Engineering Conferences International
ECI Digital Archives

Biochar: Production, Characterization and Applications | Proceedings

8-20-2017

Agronomic benefits and detriments of using biochar

Carlo Grignani
University of Turin, Italy

Raghunath Subedi
University of Turin, Italy

Chiara Bertora
University of Turin, Italy

Laura Zavattaro
University of Turin, Italy

Agronomic benefits and detriments of using biochar

Carlo Grignani,

Raghunath Subedi, Chiara Bertora, Laura Zavattaro

Dep. of Agricultural Forest and Food Sciences

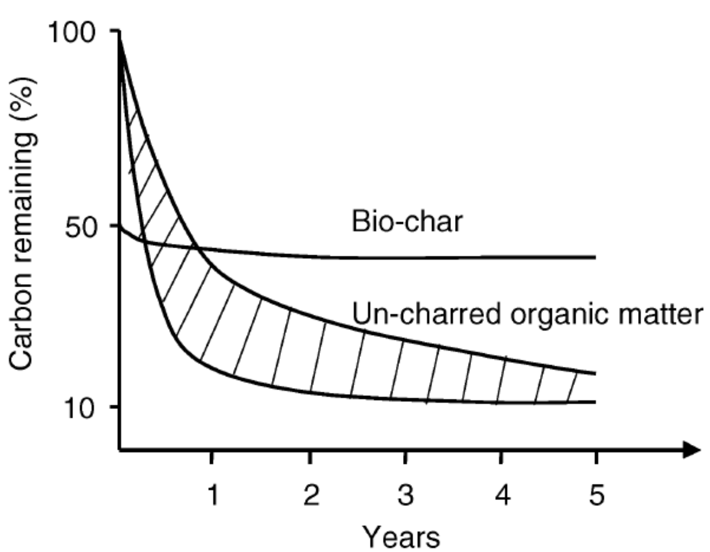
University of Turin

Engineering Conferences International

