Considering loss of biodiversity

In the past 15 years 1500 rice varieties disappeared in Indonesia (Horrigan et al. 2002)




Land-Use Challenges/Limitations





Peak phosphorus
Cordell et al. 2009, Global Environmental Change

peak oil “Hubbert’s Peak”

Nutrient flow management "dead zone" in the Gulf of Mexico

http://www.nasa.gov

http://www.astrovera.com

http://en.wikipedia.org/

“A greener revolution is needed”

Tilman et al. 2001, Science

What is needed

- Soil conservation
- Closing nutrient cycles
- Material flow management involving nutrients and carbon
- Higher nutrient use efficiency

- Climate change mitigation and adaptation

European example the Plaggen (Plaggic Anthrosols)

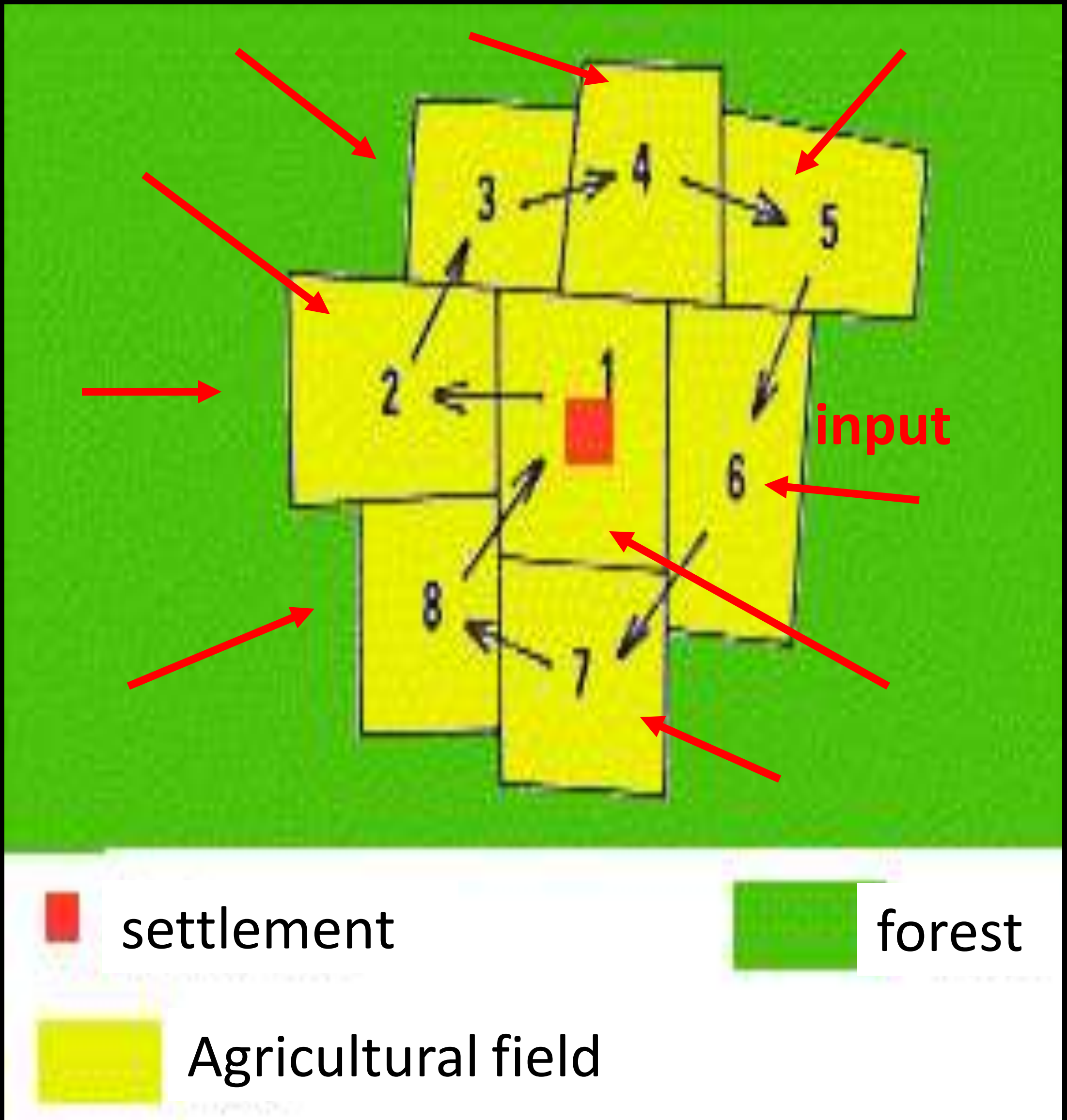
Fig 7:1 The limits of plaggen soil distribution in Western Europe (prepared by J. C. Pape, Soil Survey Institute, Wageningen, Netherlands). Plaggen soils are sandy soils that have been fertilised for several centuries with manure, seaweed, and sods. They have deep A_p horizons, rich in phosphate

