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Screening biochar for effects on nutrient balance around roots

University of Edinburgh, UK Biochar Research Centre (UKBRC)

Biochar: Climate Saving Soils, 10th December 2013

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Focus may be on above-ground ground crop response, but plant response must be mediated by roots (interactions in the “rhizosphere”)

Reason to target root interface: deployment

- Highly specified biochar could be expensive
- All soil amendments have an application cost
- In field soils biochar will be <0.1% of total soil mass (<10% in a horticultural growing medium)

Total soil content increases, being dissipated in the field each year. This will probably build the long-term fertility of the soil, free of charge.

1. Small amounts of biochar added to the furrow would provide a “high” concentration of biochar around the plant during crop establishment.
2. Adding biochar together/with N would increase probability of positive interactions with respect to biochar and nutrient storage / root uptake.

Outline

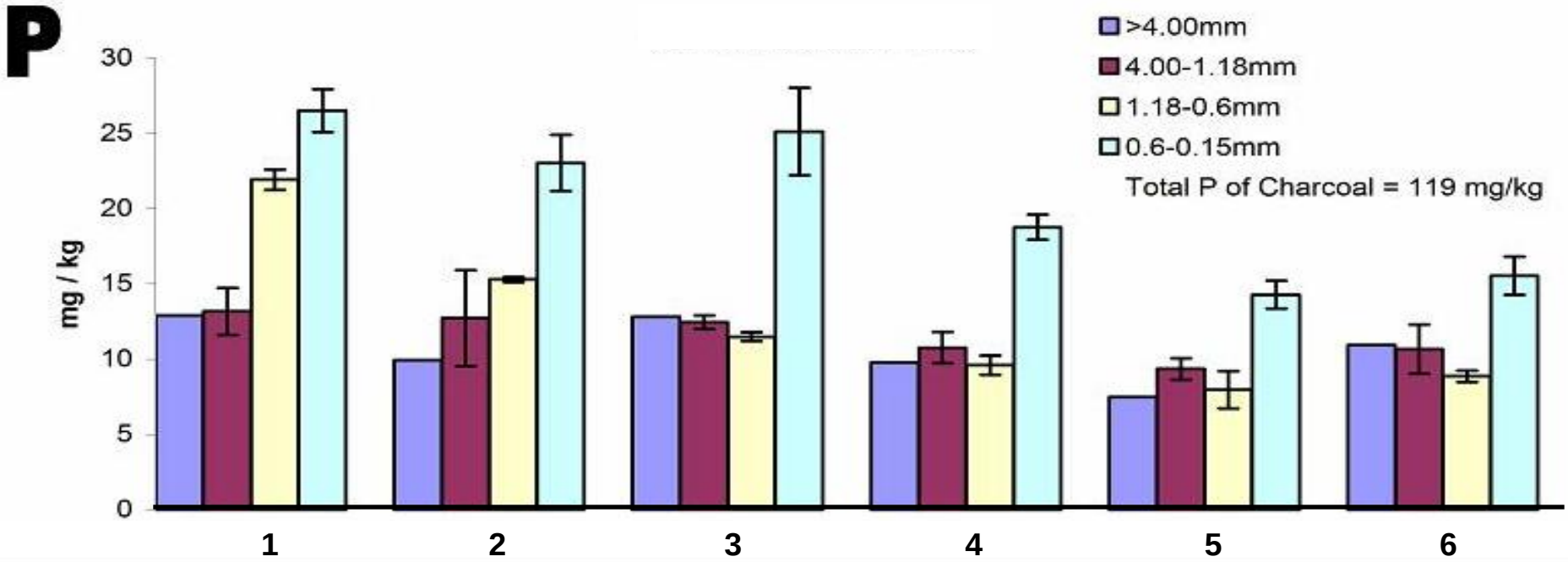
- Context
- Introduction to biochar–root interactions
- Two demonstrations of biochar screening

