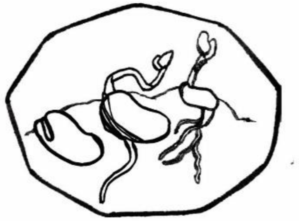
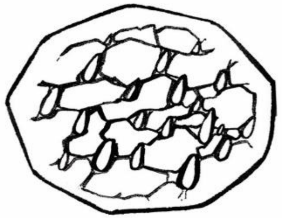
CHARCOAL'S ROLE in SOIL RESILIENCY

Charcoal stores the carbon that plants absorb in a stable form that lasts in soils for up to 10,000 years, keeping it from the atmosphere and providing benefits in our soils for millennia



PLANT GERMINATION

Charcoal's black color warms soils in early spring

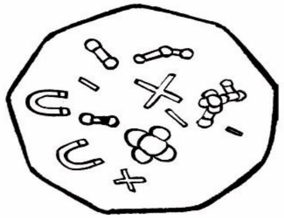


WATER RETENTION

Charcoal's absorptive structure provides increasing stability in soil moisture

SOIL BIOLOGY

Charcoal has been shown to increase soil microbes that process minerals, resulting in plants absorbing higher amounts of nutrients

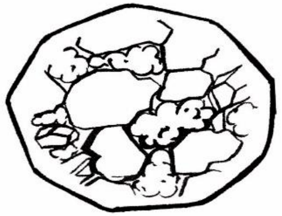


NUTRIENT RETENTION

Each micropore holds an electrical charge that bonds with soil nutrients to keep minerals in the topsoil layers