Biochar: Production, Characterization and Application Alba, August 20-25, 2017

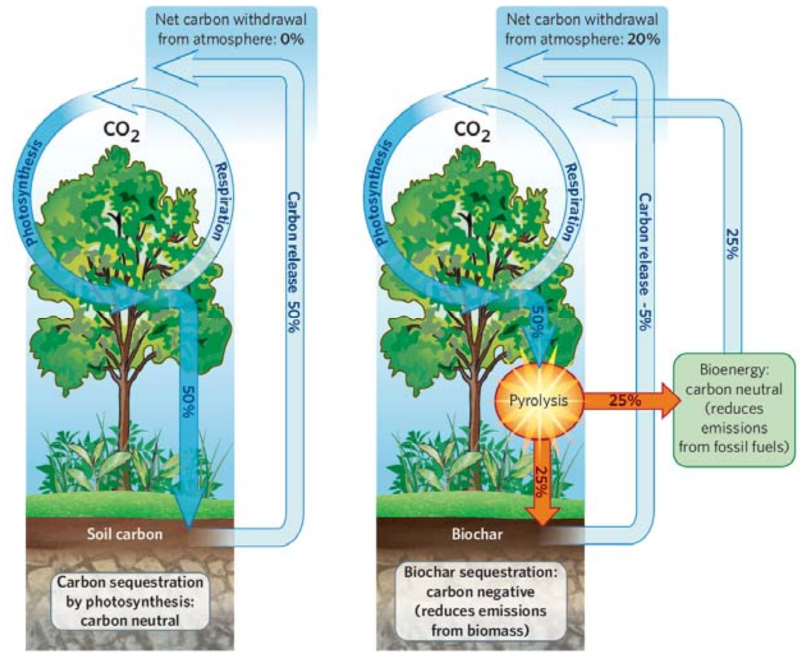
The traditional vision of biochar

SOIL FERTILITY



Lehmann et al. 2006, Mit. Adapt. Strat. Global Change

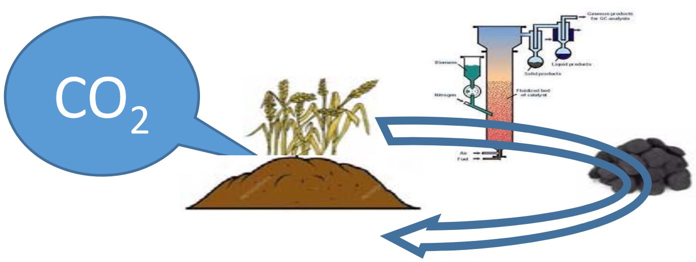
BIOENERGY



Lehmann 2007, Nature Commentary

The traditional vision of biochar

C STORAGE



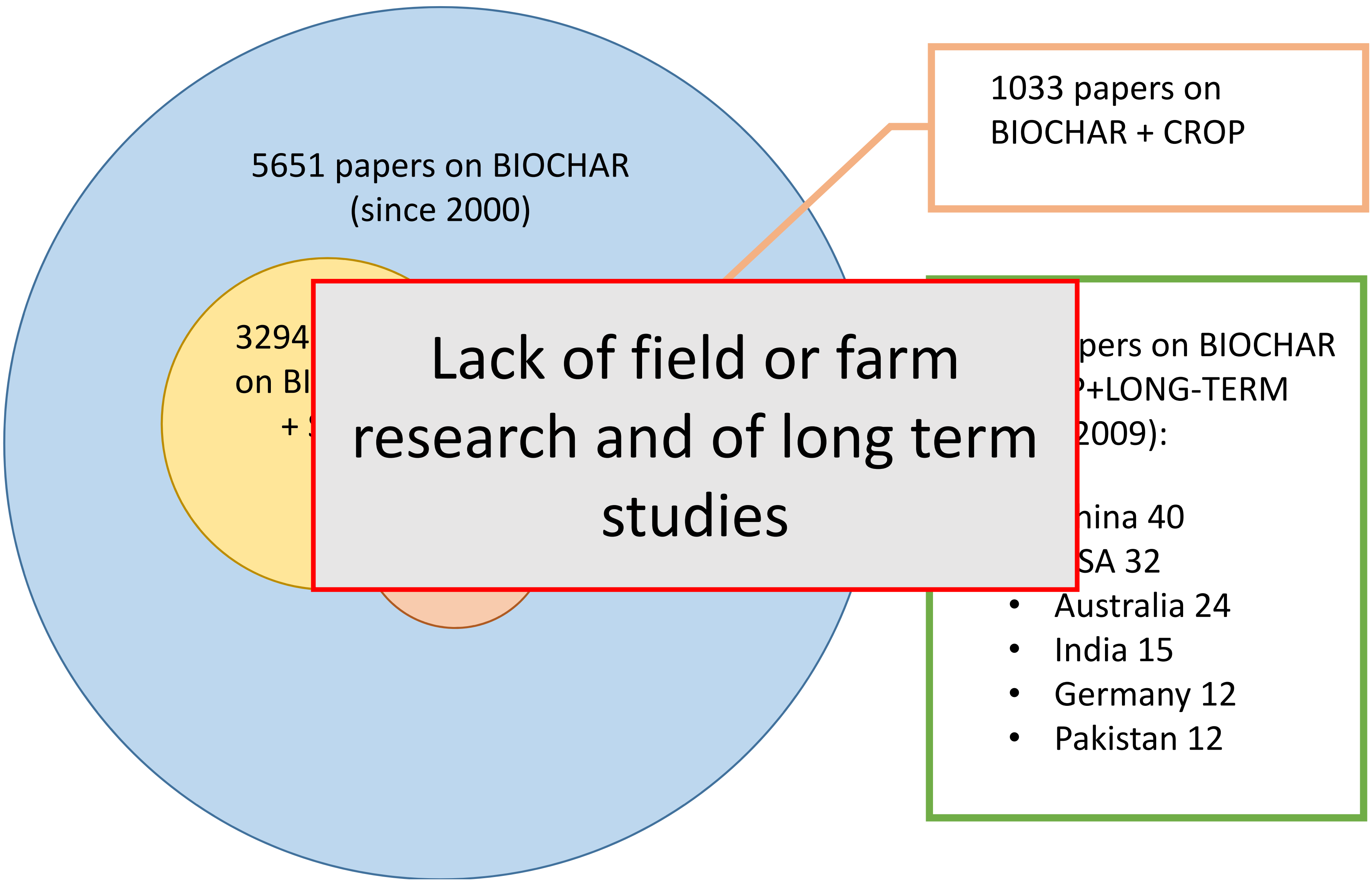
OTHER ECOSYSTEM SERVICES

- Give value to wastes: sanitisation, use by-products of renewable-energy, waste management
- Reduce problems of contaminated soils

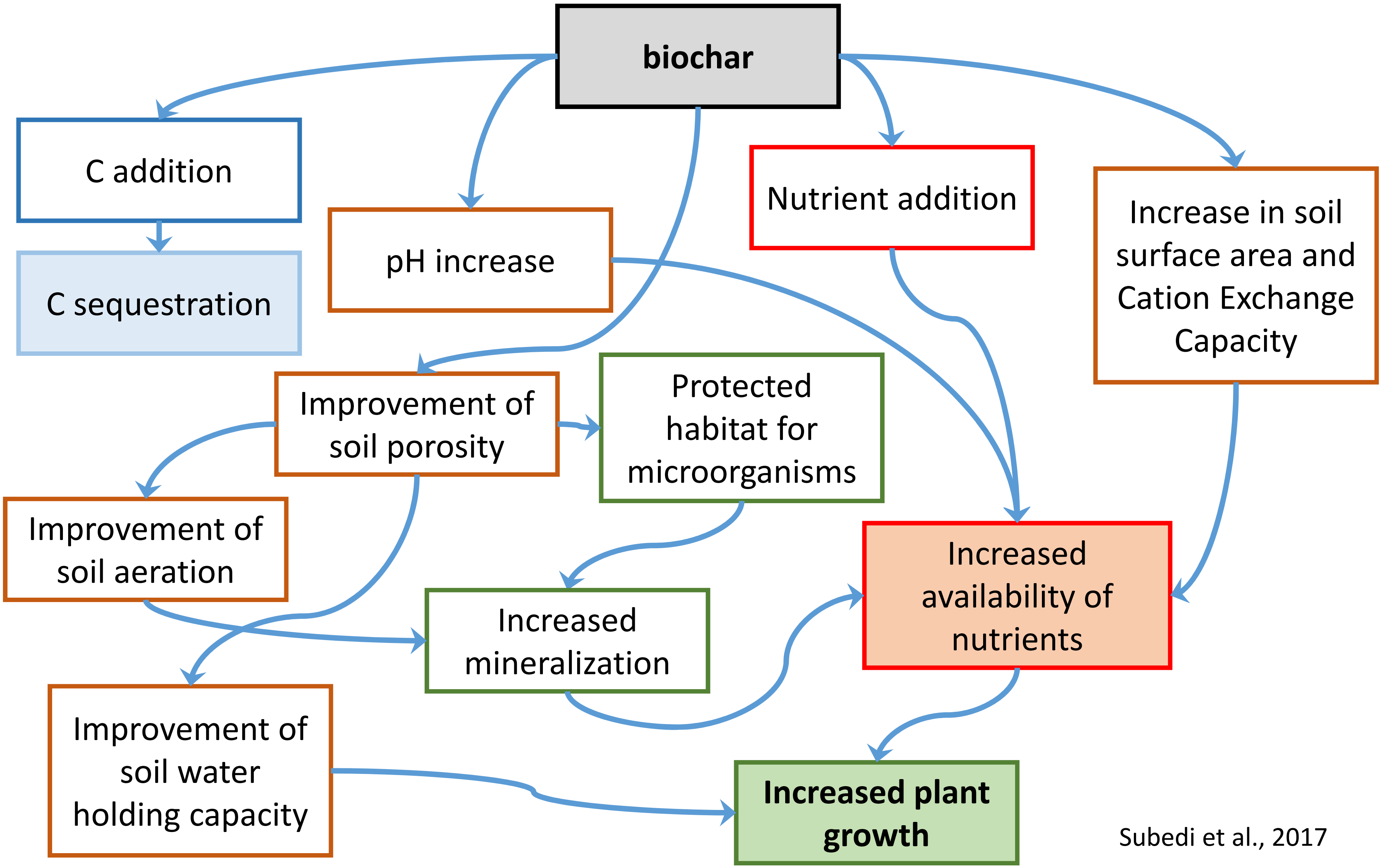
Why farmers do not ask for more biochar? Is it "only" science?