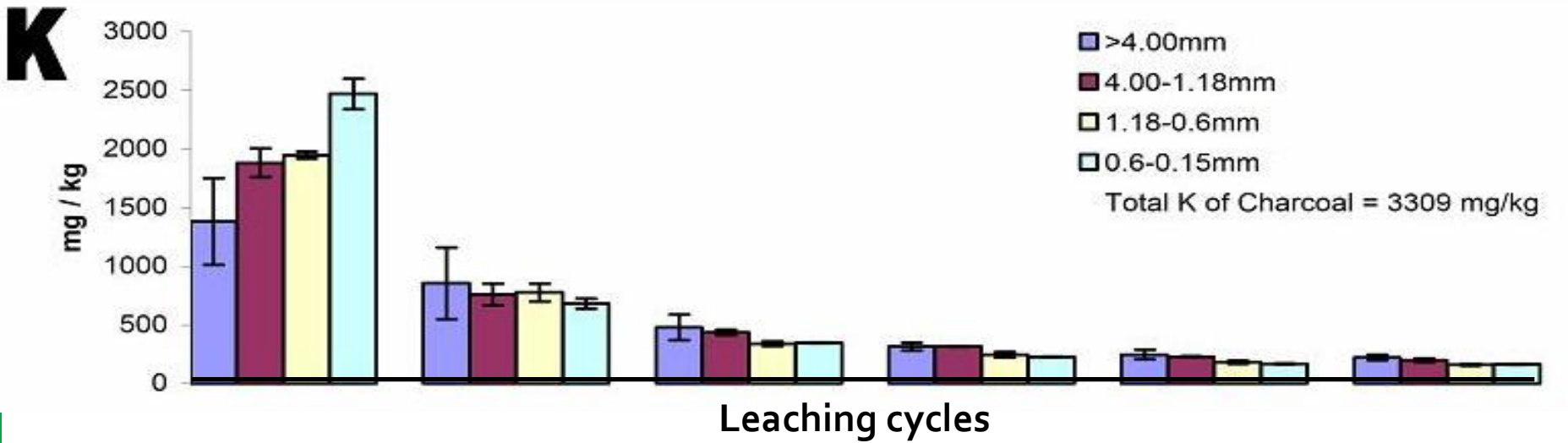
Direct biochar–root interaction

1. Provision of water, plus P, K, Mg in ash associated with biochar;
2. Provision of N from adsorption sites or pores (artificially added or stored from within soil).

Particle size (and micro-structure) are important as well as location.

Effect of particle size





Indirect biochar–root interaction

- Impacts pH (so nutrient availability)
- Short-lived compounds promoting germination and early stage growth.
- Blocking chemical signalling
- Capture and/or release of toxic compounds

These involve effects on soil, microbes and soil bio-geochemistry, localised around biochar.

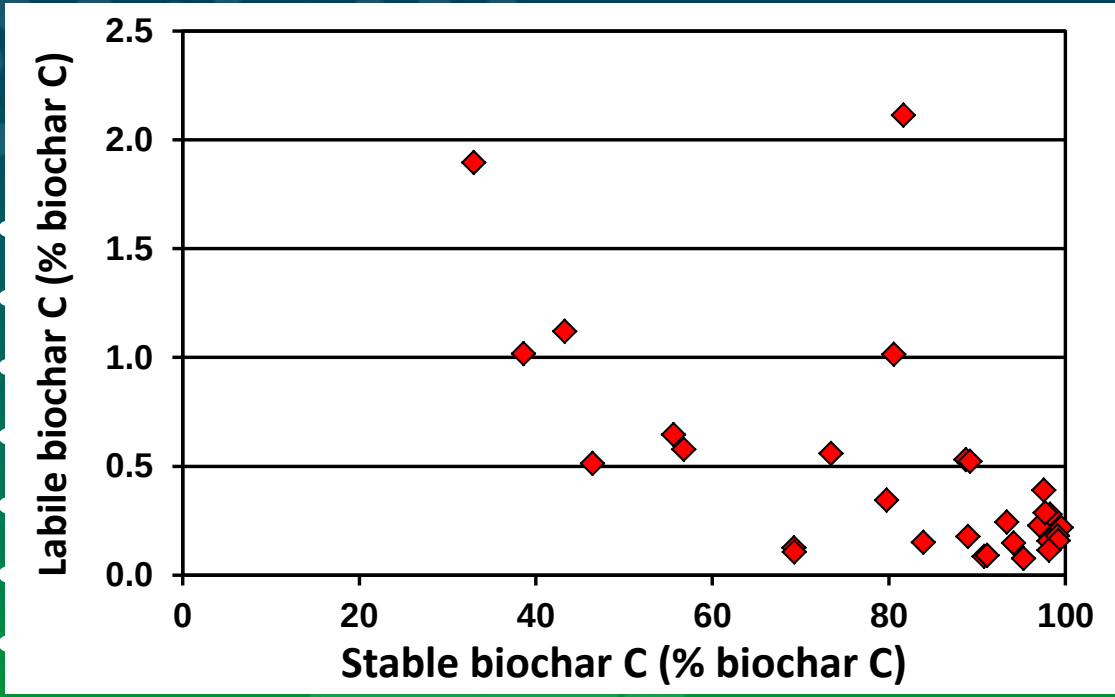
Rationale for our demonstration work

Short-term function may be targeted to achieve an economic match of biochar material to a production constraint.

Also:

1. Some biochar properties are mutually exclusive;
2. ct formulation;
3. r time:

pes;



Rationale for our demonstration work

If biochar is diverse and dynamic in its properties we'll need:

1. To shortlist biochar / products for its effects based on rapid functional tests;
2. To screen shortlisted materials by their interaction with plants via the roots.

