The effect of pH on soil microbial community structure and function: results from a manipulated pH experiment

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1. Background

Soil microbial communities and their functioning are known to differ greatly between low and high pH soils[1]. However, our ability to explicitly examine the relationship in diversity and functioning with soil pH in natural systems is problematic due to the presence of multiple confounding parameters.

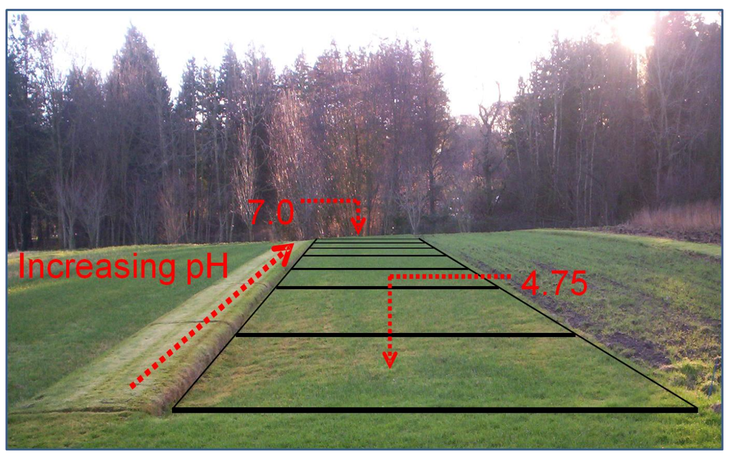
In low pH soils microbial communities are generally considered to be oligotrophic and, therefore, less functionally active compared to high pH communities[2]. However, it is unclear whether differences in functionality are due to microbial or environmental factors.

2. AIMS

To examine the linkages between soil pH, soil microbial community structure and functioning in the absence of other confounding environmental factors.

3. METHODS

Low pH (4.75) and high pH (7.0) soils were collected from an artificial agricultural pH gradient at the Scottish Agricultural College, Craibstone, Scotland.

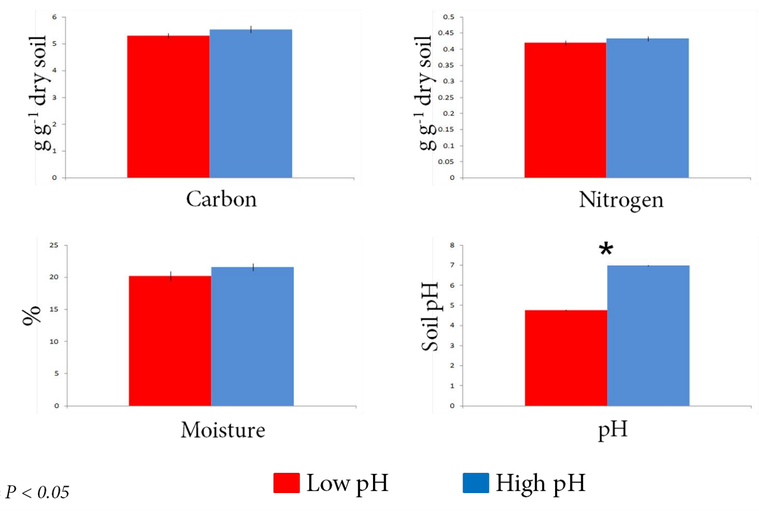


Low and high pH soils were incubated with 99 atom % ^{13}C labelled glucose or wheat stem for 170 and 670 hours respectively.

PLFA and T-RFLP analyses were used to examine differences in soil microbial communities. To assess function soil respiration, substrate specific respiration and priming effects were measured by GC-IRMS.

4. SOIL PROPERTIES

No significant differences in C and N content and moisture percent between low and high pH soils