...all that glitters is not gold

Biochar papers in Scopus



Biochar influences soil and crop



Subedi et al., 2017

Expected Benefits to Plants

Due to improved soil physical characteristics:

- Available water, aeration, root penetration

Due to improved soil chemical characteristics:

- Improved availability of nutrients

Due to improved soil biological characteristics :

- Soil microorganisms ensure better nutrient availability

Due to direct nutrient addition:

- Improved availability of nutrients

Due to indirect effects on soil biota:

- Improved microbiology and resistance to soil born pathogens

Subedi et al., 2017

Application of biochar and Crop response: a complex system

variability of biochar characteristics X variability of soil characteristics X variability of crop characteristics X variability of management practices

→ Crop response is difficult to predict

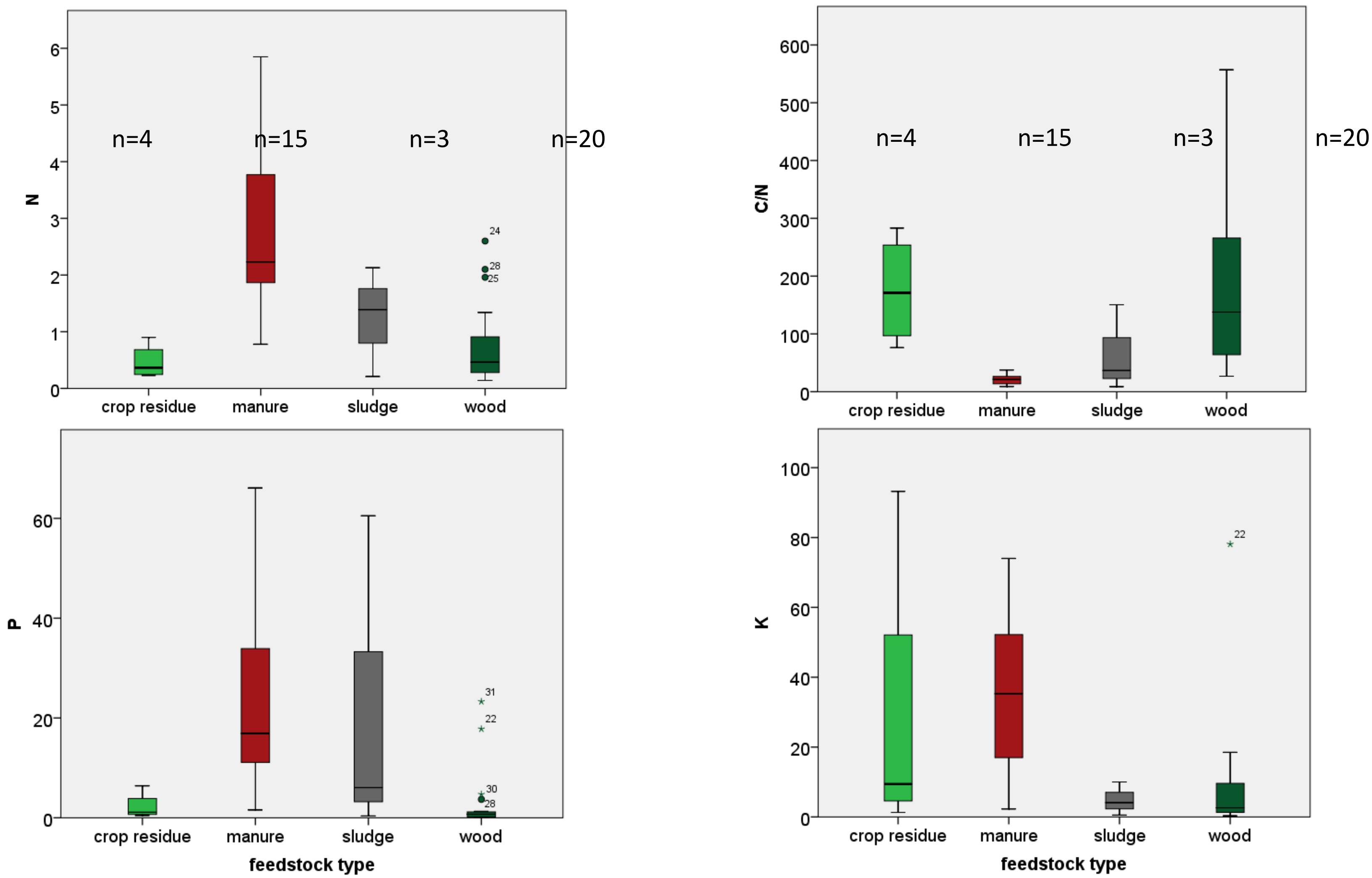
Subedi et al., 2017

Pyrolysis Conditions affects biochar

Parameters that increase at increasing Pyrolysis Temperature	
CEC	up to 500 °C
Porosity	up to 600 °C (anti-clogging of pore space)
Surface Area	up to 600 °C
P recov	fraction
Ash co	ter
pH	
Ca^{2+}, M	sh fraction
Heavy	
Param	
Biocha	
C recov	
N recov	
S recov	
Surface acidity	due to loss of acidic functional groups
CEC	At PT > 500 °C due to loss of acidic functional groups
Porosity	At PT > 600 °C due to collapse of pore and surface structures
Surface Area	At PT > 600 °C due to collapse of pore structure

However, biochar characteristics are not always easy to predict for agronomic use! Give farmers homogeneous quality groups of biochar

Feedstock type affects biochar



Structure vs Nutrient

Modified from Subedi et al., 2017

Feedstock types

- Bioenergy Crops: no
- Crop, food or wood wastes, agroindustry by-products : Yes
- Manure: to improve transferability from excess
- Other wastes….: ?
- In all cases: sufficient quantity and quality