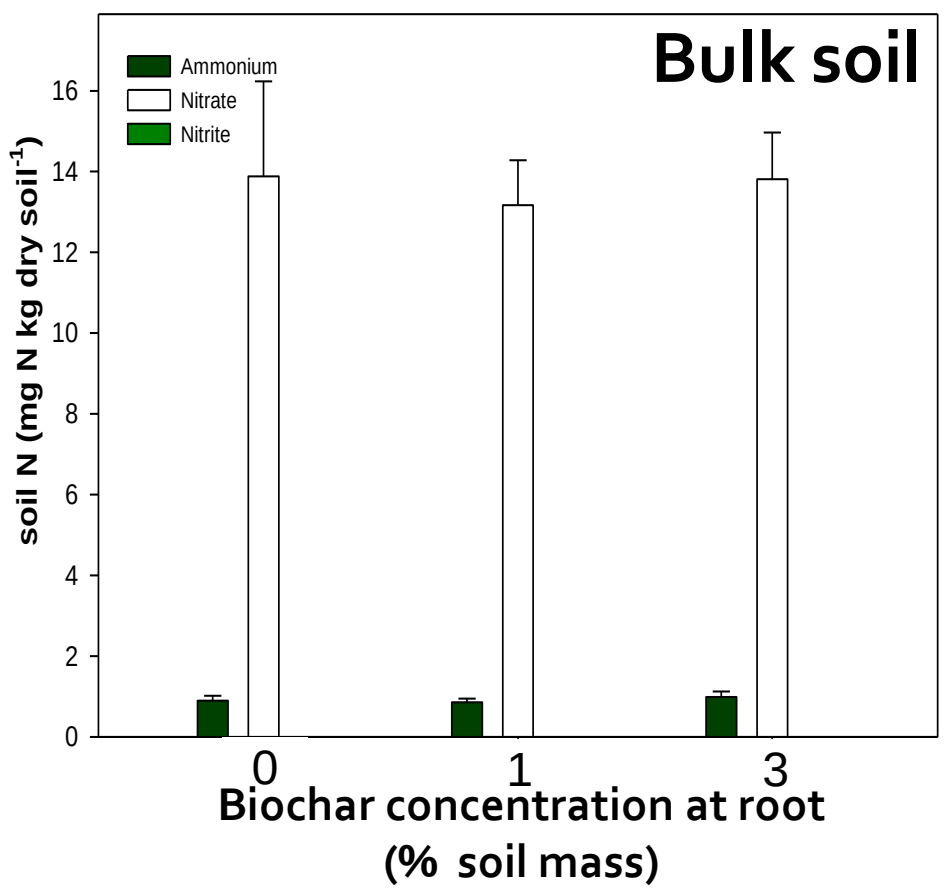
Both need to be rapid, low cost, quantifiable.

