Soil Exchangeable Cations Increase Microbial Carbon Use Efficiency and Microbial Growth in Acidic Soils

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Microbial growth and function is influenced by the properties of the surrounding soil where surface chemistry mediates interactions between individual organisms and their local microenvironment. We hypothesised that the addition of exchangeable base cations, necessary for microbial biochemical function, will increase microbial growth in acidic soils. Initially, we showed that the addition of base cations to acidic soils increased microbial carbon (C) use efficiency (CUE). The metabolic partitioning of C into either anabolic (growth and maintenance) or catabolic (respiratory) processes can vary widely between soils. Optimum concentrations of Ca^{2+} and Mg^{2+} for maximal microbial CUE in Western Australian soils were determined using this data. We then investigated if the addition of base cations increased microbial growth (microbial biomass). Limed and non-limed field-plot samples from Merredin, WA were incubated in the laboratory +/- cations and +/- organic matter residue (as a supplementary C food source). Microbial biomass C increased in the non-limed soils with the application of base cations. No response to additional Ca^{2+} and Mg^{2+} was observed in the limed soils. This response was expected as we predicted that there were sufficient inherent base cations in the limed soil for microbial function and growth. Lack of soil organic matter limited microbial biomass C in both the limed and non-limed samples. Finally, we developed a structural equation model (SEM) to explain the regulation of microbial biomass C in a wide range of managed topsoils across semi-arid Australia (n=1987 sites, 0-10 cm depth). Our findings show that the 10-fold variation in microbial biomass across the Western Australian agricultural region can be explained by organic matter (food source), base cations (required for cell biochemistry) and hydrophobicity (restricts access to organic matter and disconnects water films slowing biochemical reactions). We conclude that exchangeable base cations were a positive driver of microbial CUE and soil microbial biomass C. These findings highlight the underpinning importance of pH changes to soil chemistry that regulate microbes in soil; agricultural management practices are typically secondary to the underpinning soil surface chemistry.