Application of biochar and Crop response: a complex system

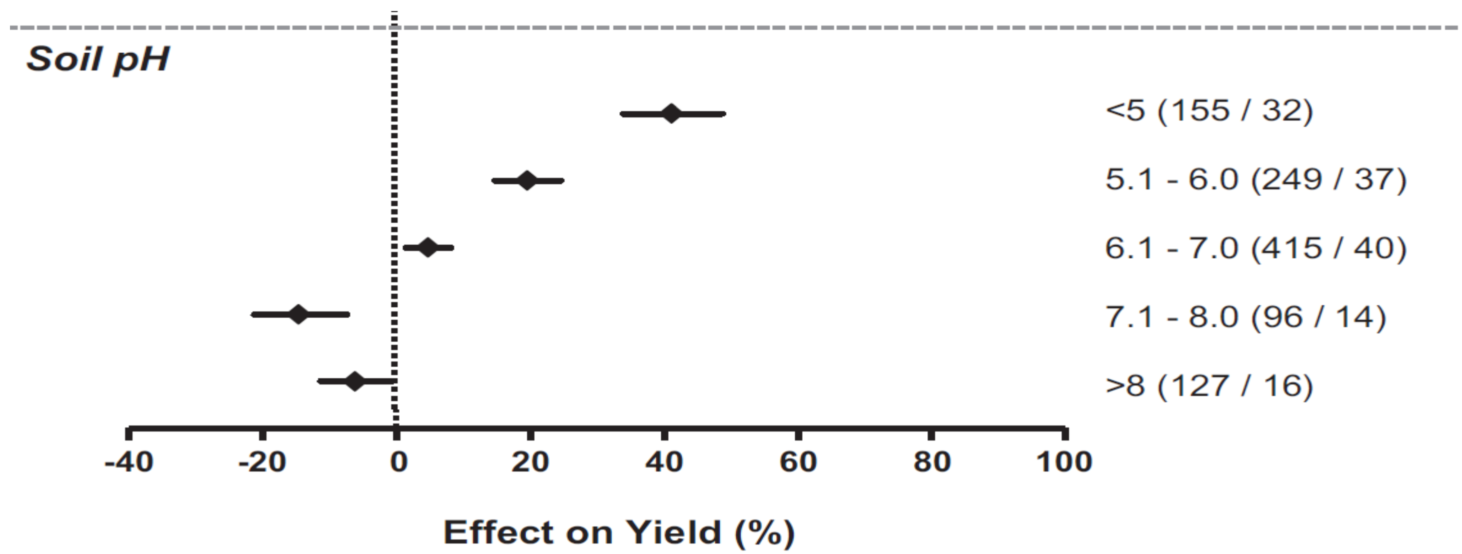
variability of biochar characteristics X variability of soil characteristics X variability of crop characteristics X variability of management practices

→ Crop response is difficult to predict

Subedi et al., 2017

Crop response to biochar and soil pH

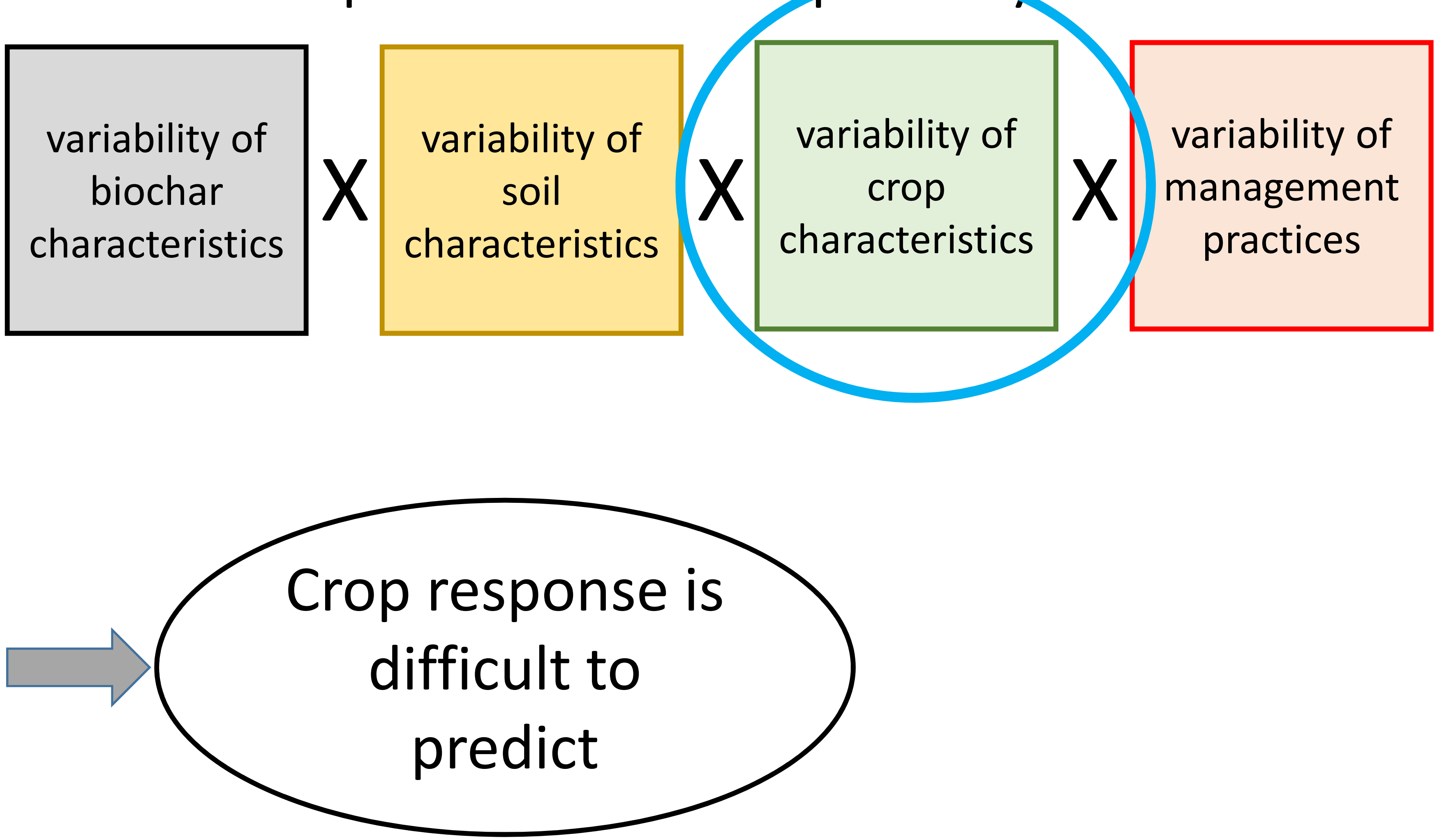
Crop productivity as a percentage of the control for five pH soil classes (n. comparisons/n. publications)



Other effects associated to soil texture: sandy soil more reactive than finer soils (water effects, particle larger surface area)

Jeffrey at al. 2017, Envir. Res. Lett.