ORGANIC MATTER

Charcoal's micropores absorb organic matter

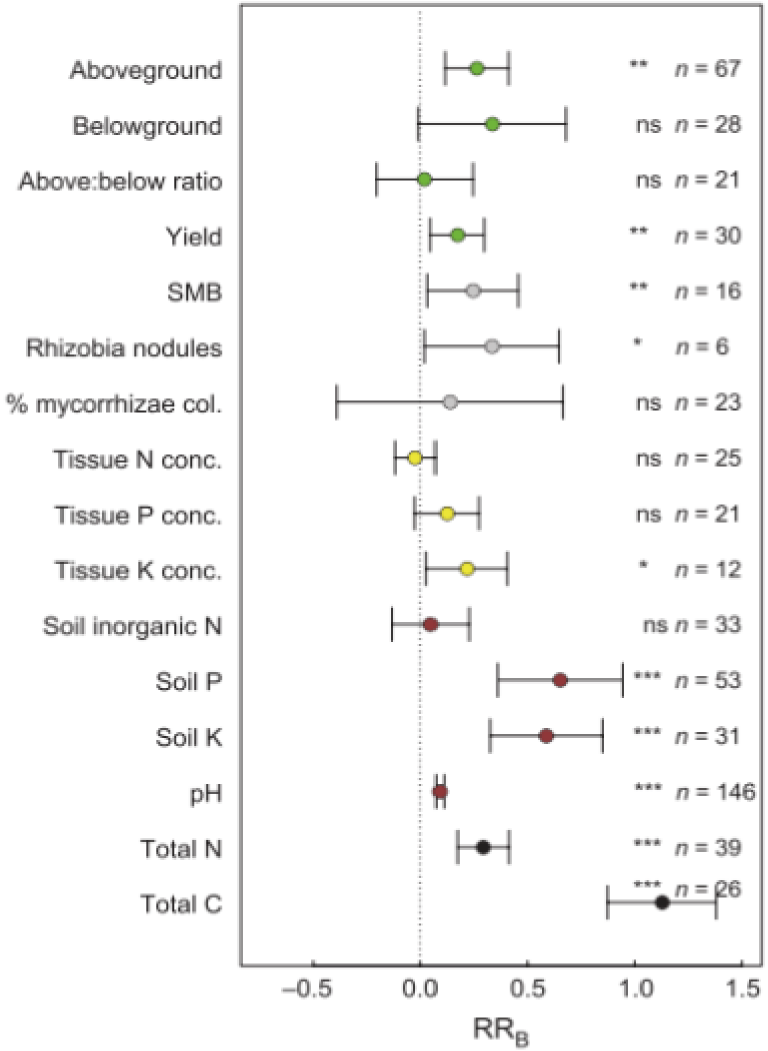


OXYGENATION

Micropores increase soil oxygen-ation, beneficial for saturated growing areas

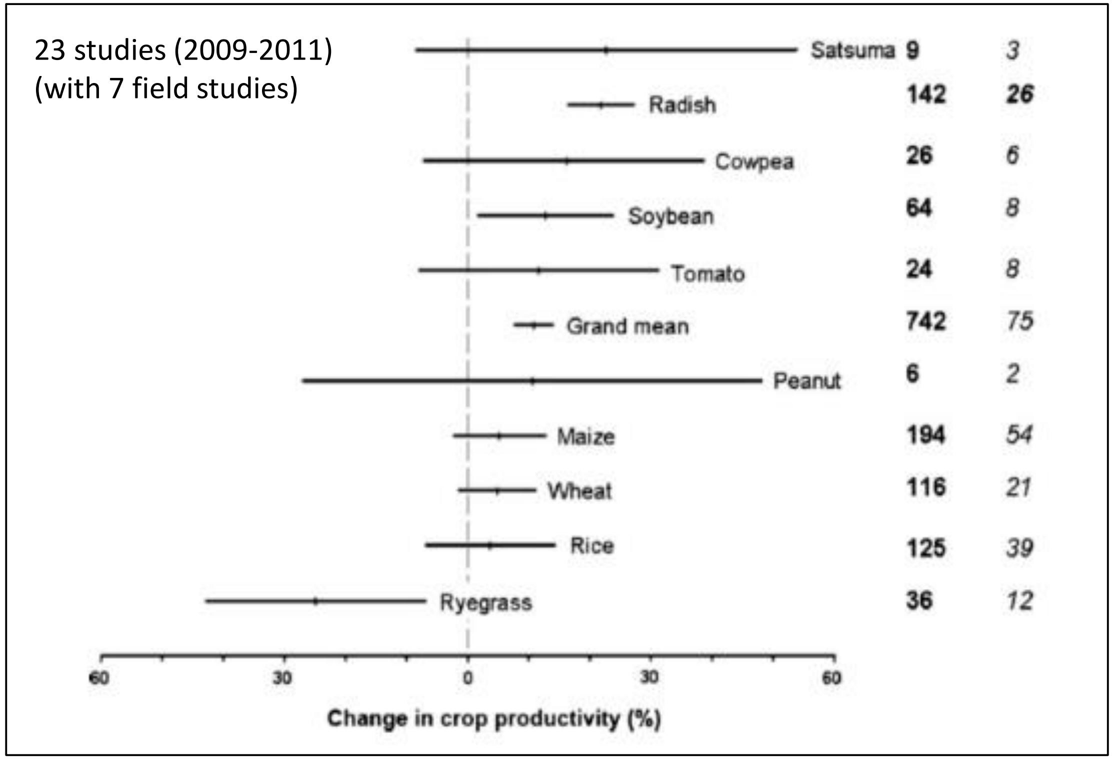

TERRA PRETA
NORMAL
BIOCHAR SOILS OF THE AMAZON
Glaser *et al*., 2007

Biochar Meta-Anlysis Studies:



RR_B = relative biochar effect = ln (Biochar/Control)
371 Independent studies

Biederman *et al.*, 2013
GCB Bioenergy



Jeffery *et al.*, 2011
Agriculture, Ecosystems & Environment

Key Meta-Analysis Papers

- An analysis done by Dr. Humin Zhou et al. in 2017 found that biochar increased Microbial Biomass Carbon an average of 26% from 413 academic research papers.
- Dr. Xiaoyu Liu and a series of other researchers published a paper examining 238 studies of biochar's influence on plant productivity. They found that vegetables increased by an average of 28.6%, and that legume crops, such as peas, beans, and vetch, increased productivity by an average of 30.3%.

Biochar Studies: Soil nutrient retentions

Biochar	Type of Study	Soils Characteristics	Observations	Citations
Corn stalks, 350 °C	Lab	Loam with low SOC level (0.79%)	29% decrease in NO_3^- leaching	(Kanthle et al. 2016)
Sewage sludge, 300 °C	Lab	Clay loam (Ultisol)	6.8%, 8.5%, 7.9% decrease in NH_4^+, PO_4^{3-}, K^+ leaching, respectively; 0.2% increase in NO_3^- leaching	(Yuan et al. 2016)
Sewage sludge, 500 °C	Lab	Clay loam (Ultisol)	19.4%, 6.4%, 12.9%, 12.1% decrease in NH_4^+, NO_3^-, PO_4^{3-}, K^+ leaching, respectively	(Yuan et al. 2016)
Sewage sludge, 700 °C	Lab	Clay loam (Ultisol)	35.9%, 9.7%, 23.7%, 23.4% decrease in NH_4^+, NO_3^-, PO_4^{3-}, K^+ leaching, respectively	(Yuan et al. 2016)
Filtercake biochar, 575 °C	Lab	Sandy clay loam	No biochar effect on NO_3^- leaching	(Eykelbosh et al. 2015)
Acacia whole-tree greenwaste biochar, 550 °C	Field	Loamy sand	No significant effect on NO_3^-, K^+ leaching, but significantly increased the concentration (34%) and flux (103%) of PO_4^{3-} leaching	(Hardie et al. 2015)
Giant reed biochar, 300-600 °C	Lab	Silt loam	2.9-11.4% and 7.0-15.4% decrease in NH_4^+-N, and NO_3^--N leaching, respectively	Zheng et al., 2015
Pig manure biochar and wood biochar, 600 °C	Lab	Sandy loam	24-26% decrease of NO_3^- leaching, no biochar effect on NH_4^+ leaching	(Troy et al. 2014)
Commercially produced from mixed feedstock of fruit trees, ~500 °C	Field	Silty clay loam	72% decrease in NO_3^- leaching, no effect on NH_4^+ leaching	(Ventura et al. 2013)