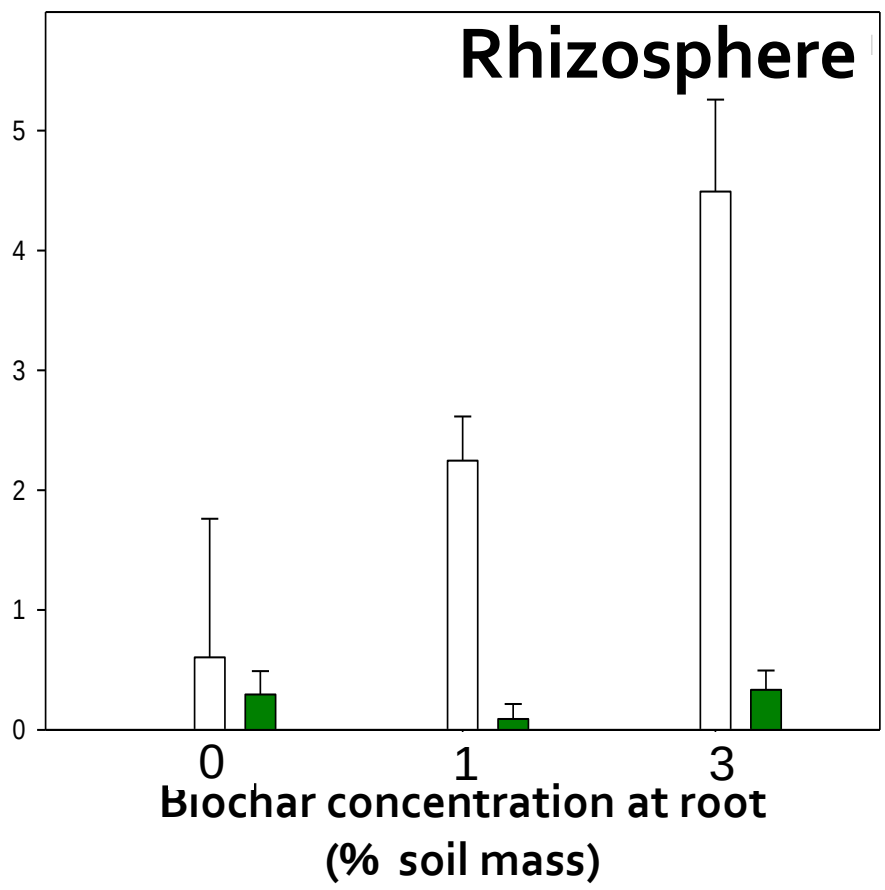
Two demonstrations of biochar screening

1. Demonstrating the impact of biochar on nitrate;
2. Effect of one type of ageing on nutrient supply.

“Rhizobox” experimental system

- Perspex 20x40cm, 0.6cm thin





Biochar effect on bulk soil

NO_3^- not affected by biochar addition (13.5 mg N kg^{-1}).

Low ammonium (NH_3^+) and no nitrite detected.

Biochar effect on rhizosphere

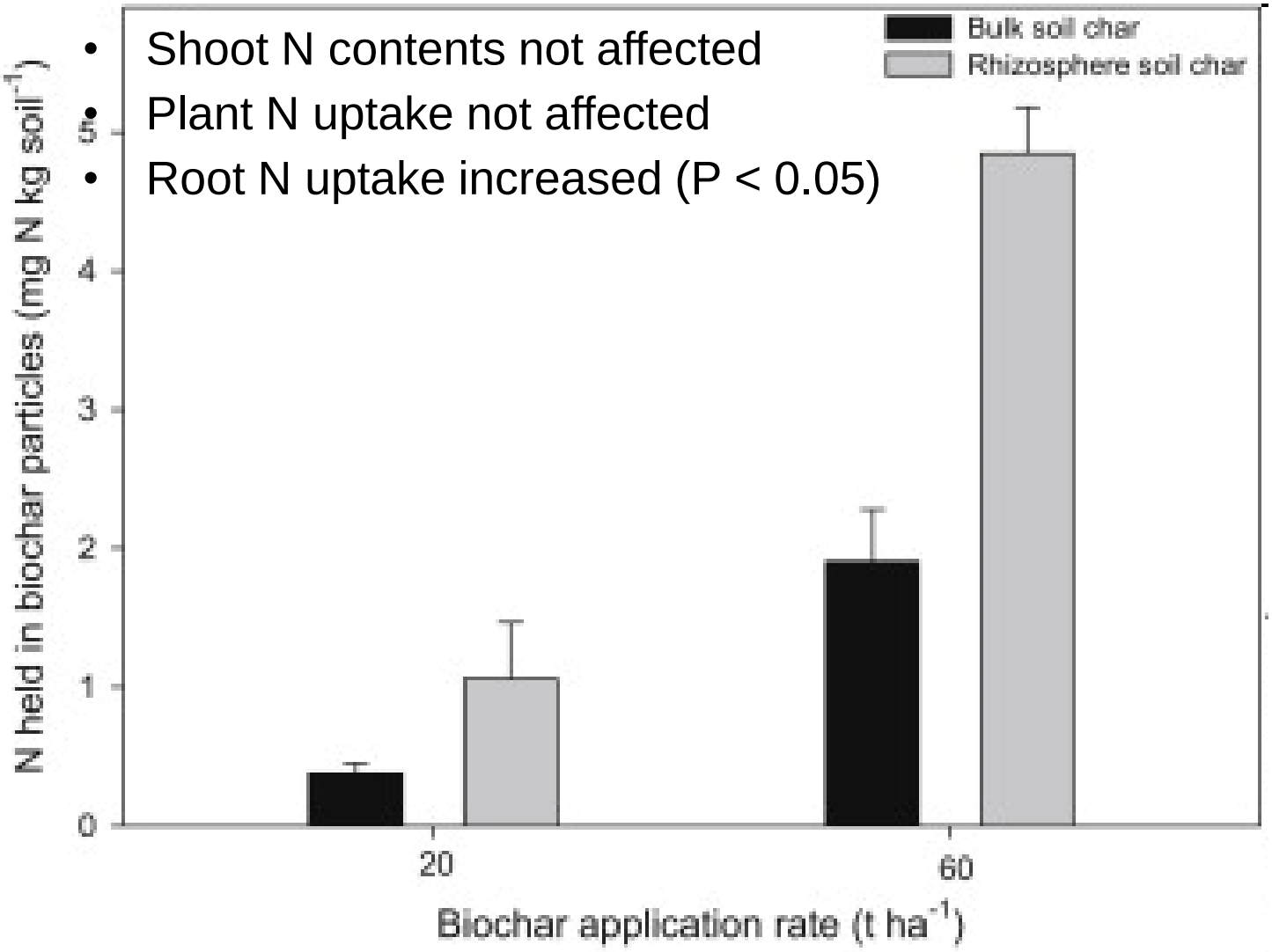
NO_3^- x7 (~2.0 & 4.5 mgN kg^{-1}) with biochar 1% and 3% at root.