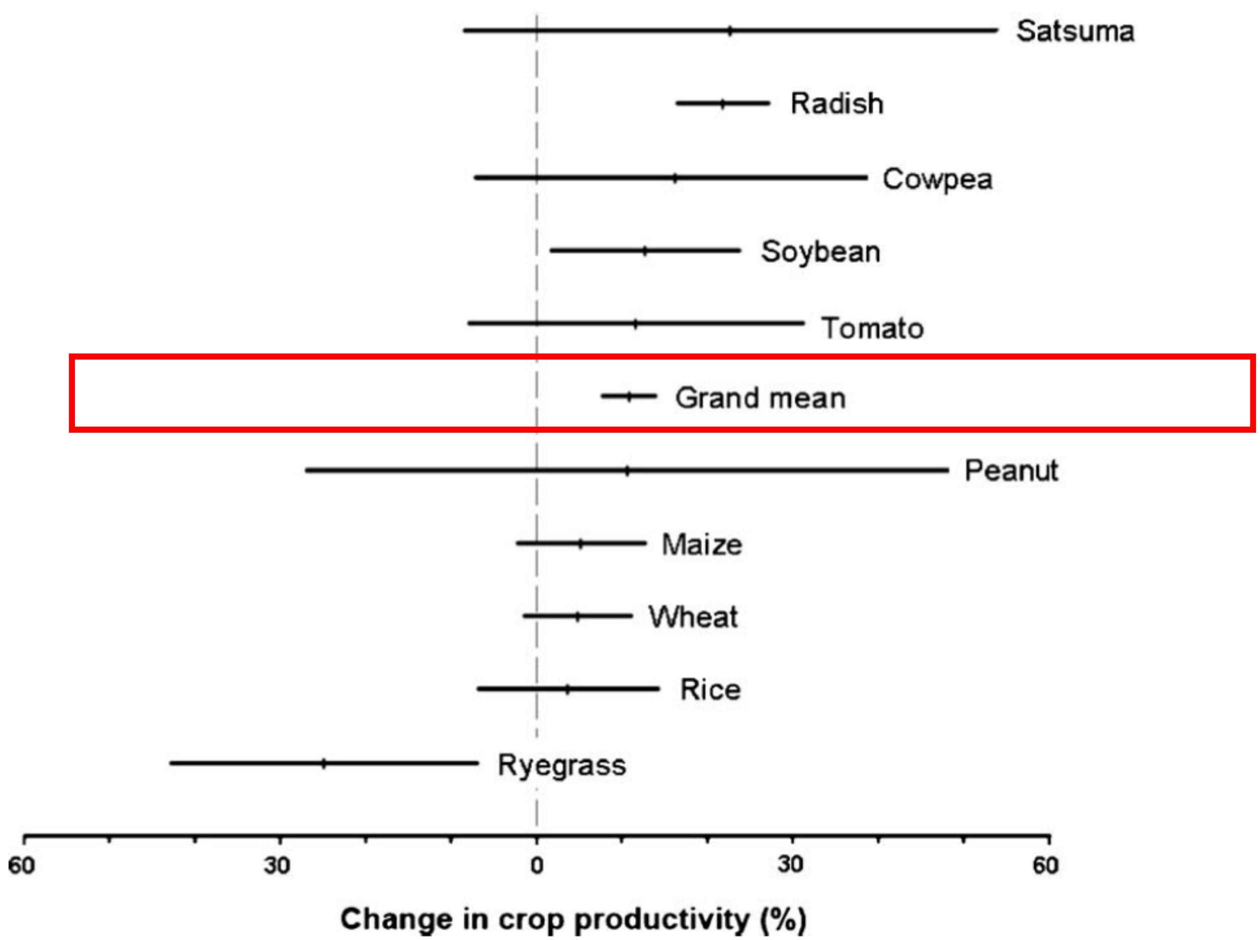
Application of biochar and Crop response: a complex system



Subedi et al., 2017

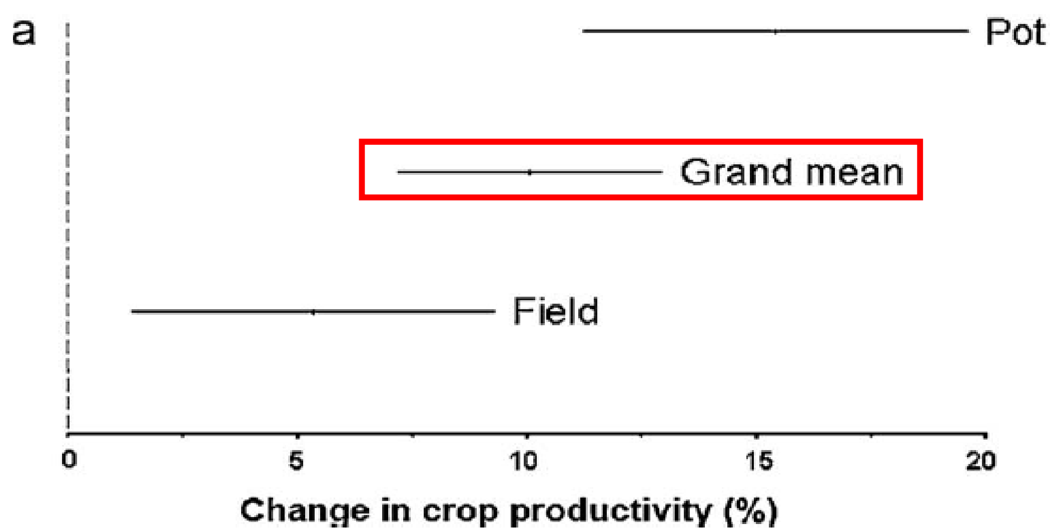
Different Crop responses to biochar

Crop productivity as a percentage of the control for some wide spread cultivated species



Jeffrey at al. 2011, J. Agric. Ecos. Environ.