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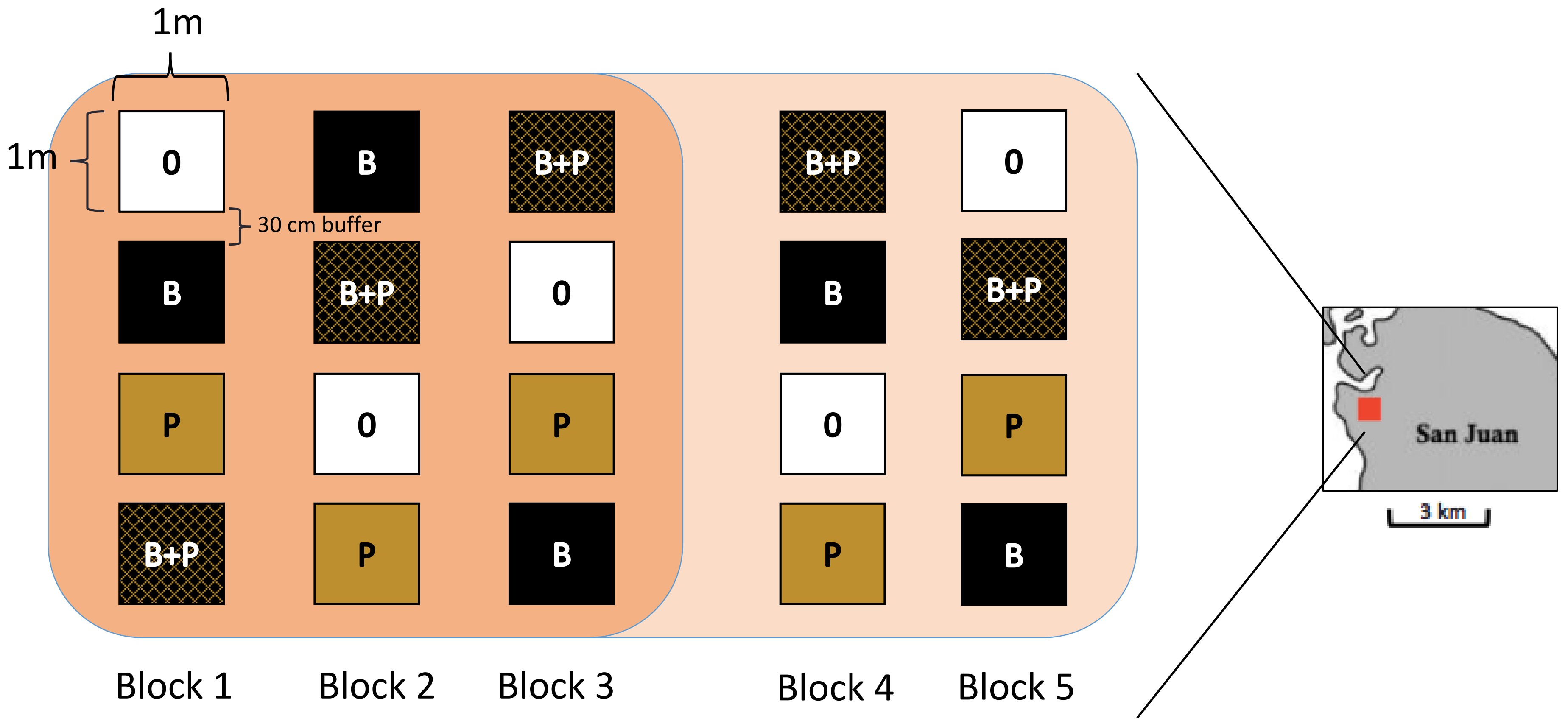
Gao & DeLuca, 2016
Advances in Plants & Agriculture Research

Key Considerations with Current Research

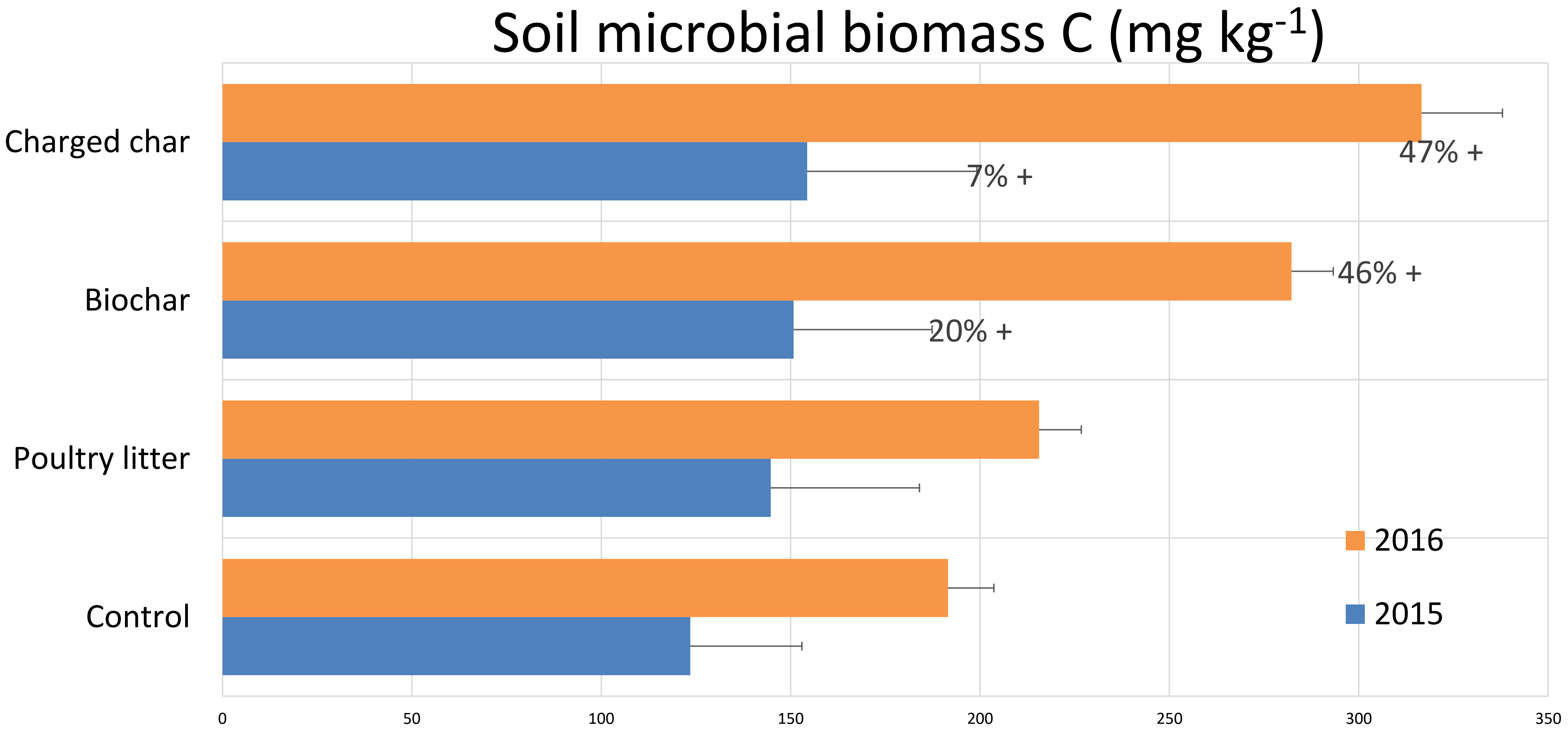
- The application of biochar to soils has also been shown to influence nutrient retentions.
- Short-term studies, pot and column trials in lab or greenhouse environment, very few are field studies.
- Also longer term field trials are in ag experiment stations using conventional farming approaches. Very few studies are conducted in the field in active organic farming systems and as a part of a holistic closed loop system.

