Heathland restoration by soil acidification – determining phytoavailable aluminium levels

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Introduction

The application of acidifying chemical treatments to soil has been shown to be an effective method for restoring heathland/acid grassland mosaic on former agricultural pasture (Fig 1). Suppression of competitive mesotrophic grasses is key to this success and is believed to be driven by increased availability of the phytotoxic aluminium ion Al^{3+}, which is mobilised by a decrease in soil pH to below 5.5. However, the exact application rate of the acidifying material required to elicit the required increase in Al availability will change between sites due to soil physio-chemical properties. Over-application can result in the leaching of acidic compounds into surface water, potentially damaging the environment. So, can Al availability be easy measured to ensure the correct application of acidifying media?

The Experiment

A block of thirty 4 x 4 m plots was set up in 2001 on pasture improved from heathland *ca.* 50 years ago. Soils in the plots were acidified using pelleted elemental sulphur applied at rates of 0, 900, 1,800, 2,400 or 3,600 kg ha^{-1}. During June 2007, 5 *Rumex acetosella* L. plants and soil were sampled from 4 plots of each treatment. Soil samples were analysed for extractable Al using 3 common extractants (0.01M $CaCl_2$(1), Morgan's reagent (2) and 1M NH_4NO_3 (3)). Soil pH and the Al concentration in the plant shoots were also measured.

Findings

- Elemental sulphur significantly decreased soil pH (Fig 2, $F = 5.84$, $P = 0.005$) and significantly increased the concentration of Al in *R. acetosella* shoots (Fig 3, $F = 3.22$, $P = 0.045$).
- The strongest relationship between soil pH and extractable Al concentration was found for 0.01M $CaCl_2$ (Fig 4) and then 1 M NH_4NO_3. Both relationships were significant.
- No significant relationship was found between soil pH and the extractable concentration of Al determined using Morgan's reagent.
- Shoot Al concentration was significantly related only to the concentration of Al extracted from the soil by 0.01M $CaCl_2$ (Fig 5).

Figures

Figure 1. Our study site (left) was lowland heath until 'improved' for pasture *ca*. 50 years ago. Acidifying the soil with elemental sulphur has resulted in the successful restoration of a heathland vegetation community (right).

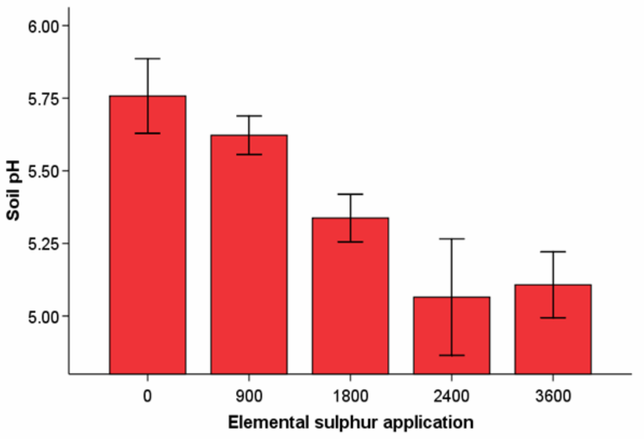

Figure 2. Changes in the pH of soil induced by the application of elemental sulphur (kg ha^{-1}) to soil (mean ± 1SE).

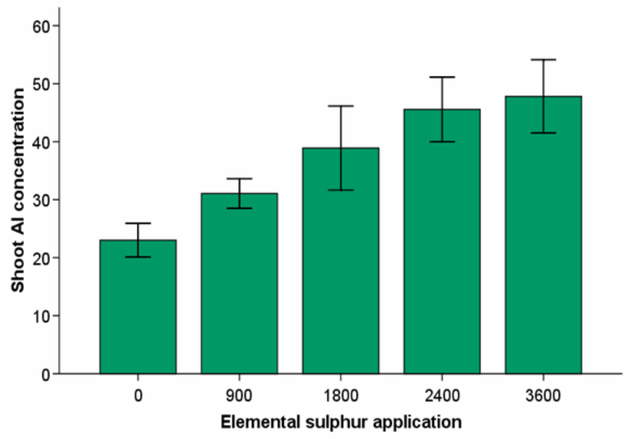

Figure 3. Al concentration (mg kg^{-1}) in *R. acetosella* shoots induced by elemental sulphur application (kg ha^{-1}) to soil (mean ± 1SE).

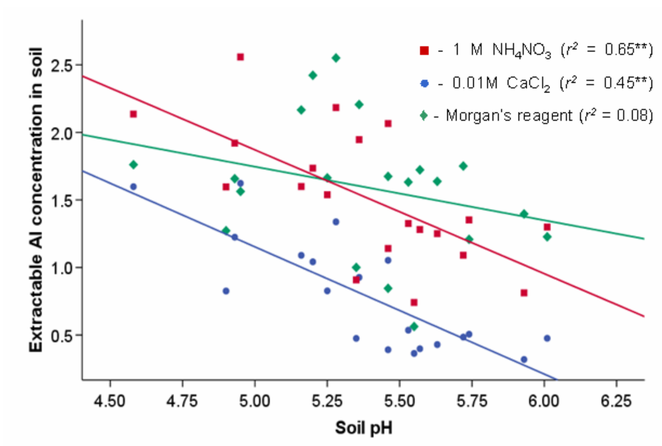

Figure 4. The relationship between soil pH and the extractable concentration (mg kg^{-1}) of Al in the soil measured by 3 extractants.

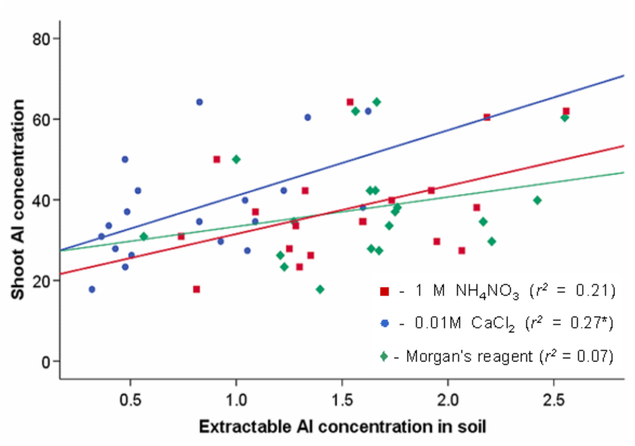

Figure 5. The relationship between the extractable concentration (mg kg^{-1}) of Al in the soil measured by 3 extractants and the Al concentration (mg kg^{-1}) in *R. acetosella* shoots.

Conclusions

- After six years, elemental sulphur amendment was still effectively acidifying the soil to levels that should be sufficient to mobilise Al into available forms.
- The acidification of the soil did increased the phytoavailability of Al as measured by both the plant shoots and the chemical extractants 0.01M $CaCl_2$ and 1M NH_4NO_3, but not Morgan's reagent.
- Only the 0.01M $CaCl_2$ extractable Al concentration could predict the concentration of Al in plant tissues and this extractant also showed the strongest relationship with soil pH.
- The most appropriate extractant to determine the effectiveness of treatments to raise the phytoavailable levels of Al in soils is 0.01M $CaCl_2$.

References

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2 - McLean, E.O. 1965. Aluminium. In: C.A. Black, D.D. Evans, J.L. White, L.E. Ensminger, F.E. Clark, Methods of Soil Analysis: Part 2 Chemical and Microbiological Properties. American Society of Agronomy, Wisconsin, USA. pp. 978-998.

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