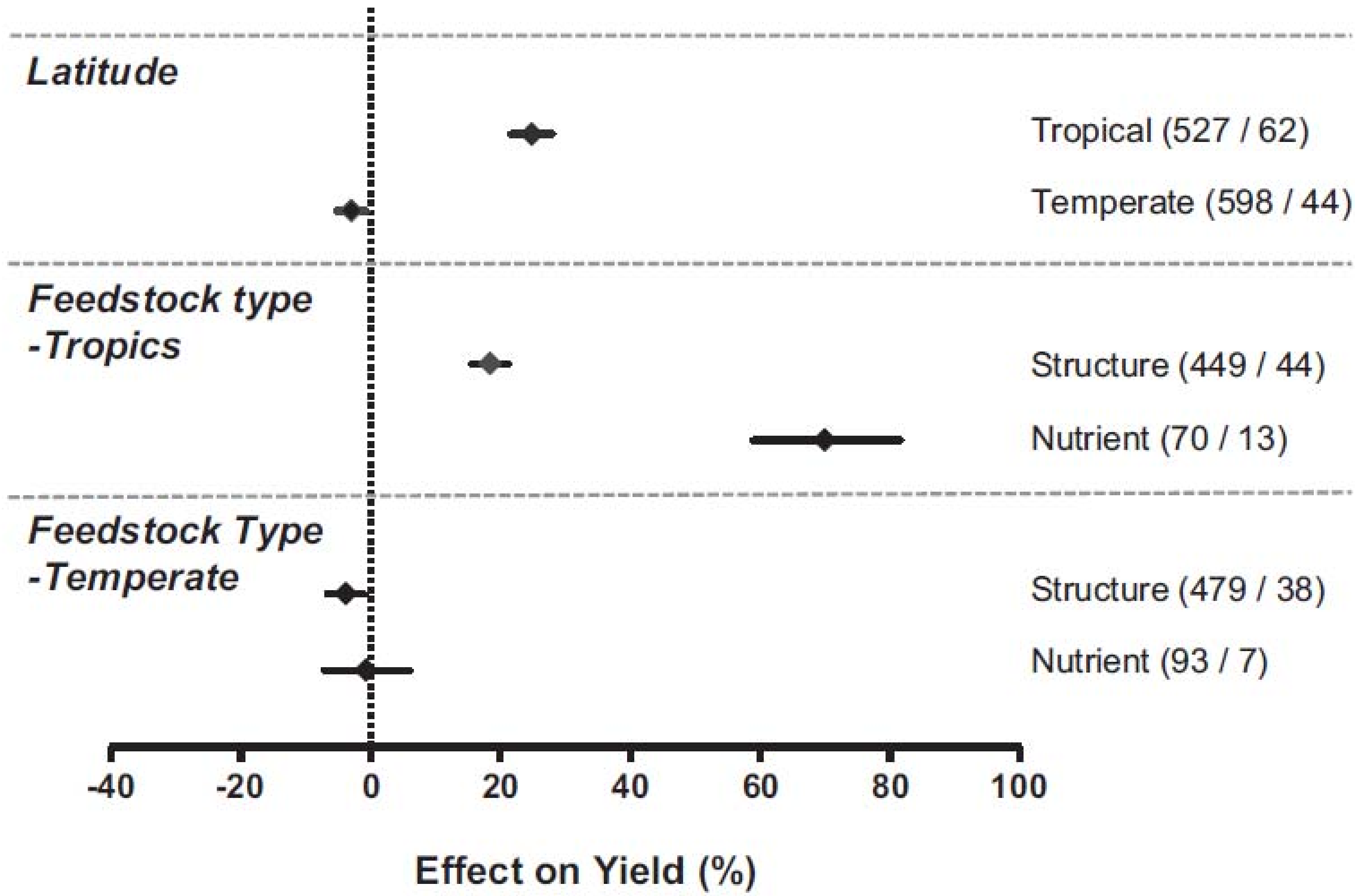
Need for field research on crop effects



Jeffrey at al. 2011, J. Agric. Ecos. Environ.

Tropical vs temperate biochar effects on crops

Crop productivity as a percentage of the control



Jeffrey at al. 2017, Envir. Res. Lett.

Application of biochar and Crop response: a complex system

variability of biochar characteristics X variability of soil characteristics X variability of crop characteristics X variability of management practices

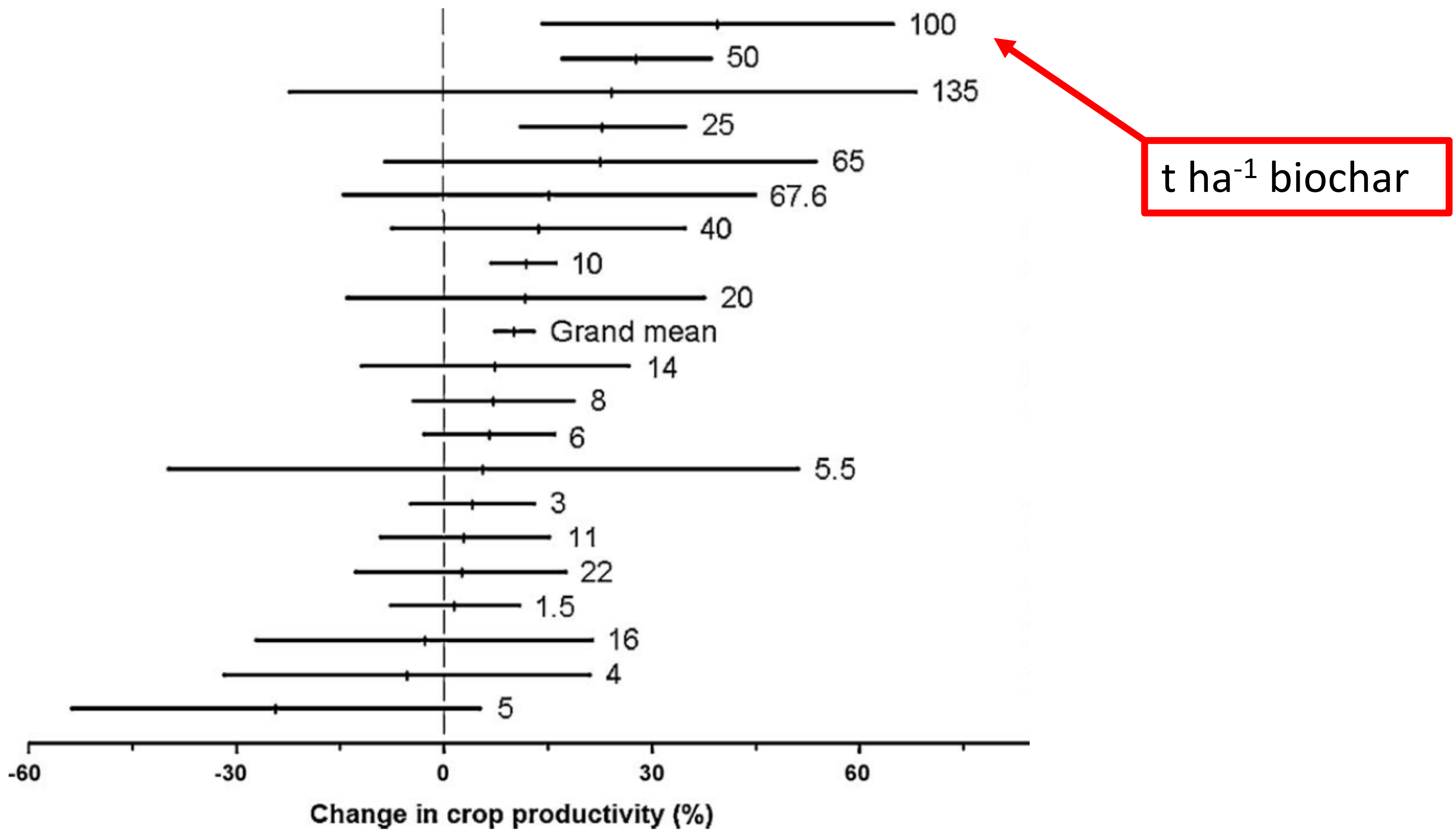
- Amount
- Interaction with fertilization
- Incorporation depth
- Timing
- Particle size
- Interaction with tillage
- Elapsed incorporation time
- Type of experiment
- Environmental conditions