Field Trials Design @ Each Farm

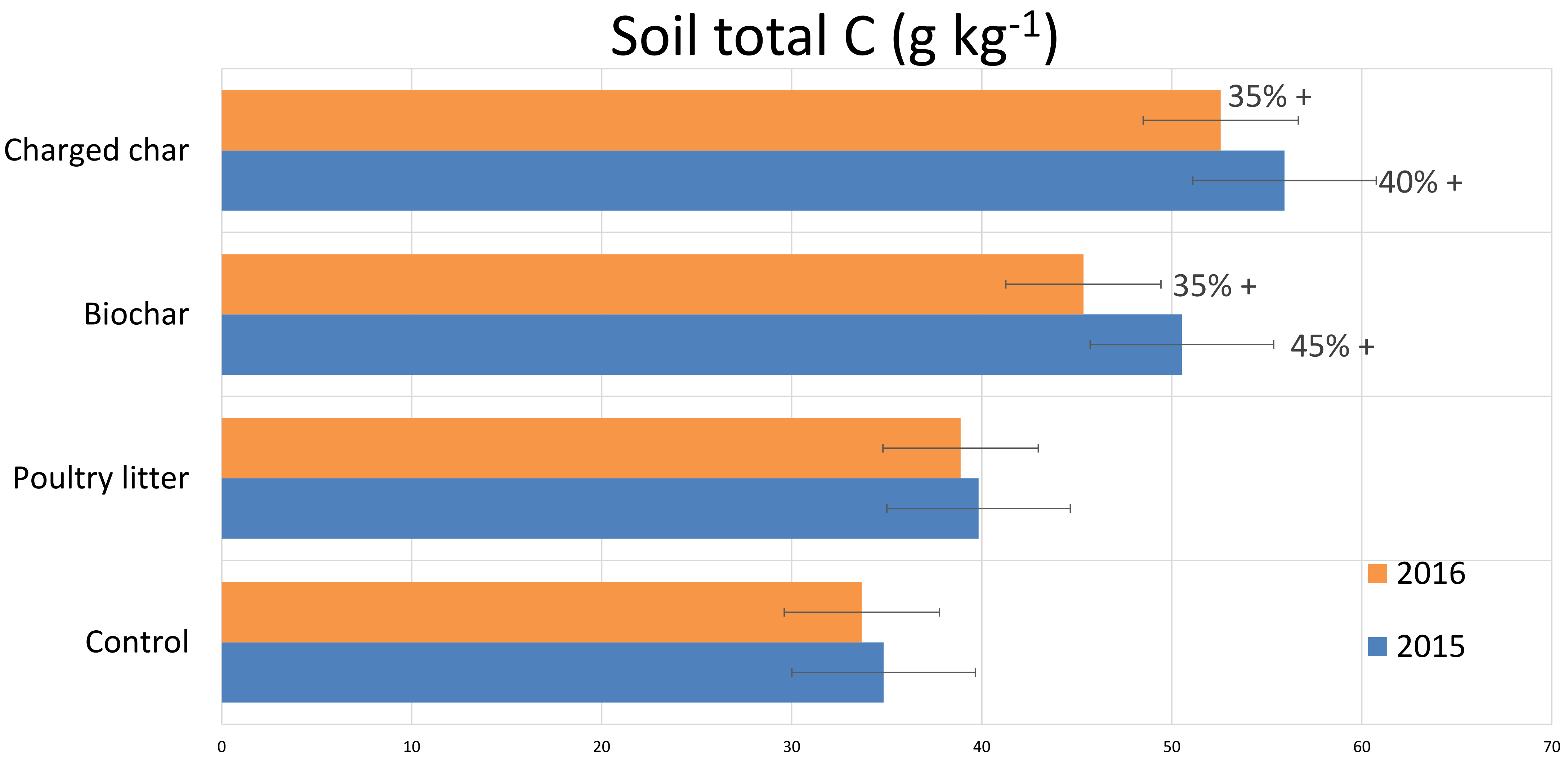


- 0 Control
- B Biochar (20 t ha^{-1})
- P Poultry litter (70 kg N ha^{-1} poultry litter)
- B+P Biochar charged with poultry litter (20 t ha^{-1} + 70 kg N ha^{-1})