Addition of sods mixed with farmyard manure

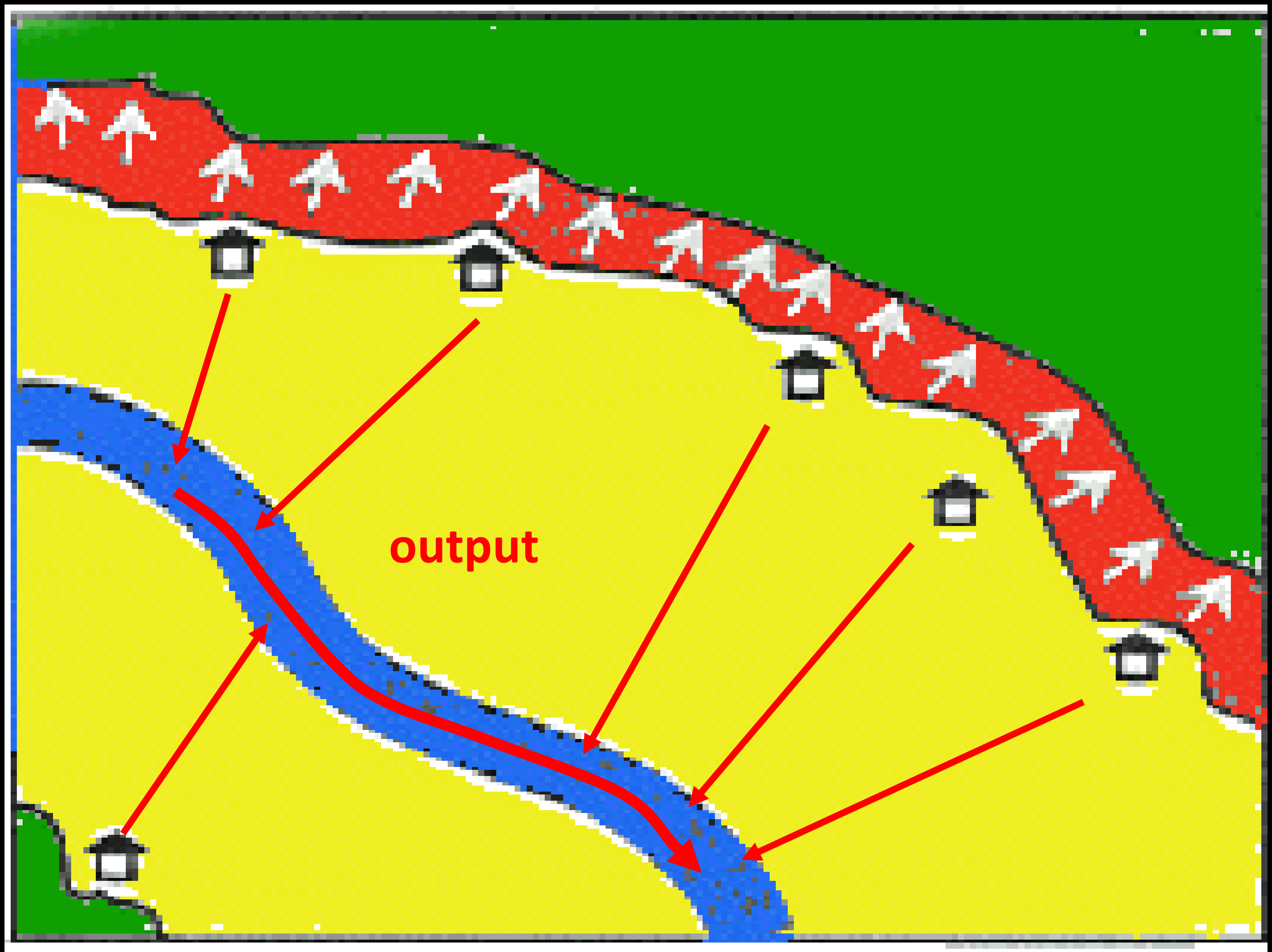
Anthrosols Brazil – Terra Preta

Charcoal Terra Preta

Terra Preta geneses



Modern agriculture outside markets



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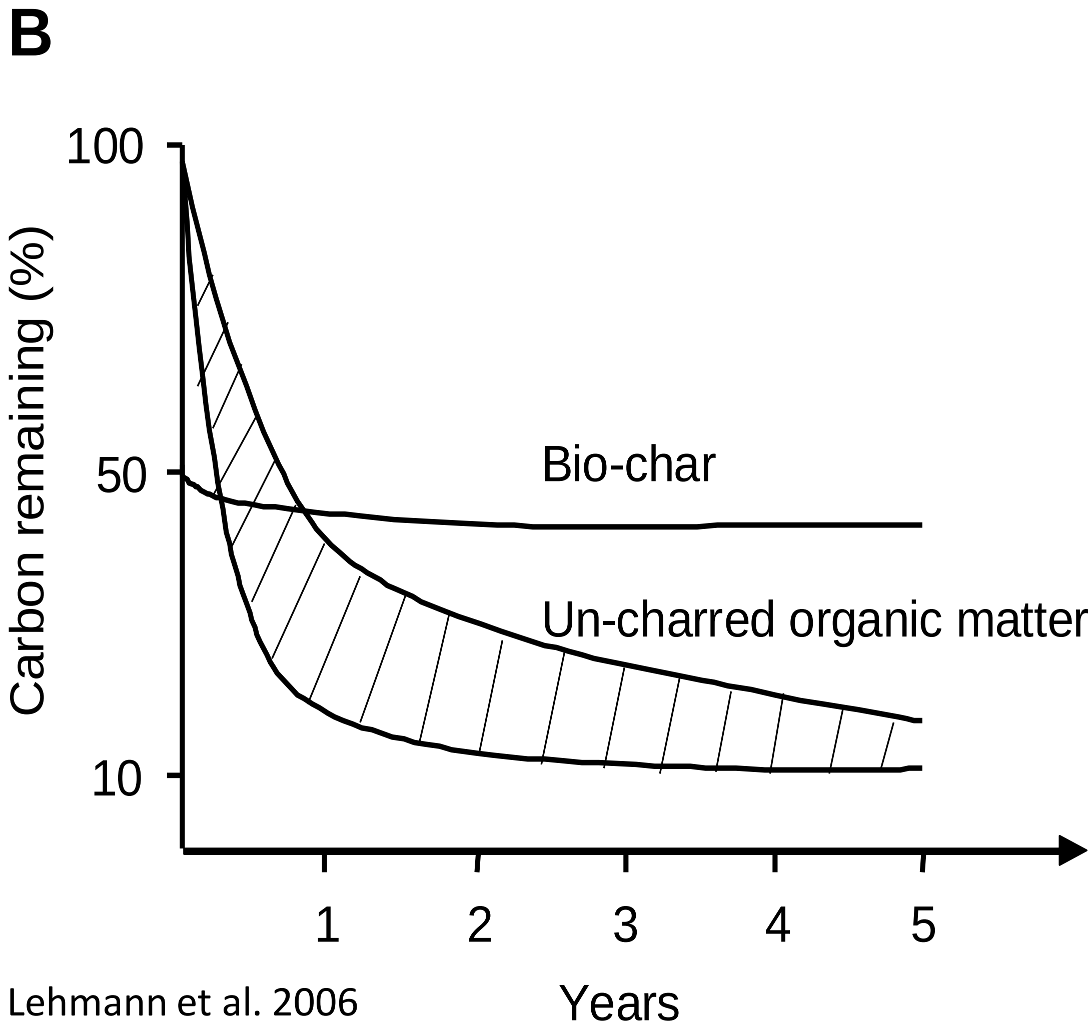
Opportunities and Challenges