Crop response is difficult to predict

Subedi et al., 2017

Crop response to biochar application rates

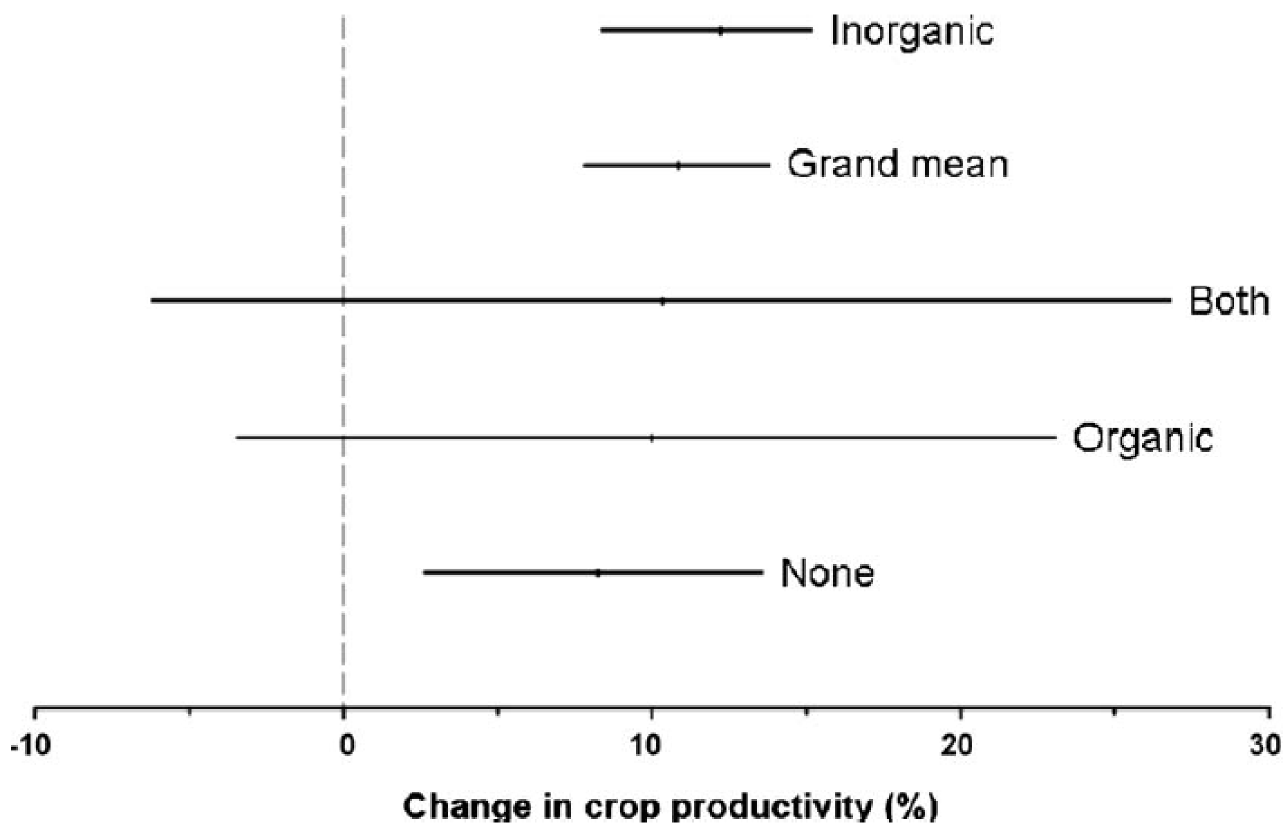
Crop productivity as a percentage of the control (meta-analysis of 782 replicates in 177 treatments)



Jeffrey at al. 2011, J. Agric. Ecos. Environ.

Response to biochar-fertiliser interactions

Crop productivity as a percentage of the control (meta-analysis of 7632 replicates in 172 treatments)



Jeffrey at al. 2011, J. Agric. Ecos. Environ.

Threats to agricultural use

Direct addition of toxic compounds for soil life

- Volatile organic compounds (VOCs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Polychlorinated benzenes (PCBs)
- Heavy metals
- Excessive salinity (Na^+)

Excessive liming effect (in alkaline soils)

Immobilization

- Absorption of pesticides
- Absorption of metals (imbalance in plant nutrition)

Production of dust at application

Subedi et al., 2017

Major problem: heavy metals

Several biochars in the scientific literature do not respect quality standards

Element	> International Biochar Initiative threshold (IBI, 2014)	> European Biochar Certificate threshold (EBC, 2012)	n
As	36%	0	11
Cd	11%	11%	37
Cr	7%	3%	29
Cu	45%	38%	40
Pb	5%	5%	37
Mn	0	0	23
Mo	80%	0	10
Ni	16%	21%	38
Zn	51%	41%	39
PAH	0	0	12

Subedi et al., 2017

Is Biochar really climate-friendly?

C sink

What about GHG?