No $NH4^+$ and no effect on nitrite concentrations

Prendergast-Miller et al 2011, Soil Biol. Biochem 43:2243-2246

Reflected in manually recovered biochar

- Shoot N contents not affected
- Plant N uptake not affected
- Root N uptake increased ($P < 0.05$)



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Two demonstrations of biochar screening

1. Demonstrating the impact of biochar on nitrate;
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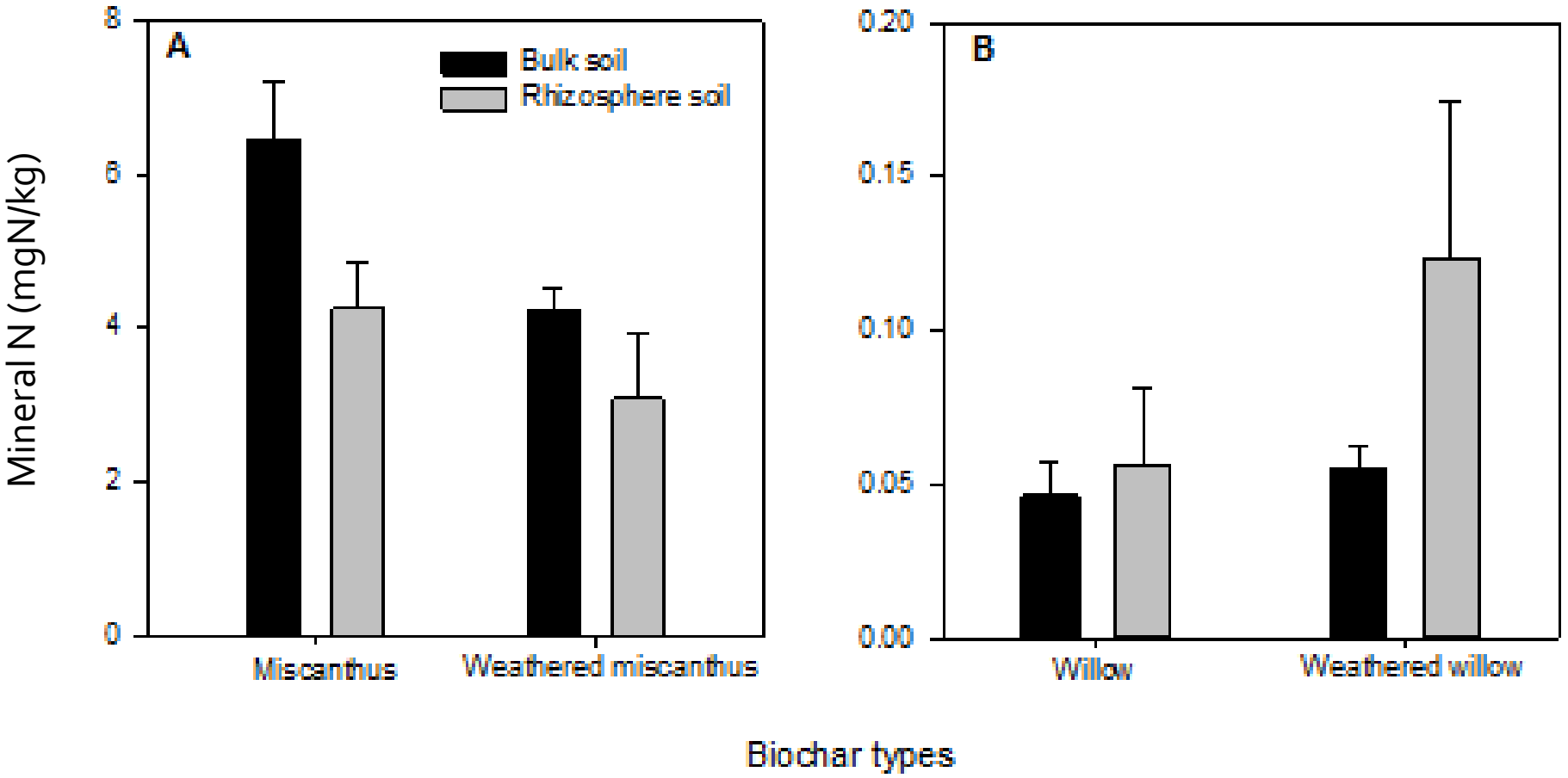
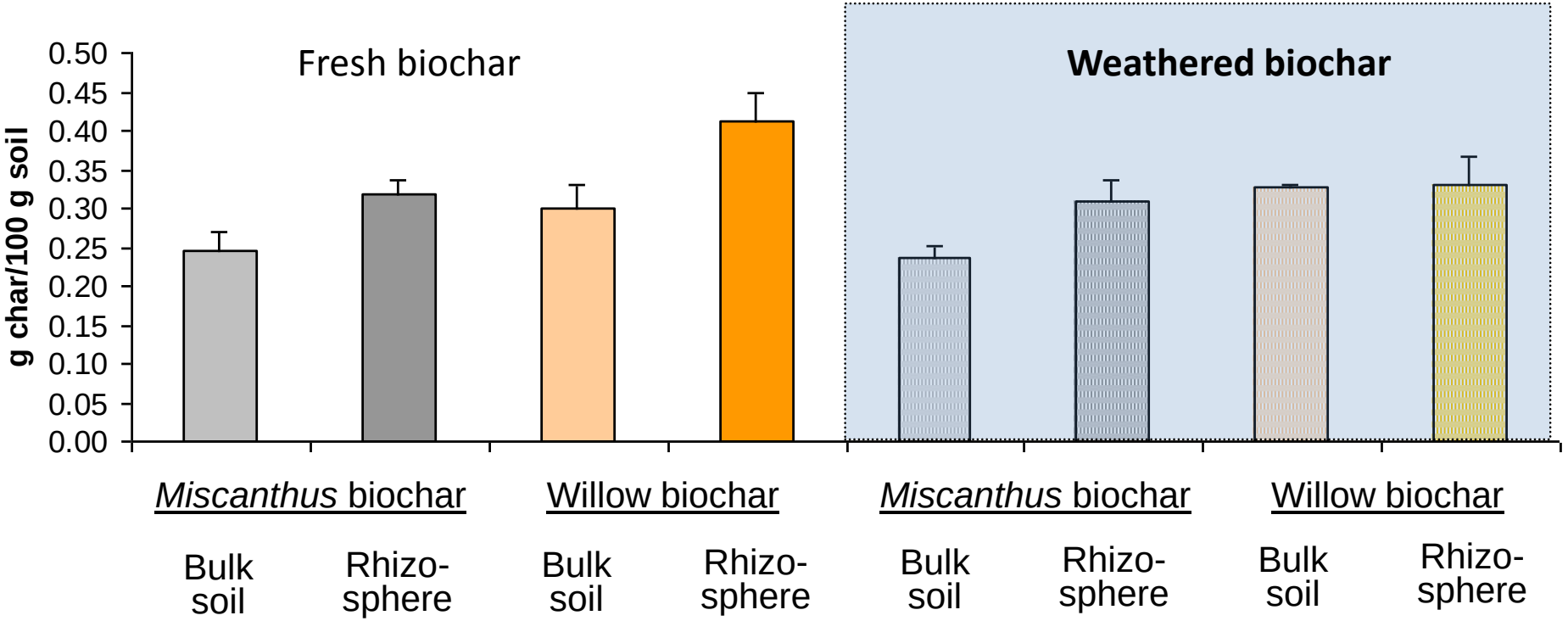
Localisation of N_{min} in the biochar–rhizosphere