Bioenergy, carbon sequestration and sustaining soil fertility seems feasible

- Only a proportion of the carbon used for energy
- Proportion used to sequester carbon
- and improve soil fertility

Charcoal Carbon Sink - Traditional Knowledge

Long lasting carbon sequestration



Lehmann et al. 2006

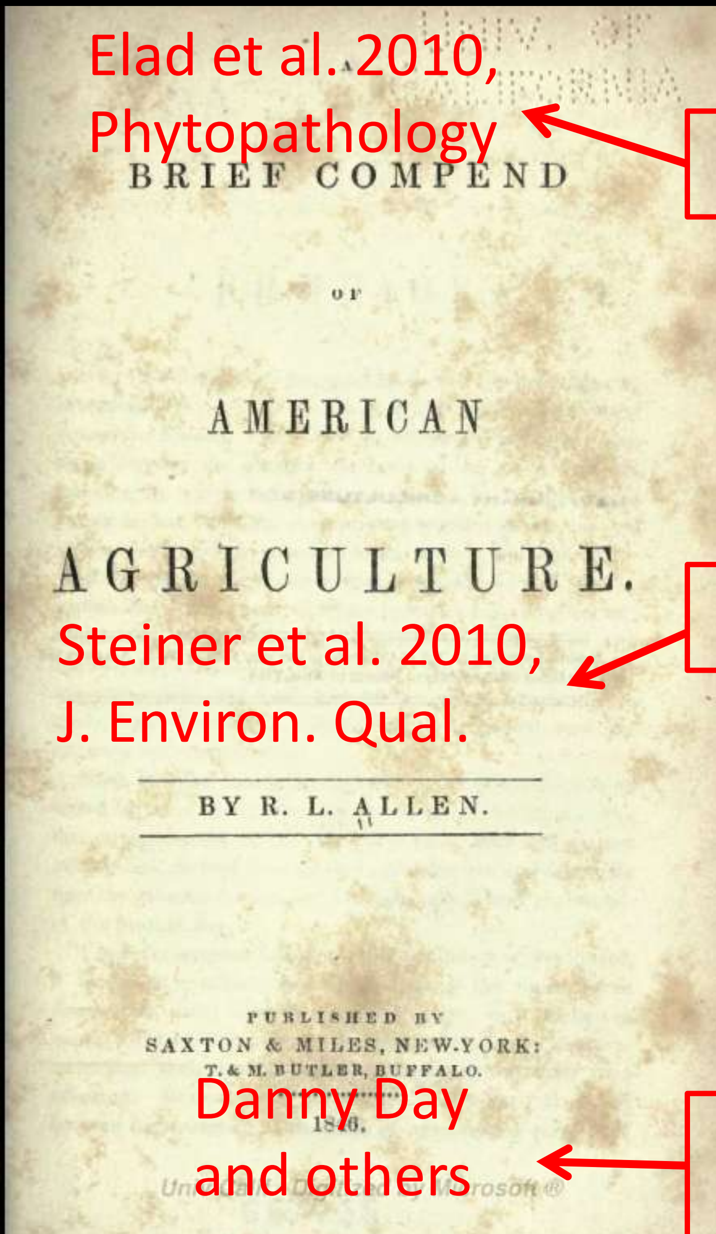
Historic Biorefining

Historic Biorefining

Fotos: Anita Buchart

Actor: Friedrich Frühwirth

Traditional Use US (1847)


BRIEF COMPEND

OF

AMERICAN

AGRICULTURE.

BY R. L. ALLEN.

PUBLISHED BY

SAXTON & MILES, NEW-YORK:

T. & M. BUTLER, BUFFALO.

"Charcoal absorbs and condenses the nutritive gases within its pores."

Charcoal often checks rust in wheat, and mildew in other crops"

"Ammoniacal liquor holds large quantities of nitrogen,….charcoal dust may be added , ..the charcoal soon combine with the ammonia, ..it is a powerful manure,"

"Guano should be mixed with twice its bulk of charcoal dust"

"Charcoal should be added to liquid manure to absorb the ammonia"

" Poudrette is the name given to the human faeces after they have been mixed with charcoal dust.."

"A dressing of charcoal has in many instances, been found so beneficial that it has been extensively introduced in France for the wheat crop"

"The turnep (Brassica rapa.) Charcoal dust applied in the same way has been found to increase the early growth from four to ten-fold."