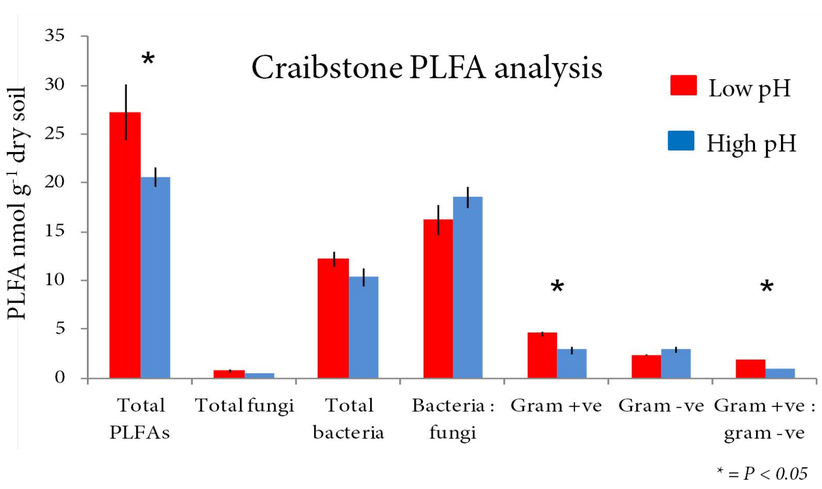


* = $P < 0.05$

5. RESULTS

PLFA

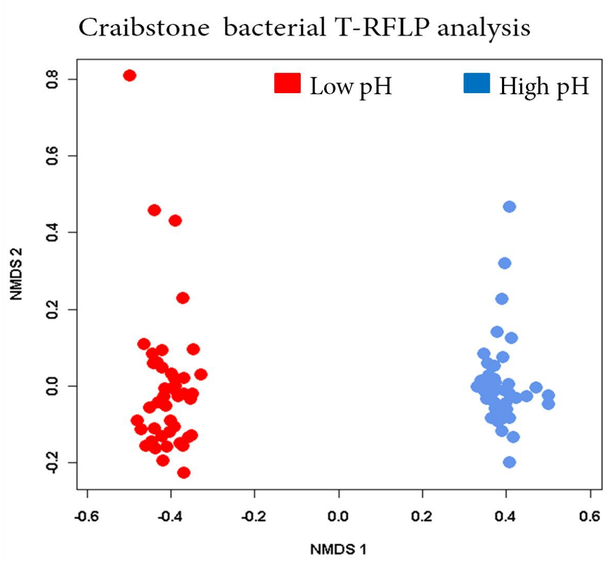
Prior to substrate addition total PLFAs, gram positive PLFAs and the gram positive to gram negative ratio were significantly higher in low pH soil., However, the bacterial to fungal ratio and gram negative PLFAs were higher in high pH soil.

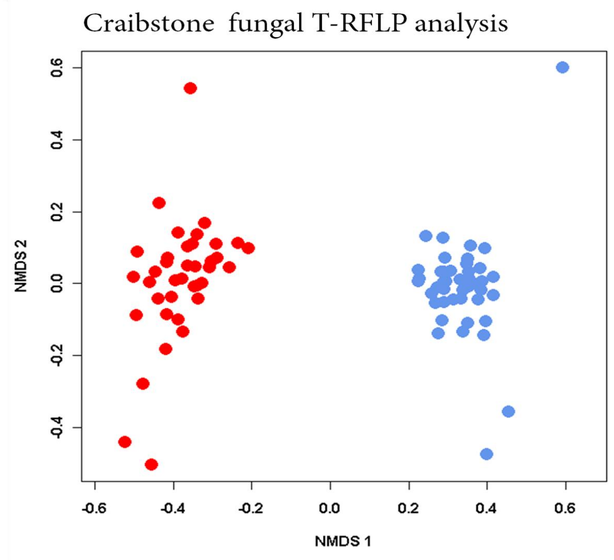


* = $P < 0.05$

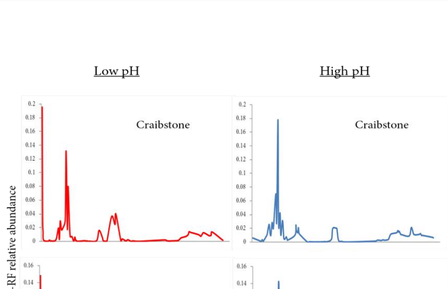
T-RFLP

Differences in microbial community structure between low and high pH soils following substrate addition were examined using PERMANOVA. Soil pH was shown to be the main driver of bacterial ($R^2 = 0.66$, $P < 0.001$) and fungal ($R^2 = 0.44$, $P < 0.001$) communities over substrate-driven changes and temporal fluctuations.





Bacterial communities from the Craibstone pH gradient were found to be similar in community structure to soils sampled across a natural pH gradient throughout Britain as part of the Countryside Survey 2007[3]. Soil pH had a similar effect upon bacterial community structure at the field scale and national scale.