Photo: Si Gao

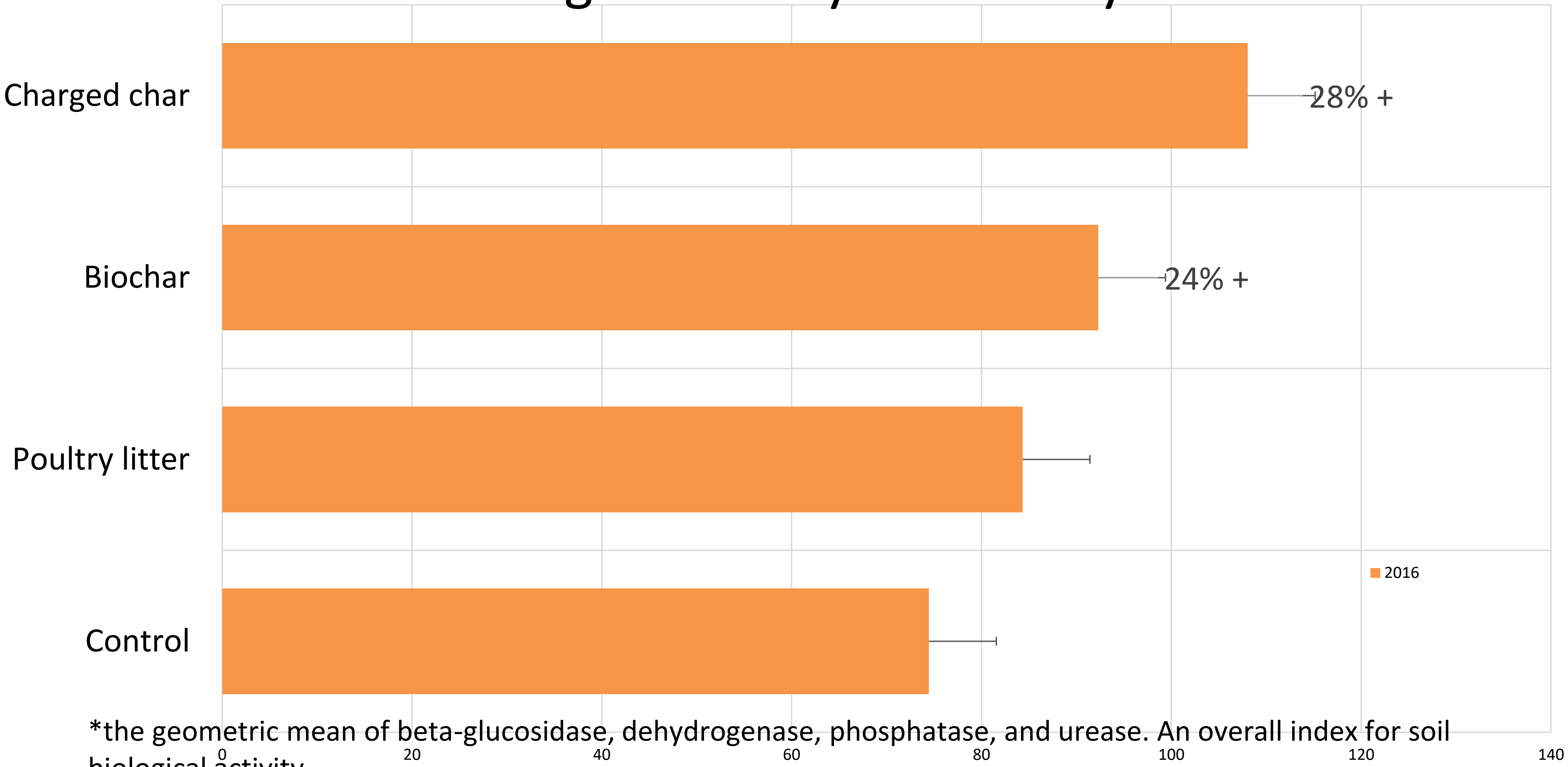


Soil microbial biomass C (mg kg-1)
Charged char
Biochar
Poultry litter
Control
47% +
7% +
46% +
20% +
2016
2015
0
50
100
150
200
250
300
350