Slash and Char as Alternative to Slash and Burn

~50% of C remains as charcoal

Photo: Steve Welch

~2% of C remains as charcoal

Biochar Research Terra Preta Nova

EMBRAPA research station Brazil

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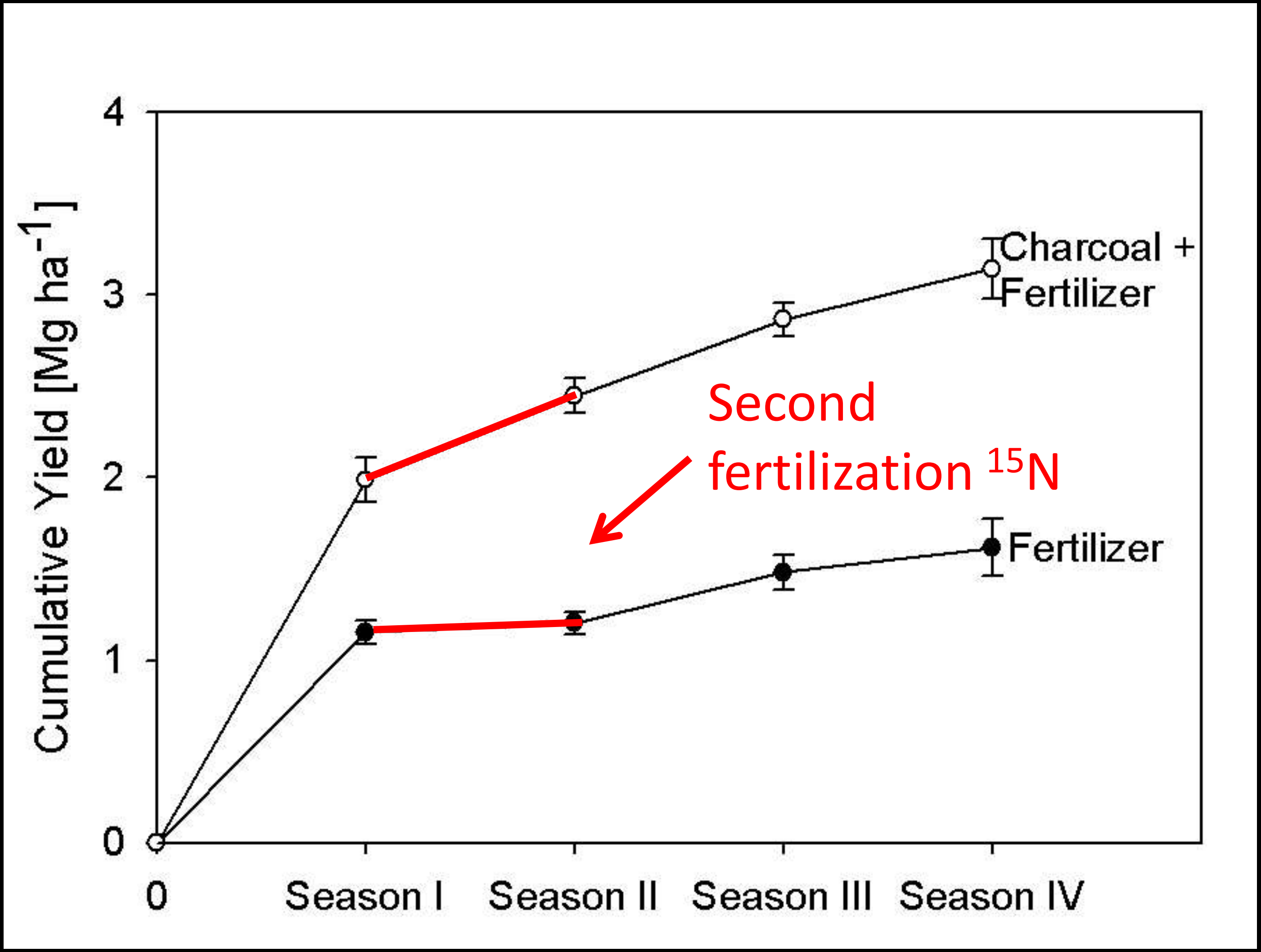
Crop Response

Steiner et al. (2008), Plant and Soil, n=5, means and SE



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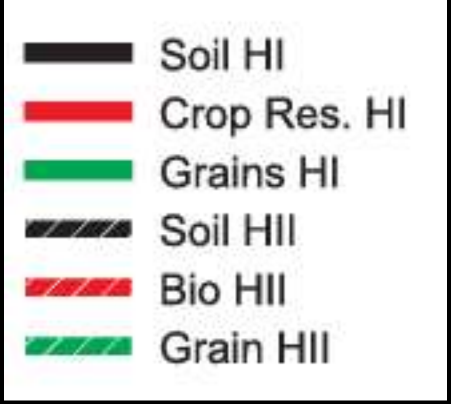
Crop Response