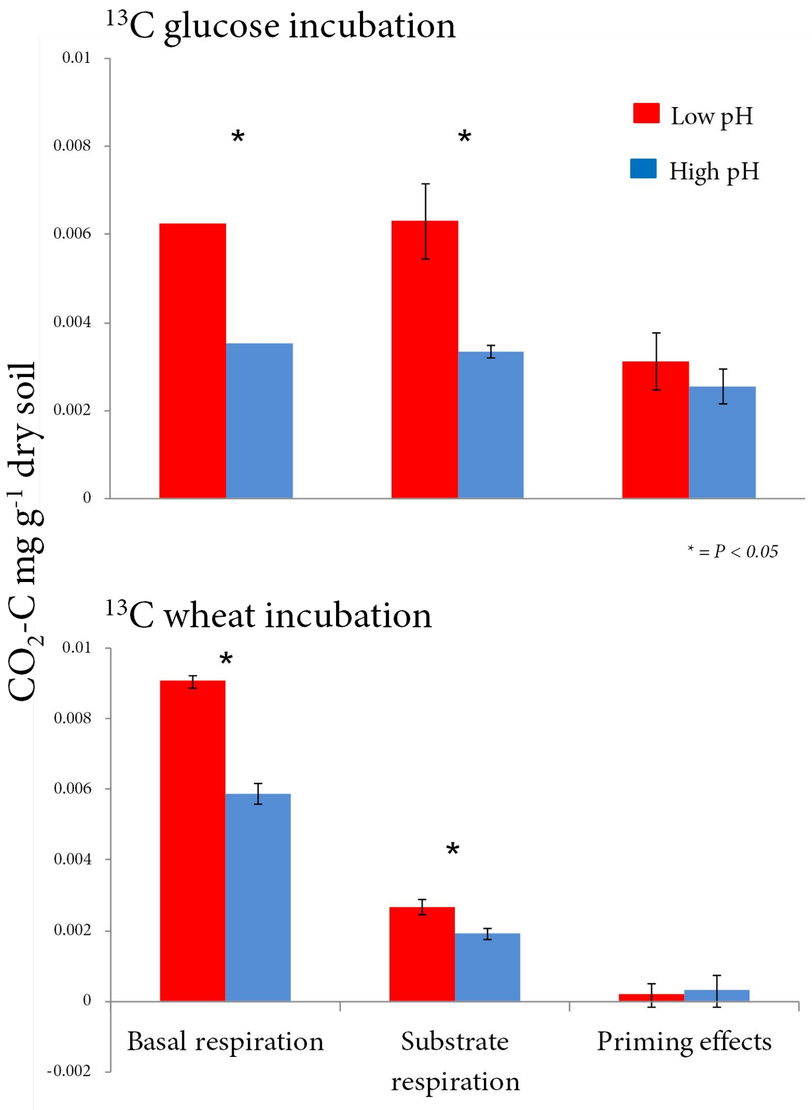


5. RESULTS

Soil C functioning

Mean cumulative basal respiration and substrate decomposition rates were significantly greater in low pH soil.

No significant differences in priming effects (extra mineralisation of soil organic matter following substrate addition) were observed between low and high pH soils. However, substrate complexity was shown to affect the intensity of the priming effect.



Priming effects calculated according to Fontaine *et al.* (2004)[4]

6. CONCLUSIONS

Contrary to expectations, total PLFAs and increased C functioning were greatest in low pH soil despite the dominance of oligotrophic Acidobacteria[3,5]. Our results show that with sufficient biomass low pH microbial communities are capable of greater functionality than high pH microbial communities. These findings highlight the importance of biomass over microbial community structure and edaphic conditions in determining soil C cycling in low and high pH soils.

7. REFERENCES

1. Baath E & Anderson TH (2003) Comparison of soil fungal/bacterial ratios in a pH gradient using physiological and PLFA-based techniques. *Soil Bio & Biochem* ***35: 955-963.***
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3. Griffiths RI, Thomson BC, James P, Bell T, Bailey M & Whiteley AS (2011) The bacterial biogeography of British soils. *Envir. Microbiol.* ***13: 1642-1654.***
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5. Sait M, Hugenholtz P & Janssen PH (2002) Cultivation of globally distributed soil bacteria from phylogenetic lineages previously only detected in cultivation-independent surveys. *Envir. Microbiol.* ***4: 654-666.***