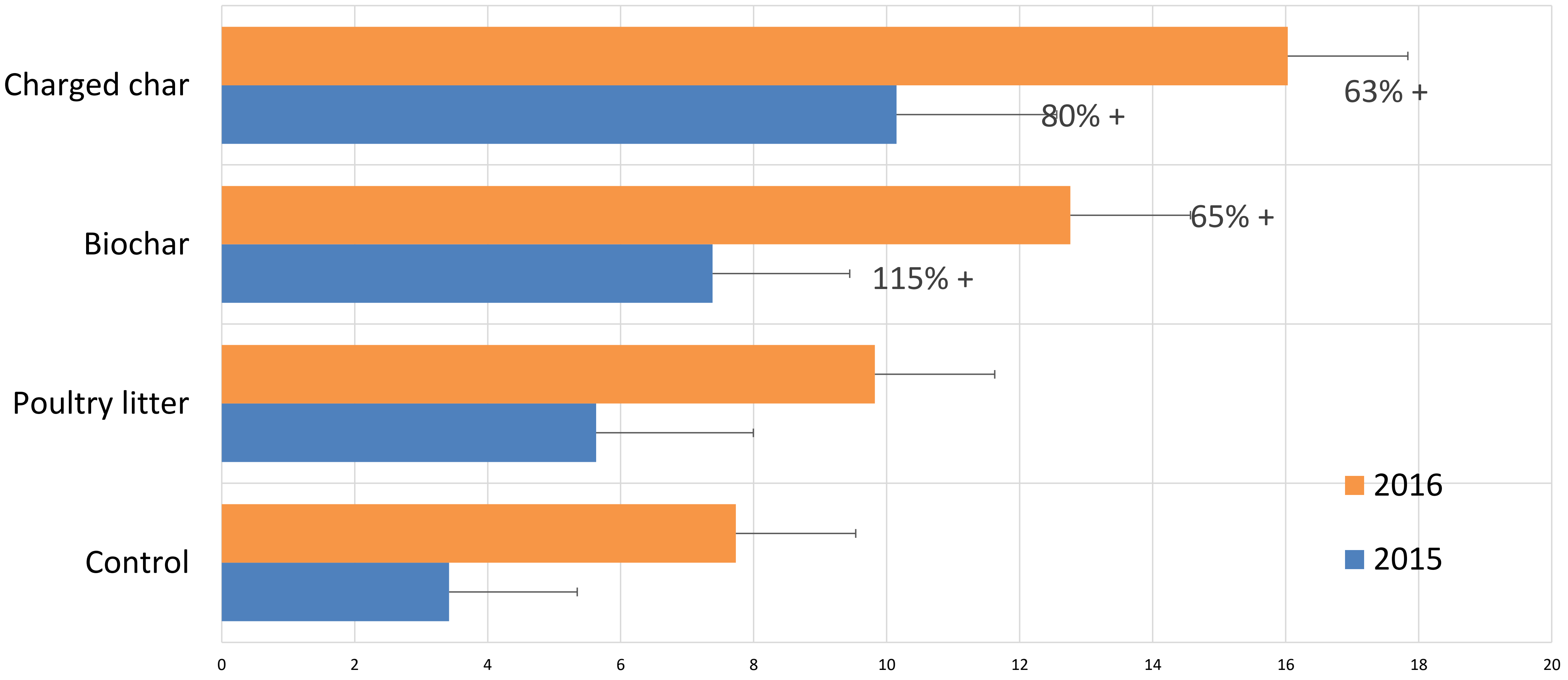
Soil total C (g kg-1)
Charged char
Biochar
Poultry litter
Control
35% +
40% +
35% +
45% +
2016
2015
0
10
20
30
40
50
60
70

Average soil enzyme activity*

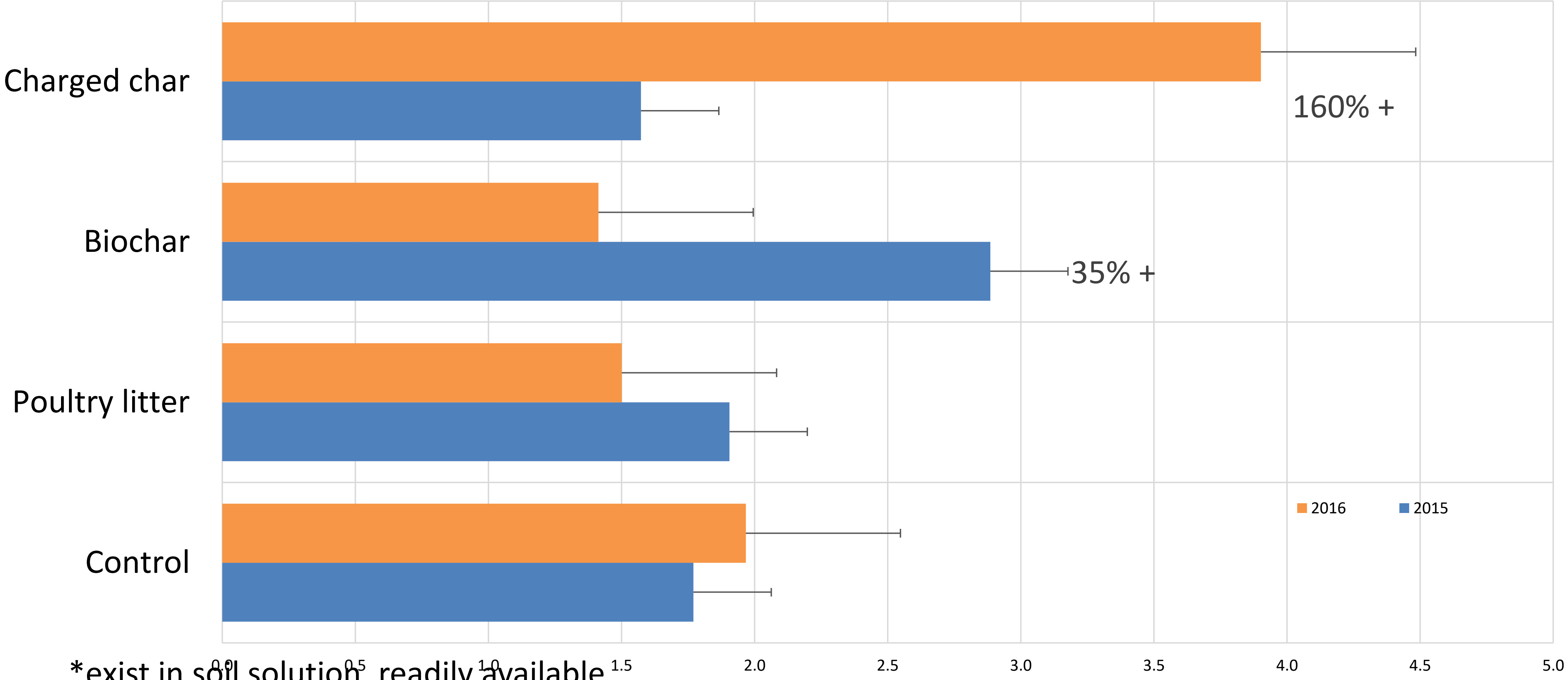


*the geometric mean of beta-glucosidase, dehydrogenase, phosphatase, and urease. An overall index for soil biological activity.