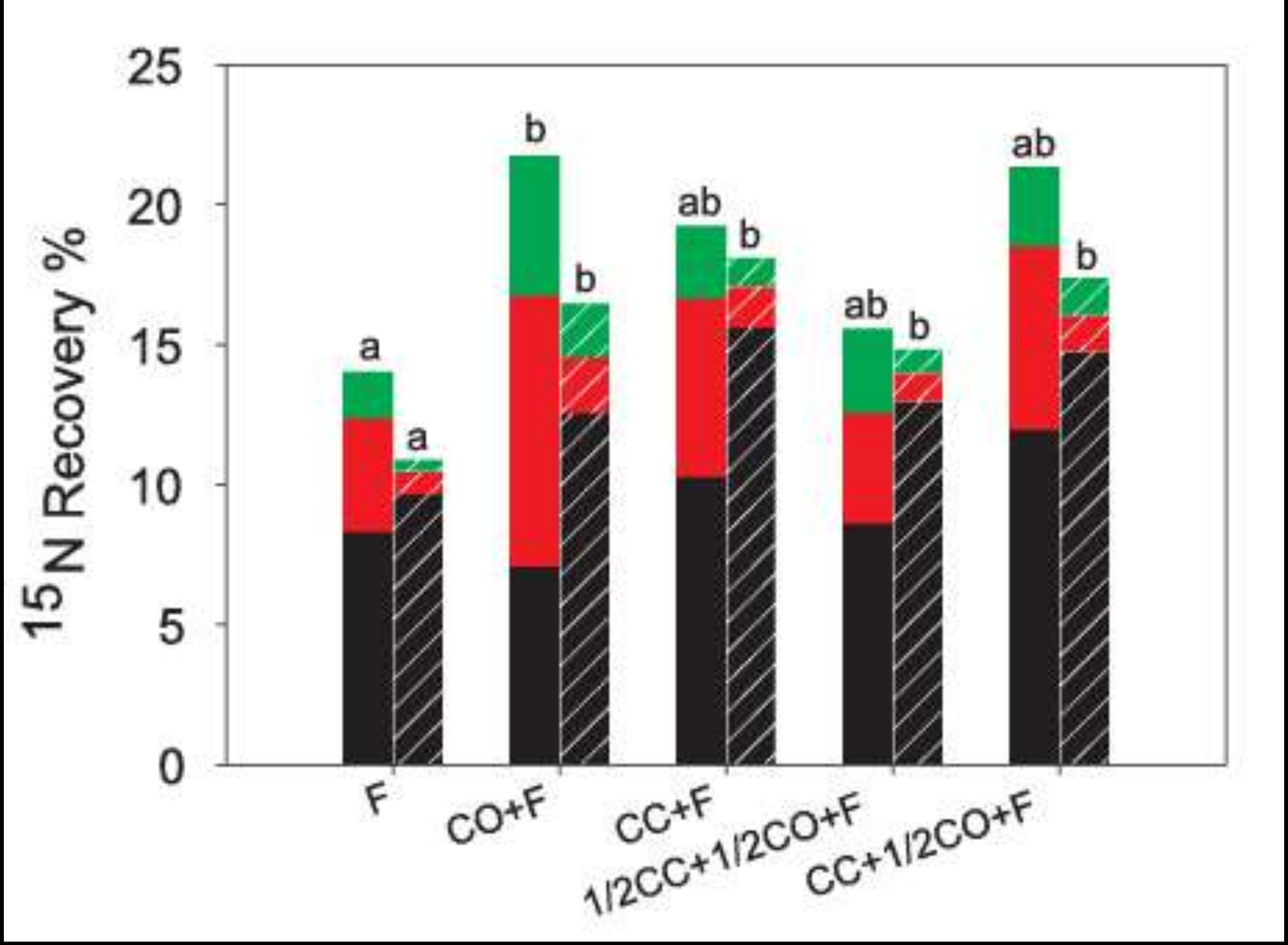
Plants after 55 days

NPK fertilizer & charcoal

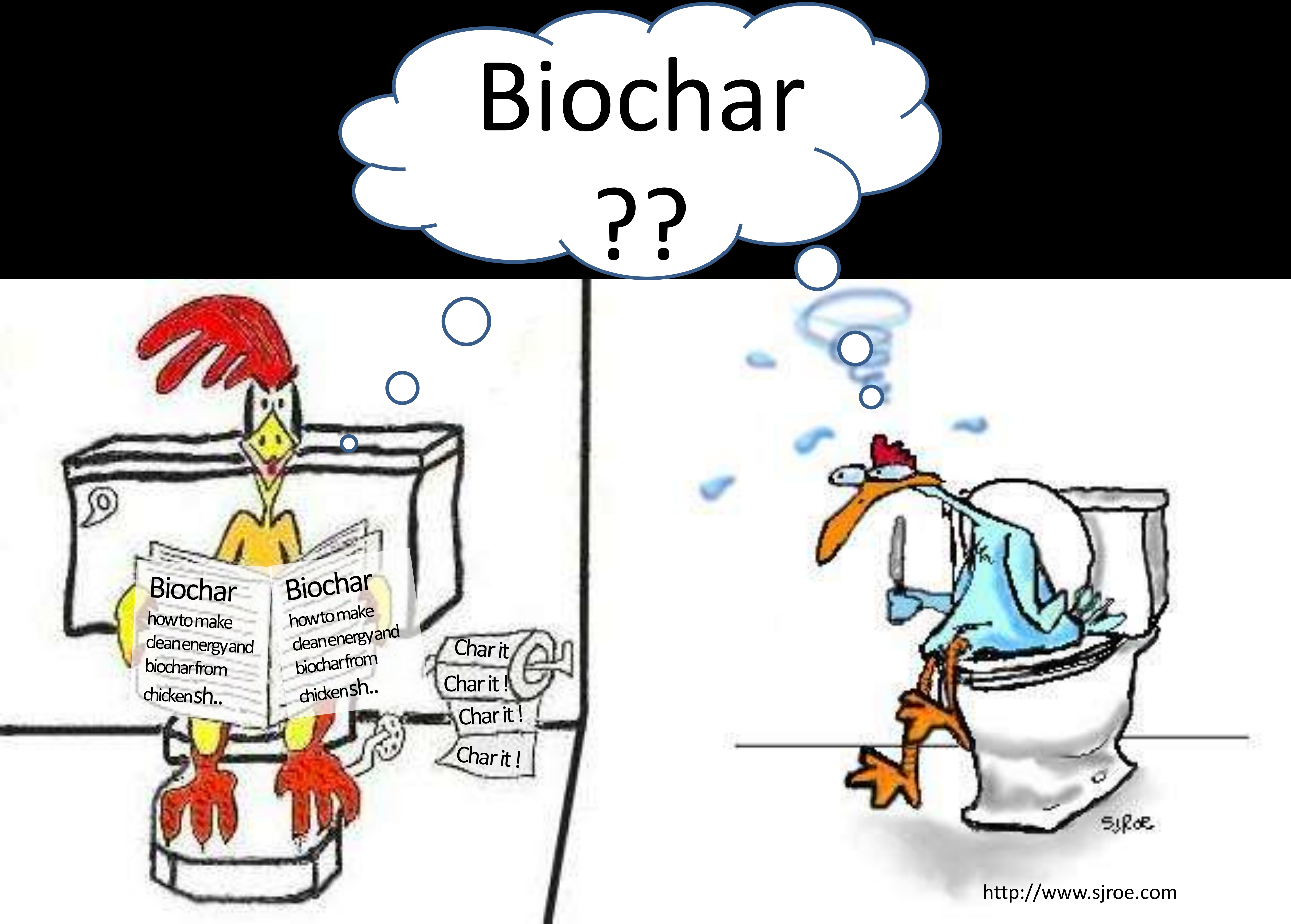
NPK fertilizer without charcoal

Research results, increased N recovery





Steiner et al. (2008), J Plant Nutr Soil Sci, n=5, means and SE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Char it
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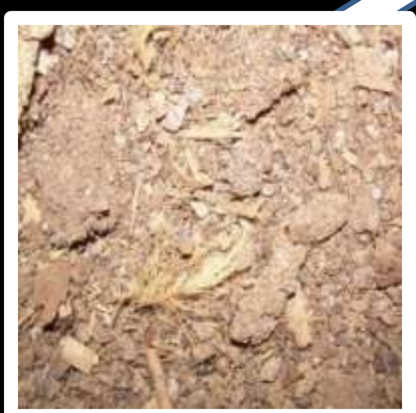
Poultry litter stabilization, pathogen and odor reduction