In most cases biochar mitigates N_2O emissions

M.L. Cayuela et al. / Agriculture, Ecosystems and Environment 191 (2014) 5–16 11

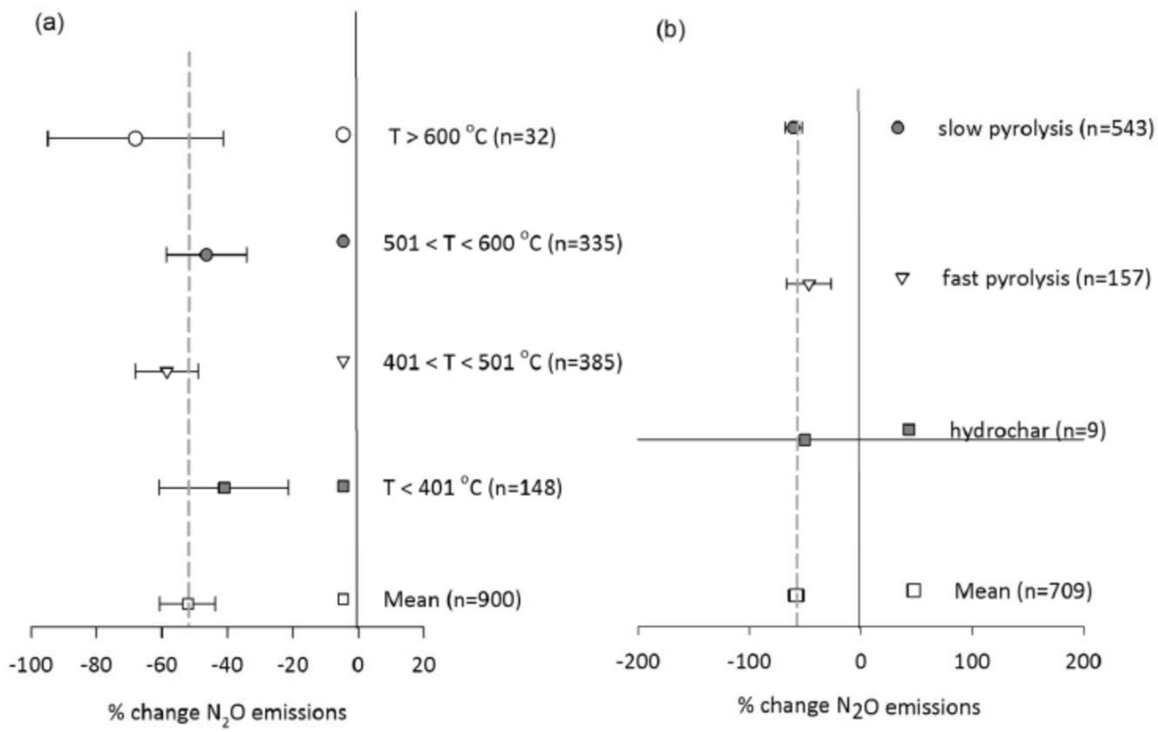
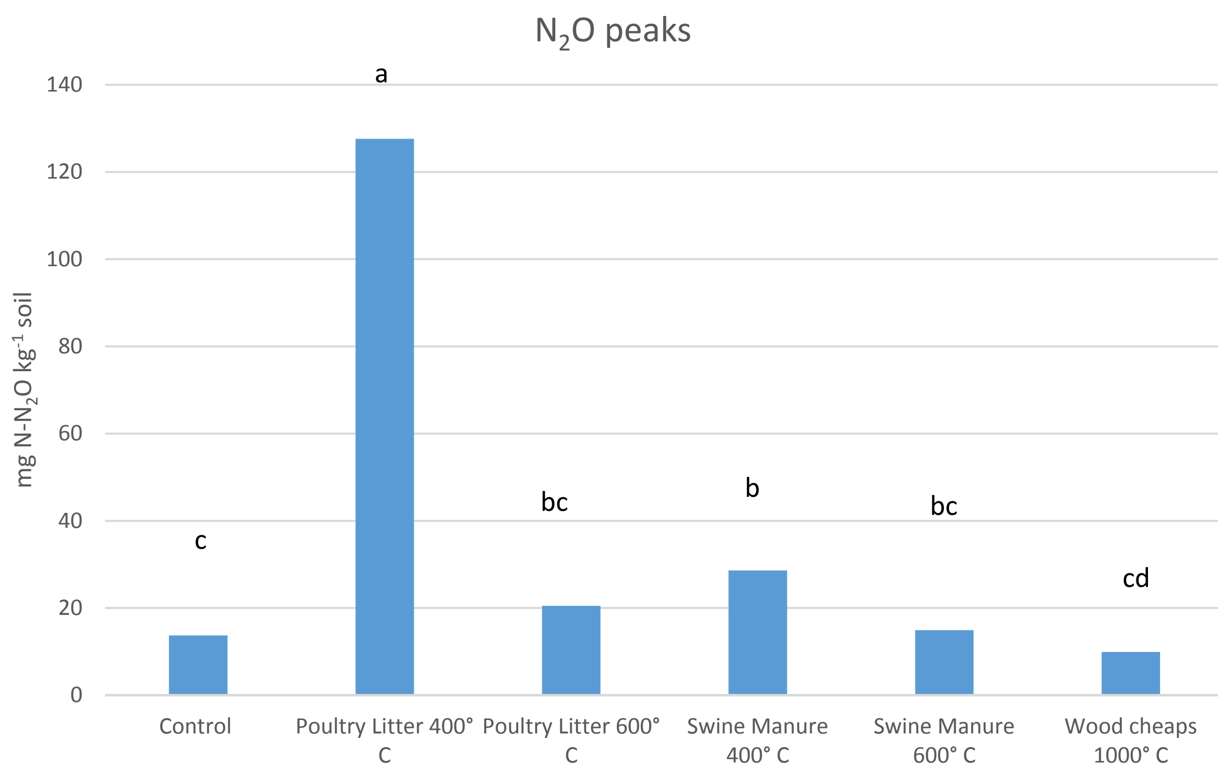


Fig. 2. Mean change in N_2O emissions depending on the reported temperature of pyrolysis (a) and the type of pyrolysis (b). Symbols represent mean effect sizes (percentage of change in N_2O emitted) with 95% confidence intervals (Rosenthals' Fail Safe N: 9824 and 7004 for (a) and (b) respectively). The numbers shown in parentheses correspond to observations in each class upon which the statistical analysis is based. The dotted line indicates the mean effect size for all temperatures (a) and type of pyrolysis (b).



it depends on biochar properties

Conclusions

Effects on soil and crop

- Generally positive, but very variable; need for biochar characterization
- Better acidic and sandy soil; better for tropical conditions
- Need for long term studies, need for information on management

Effects on soil life

- Variable but not negative

Effects on the environment

- Positive for GHG, but not for “nutrient biochar”
- Questionable for HM and some organic compound

Effects on the agro-systems

- Biochar availability: only wood derived biochar?
- Biochar does not exist: biochar**S** exist
- Biochar acceptability (use of wastes, need for engineering energy production)
- Longevity effects of biochar applications: almost unknown

Thank you for your attention

Frontiers special issue

Frontiers will be launching a series of Research Topics for
Waste Management in Agrosystems section

Prof. Lars Stouman Jensen (DK) and Carlo Grignani (I) coordinate the topic
End-user requirements for recycling, bio-based fertiliser products

carlo.grignani@unito.it