Soil potentially mineralizable N (mg kg^{-1} 14d)

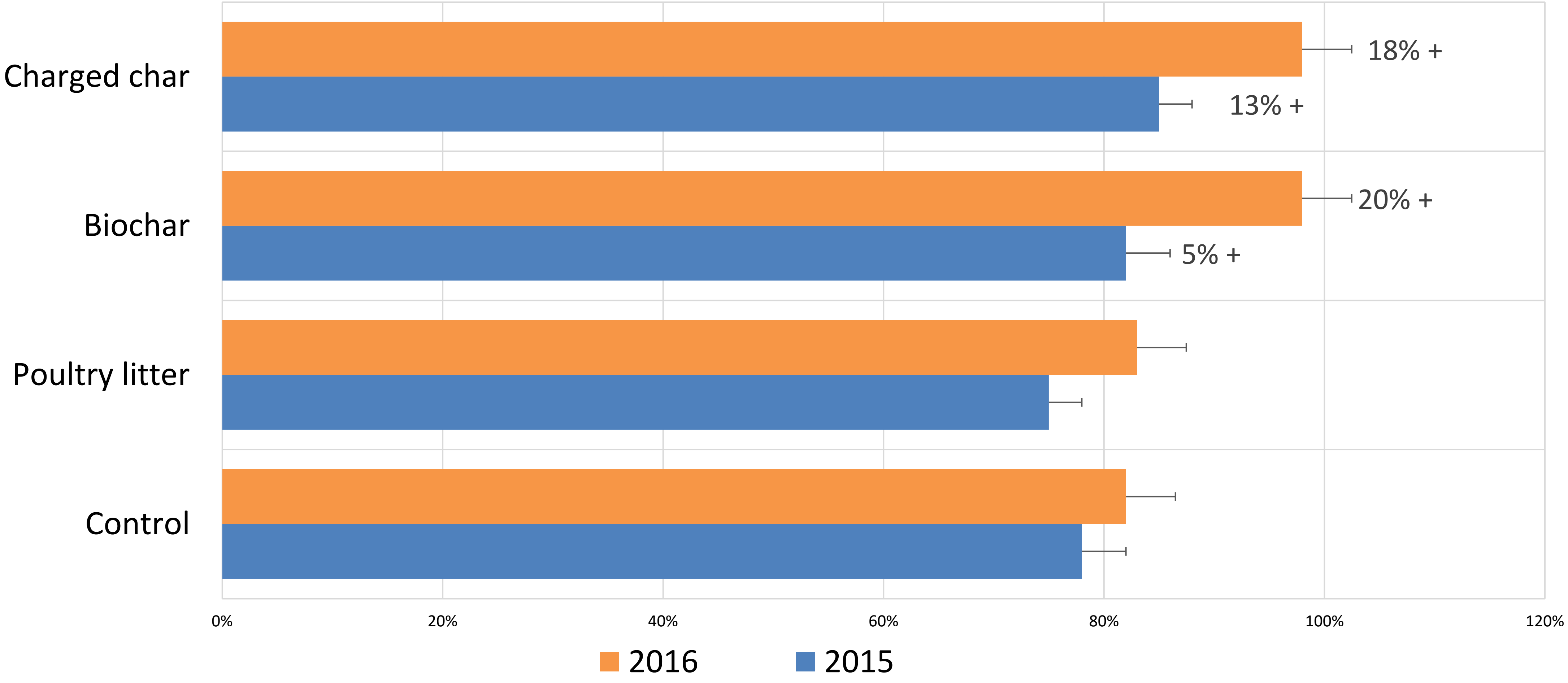


Soil soluble inorganic P* (mg kg^{-1})