Ash (complete combustion)

- high concentration of minerals (P, K, Ca, Mg,.
- Loss of nitrogen (N)

Biochar (pyrolysis, carbonization)

- concentration of minerals (P, K, Ca, Mg,.
- 70% of N lost (400 °C depending on temp.)

Compost (composting)

- Concentration of minerals (P, K, Ca, Mg,.
- Loss of nitrogen (NH3 volatilization, 70 – 88%, Ogunwande et al., 2008)

Biochar

Nutrient Contents

	pH	C	N	P	K
		---------- g kg^{-1} ----------			
Poultry Litter	9.74	392	30.9	35.9	58.6
Peanut Hulls	10.1	804	24.8	1.97	16.4
Pine Chips	8.30	817	2.23	0.14	1.45

Nitrogen fertilization efficiency

Poultry litter (PL)

Mineral fertilizer (MF) based on PL

Carbonized PL (PLc)

MF based on PLc

1.5 Mg ha^{-1} (52.5 kg N ha^{-1})

3 Mg ha^{-1} (105 kg N ha^{-1})

6 Mg ha^{-1} (210 kg N ha^{-1})

MF =
NH_4NO_3
KCl
$CaHPO_4$
and $MgSO_4$

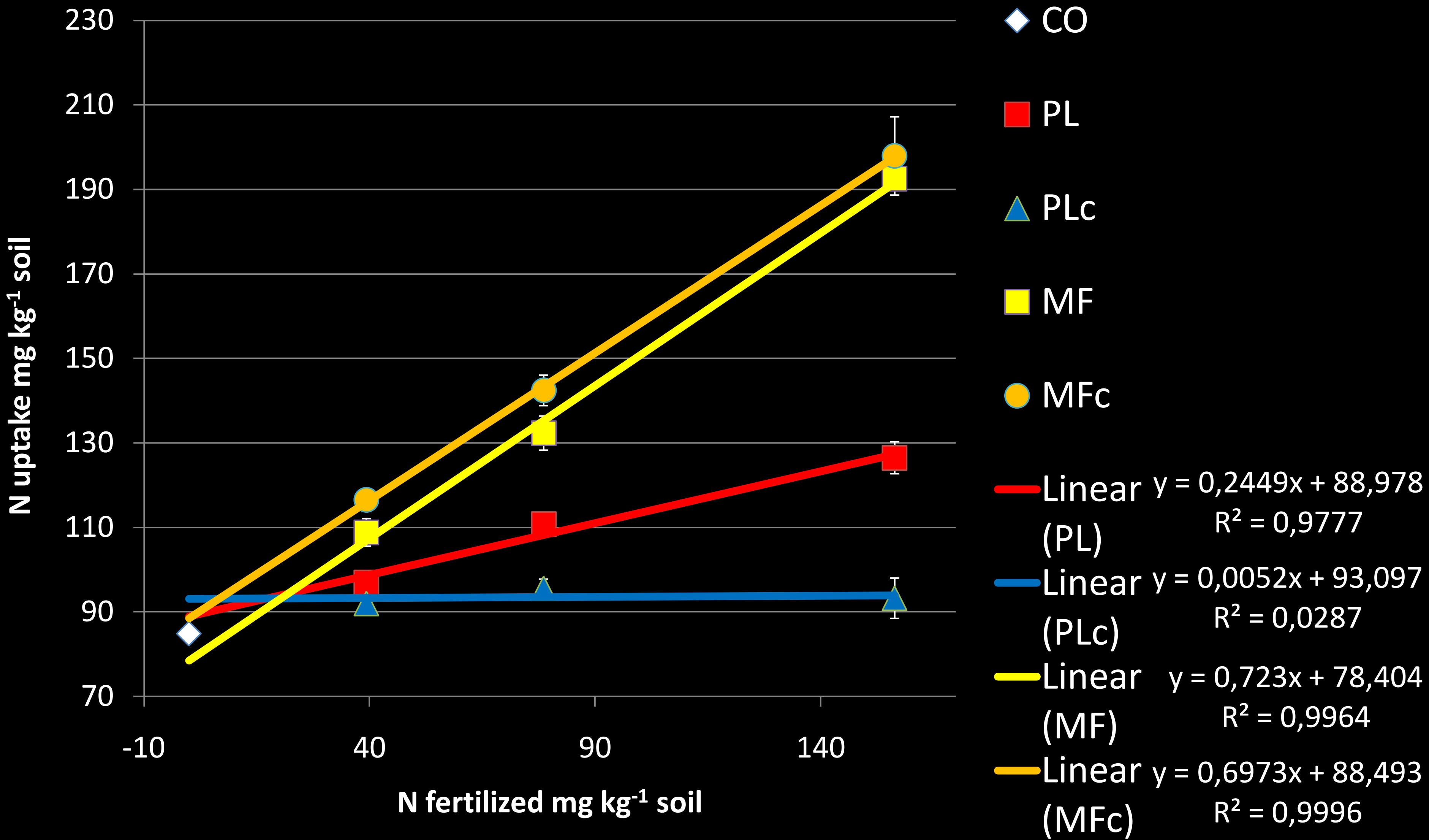
In addition one unfertilized control

Nitrogen fertilization efficiency

Five plants per pot, 4 replicates
First harvest 72 days after planting, thereafter once a month for 3 consecutive harvests