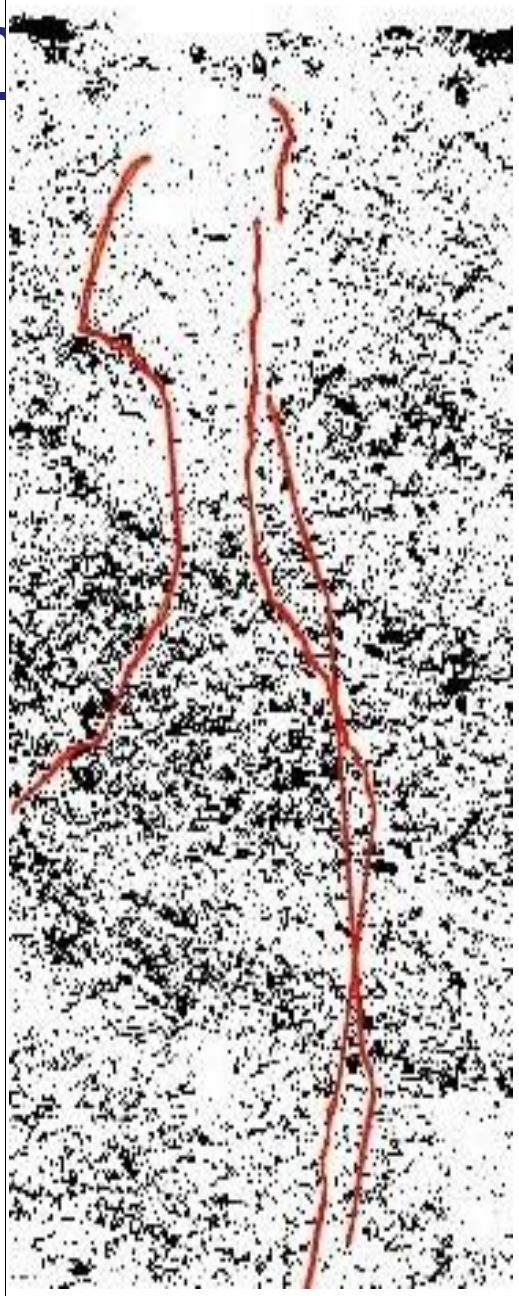
Biochar more abundant in proximity to roots