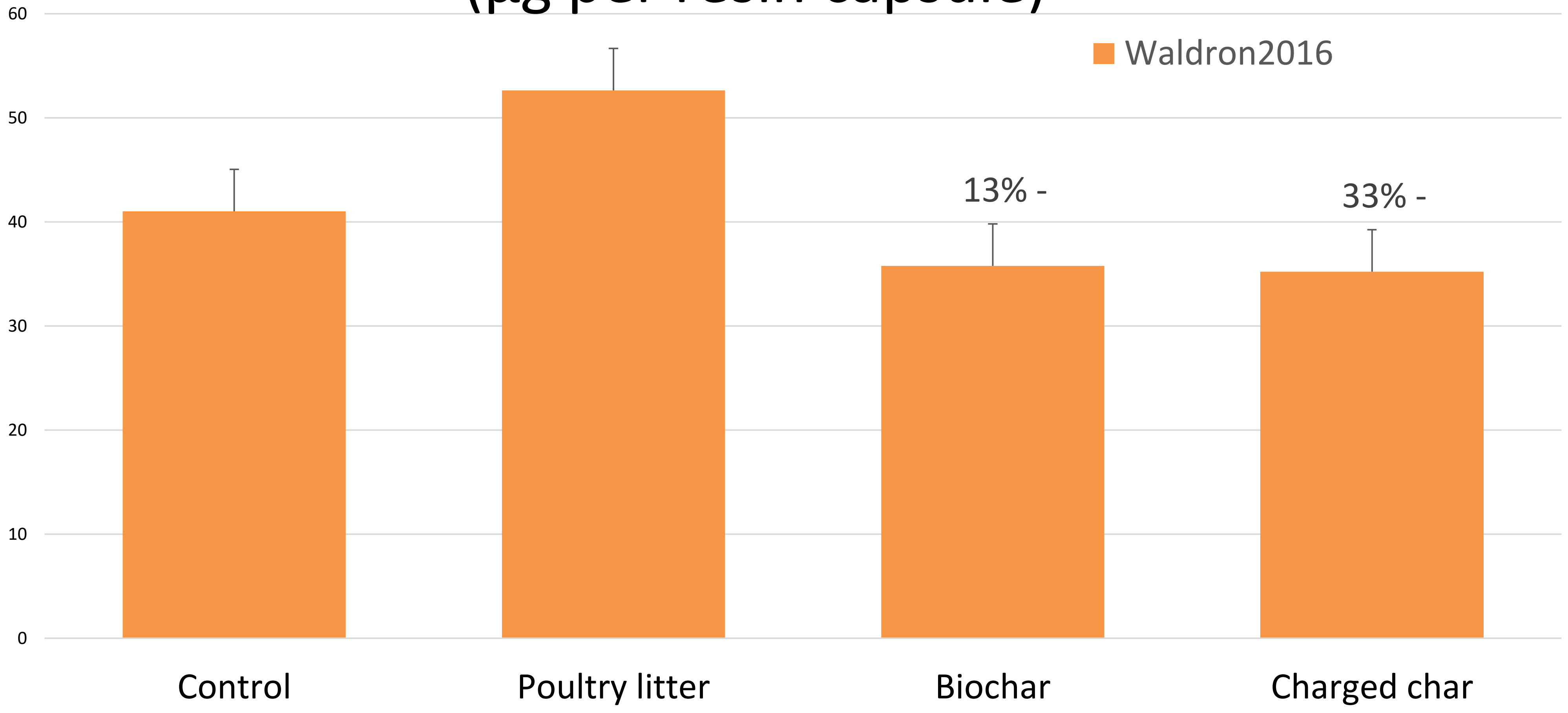


*exist in soil solution, readily available.

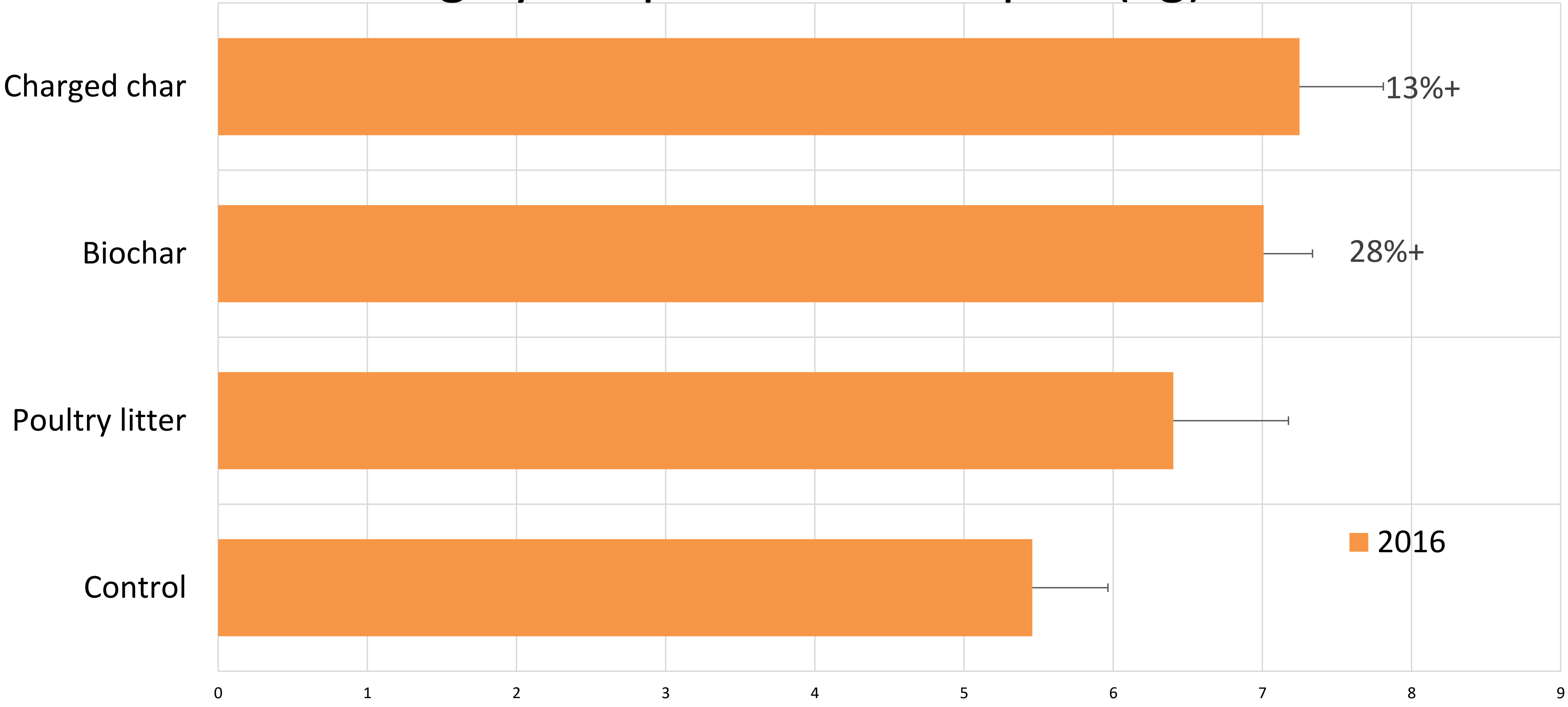
Soil water-hoding capacity



Accumulated NH_4^+ -N below rooting zone (µg per resin capsule)



Average yield per treatment plot (kg)



Nutrient Density in Dry Beans 2015