Chromi-Alumic Acrisol = Fine, kaolinitic, thermic Typic Kanhapludults

Results N uptake in relation to N fertilized

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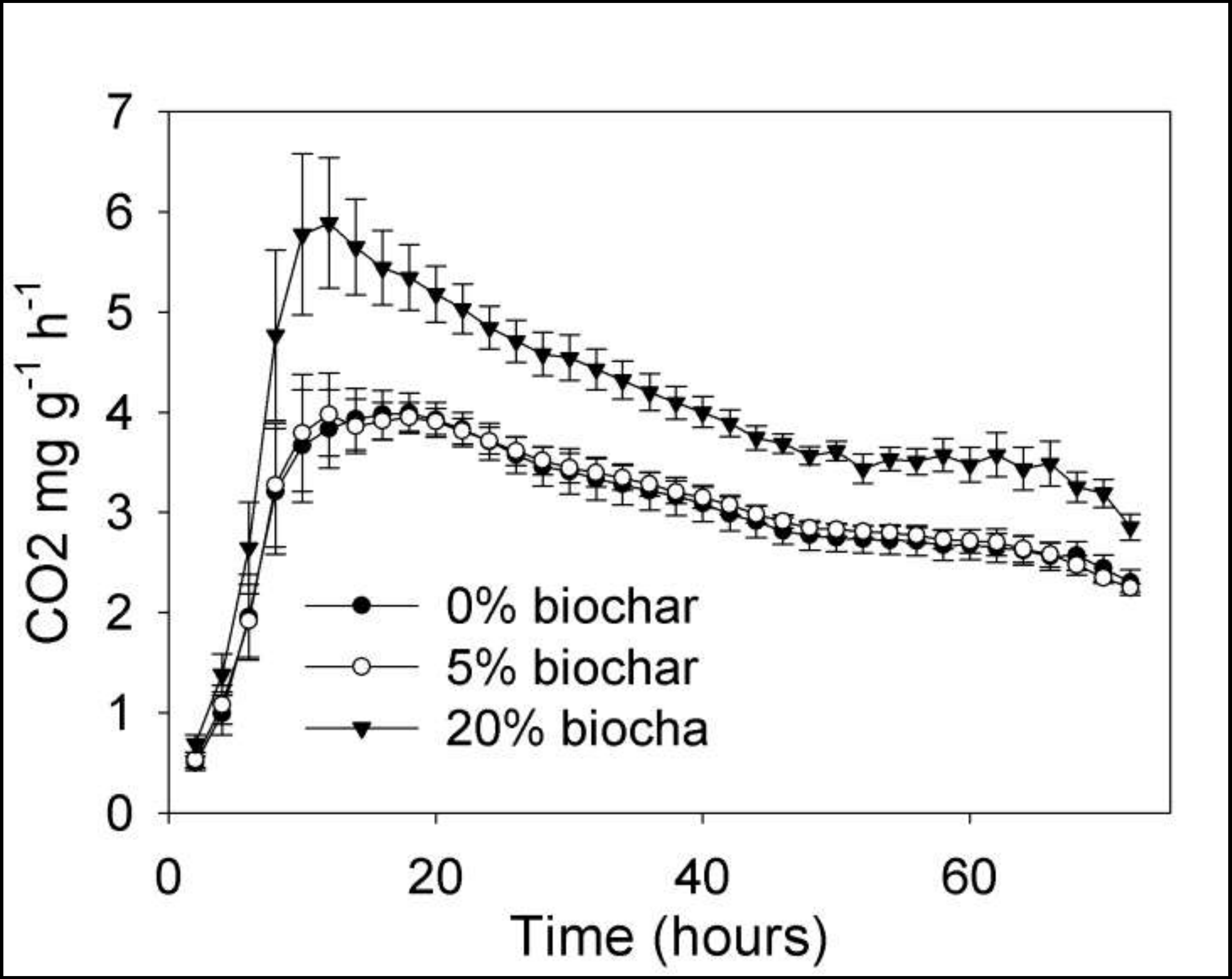
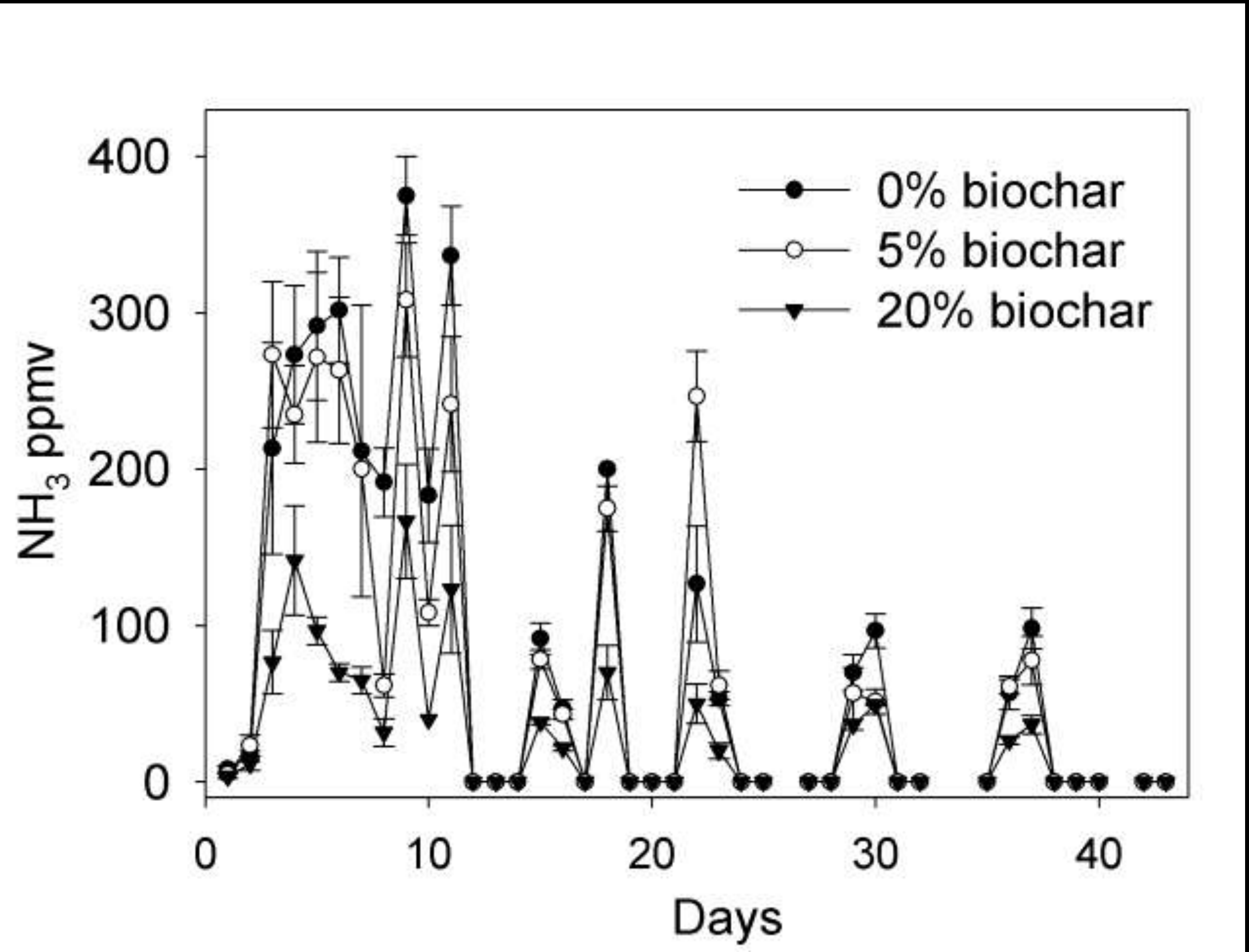
Biochar as Bulking Agent in composting