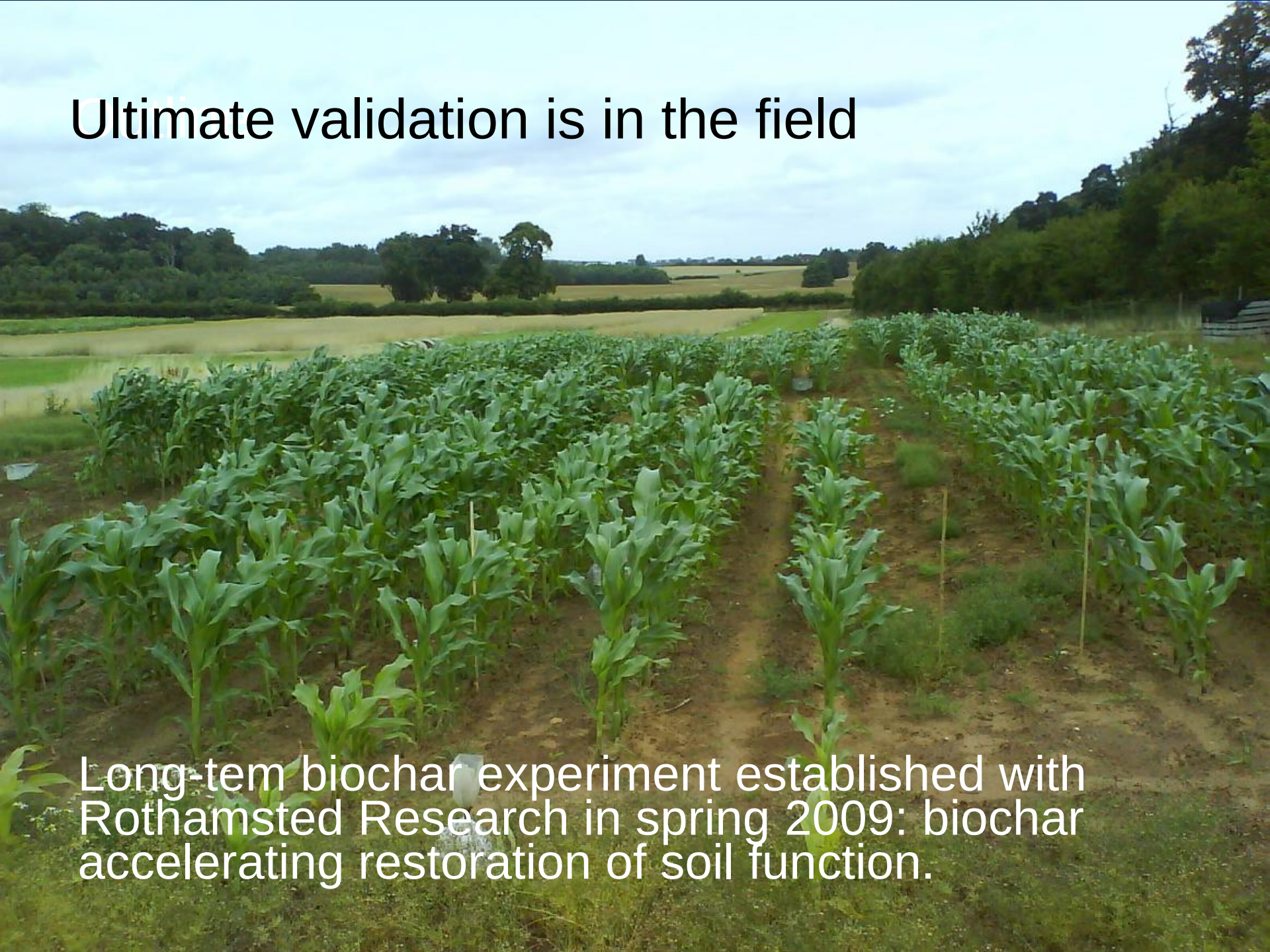
Automating screening – im

No biochar

biochar

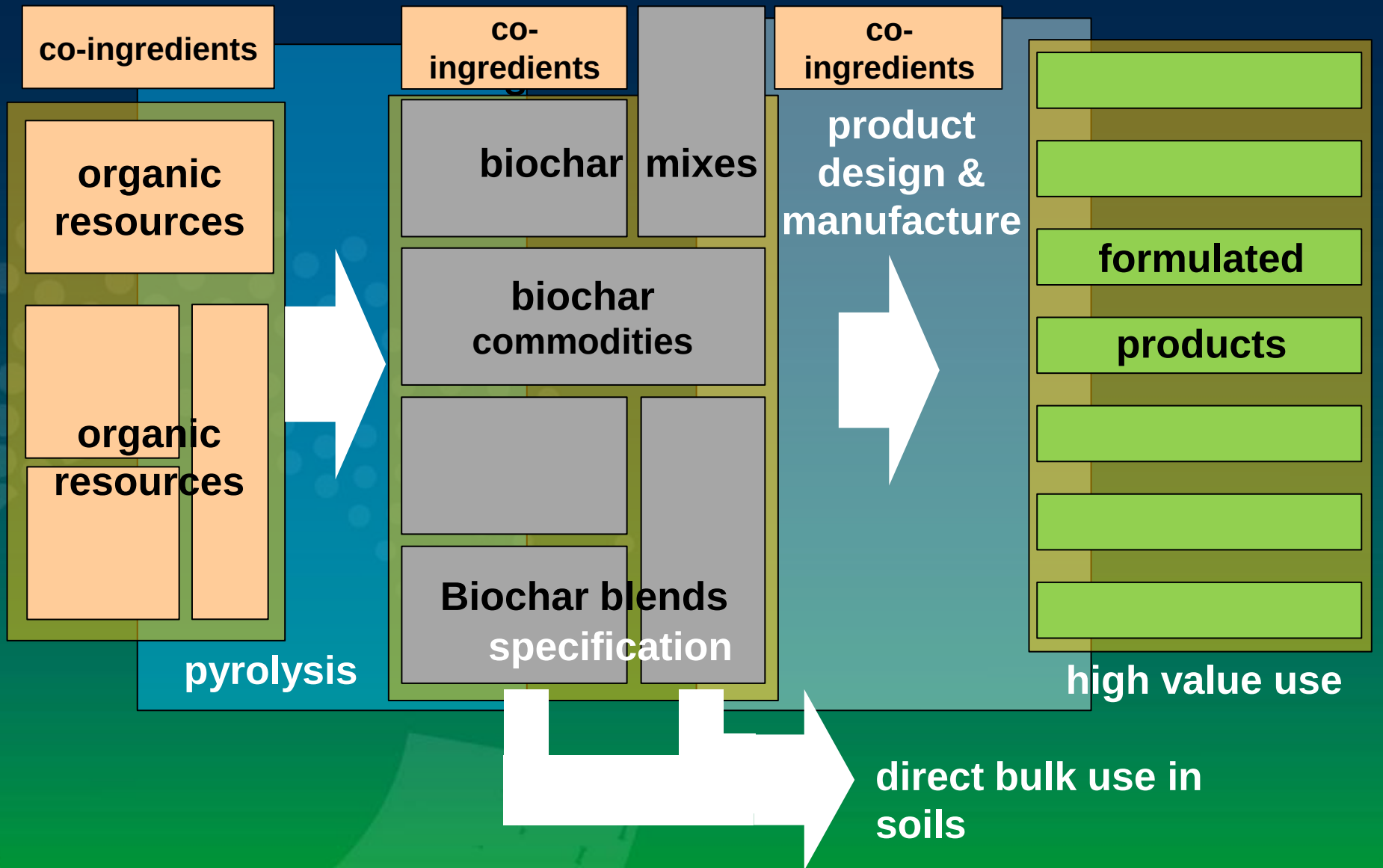


Ultimate validation is in the field



Long-tem biochar experiment established with Rothamsted Research in spring 2009: biochar accelerating restoration of soil function.

Opportunities for added-value products



Conclusions

- Nitrate concentration in the rhizosphere (but not bulk soil) was increased by biochar;
- High rhizosphere nitrate concentrations present in soil containing fresh and weathered biochar;
- Proportion of rhizosphere associated with the biochar can be dis-proportionate to biochar mass/volume.
- Biochar screening using rhizoboxes (with digital image analysis) could complement functional test methods in establish / formulating effective biochar products.

Other oontributors: Clare Peters, Mike Duvall and Alua Suliemenova

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