Faster decomposition increased respiration



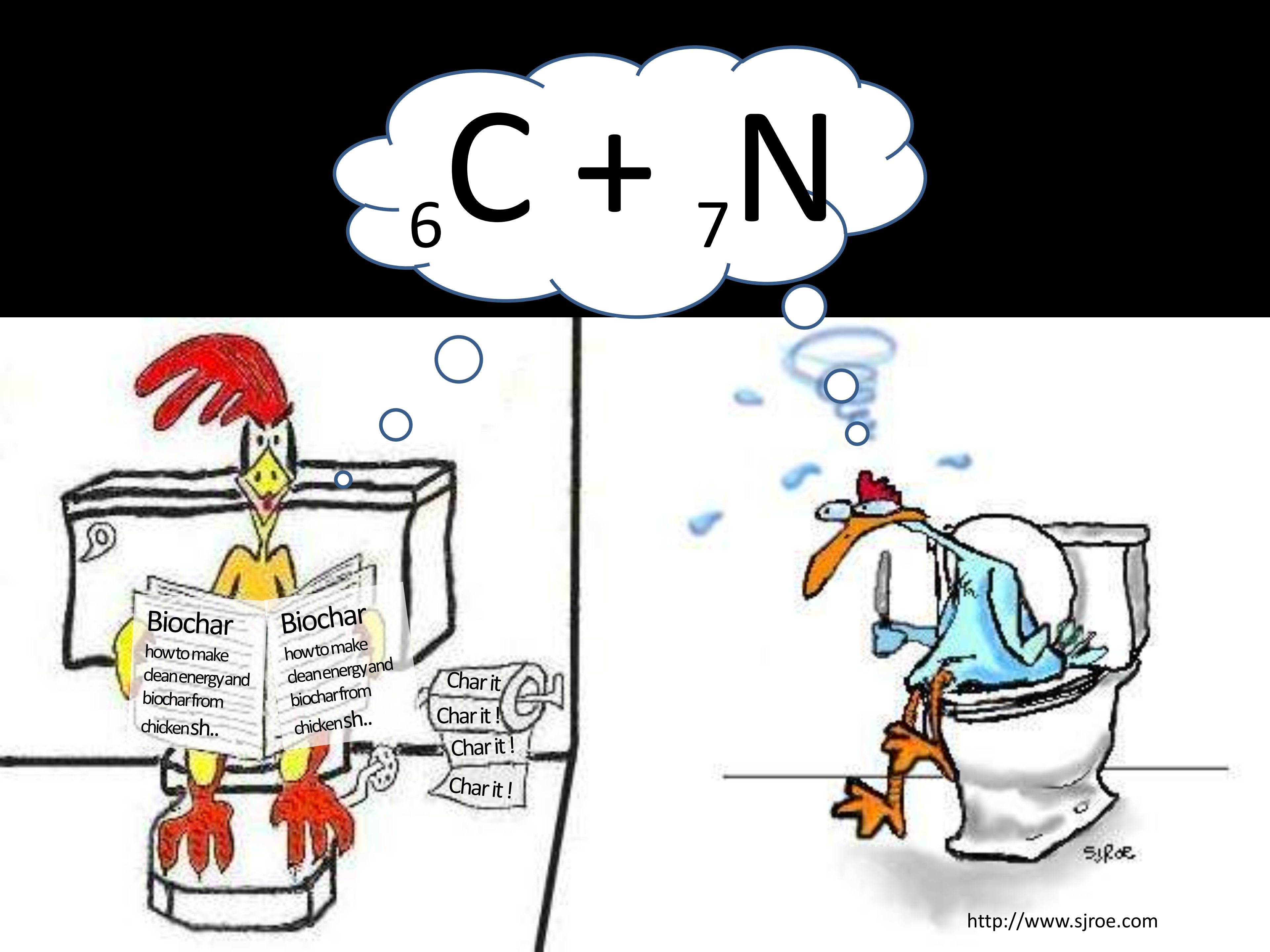
Reduced Nitrogen Losses with 20% biochar



Ammonia emissions reduced by up to 64%

Total N losses reduced by up to 52%

Compost with and without biochar



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