Supplementary Information 1 Theoretical full diagram and rationally

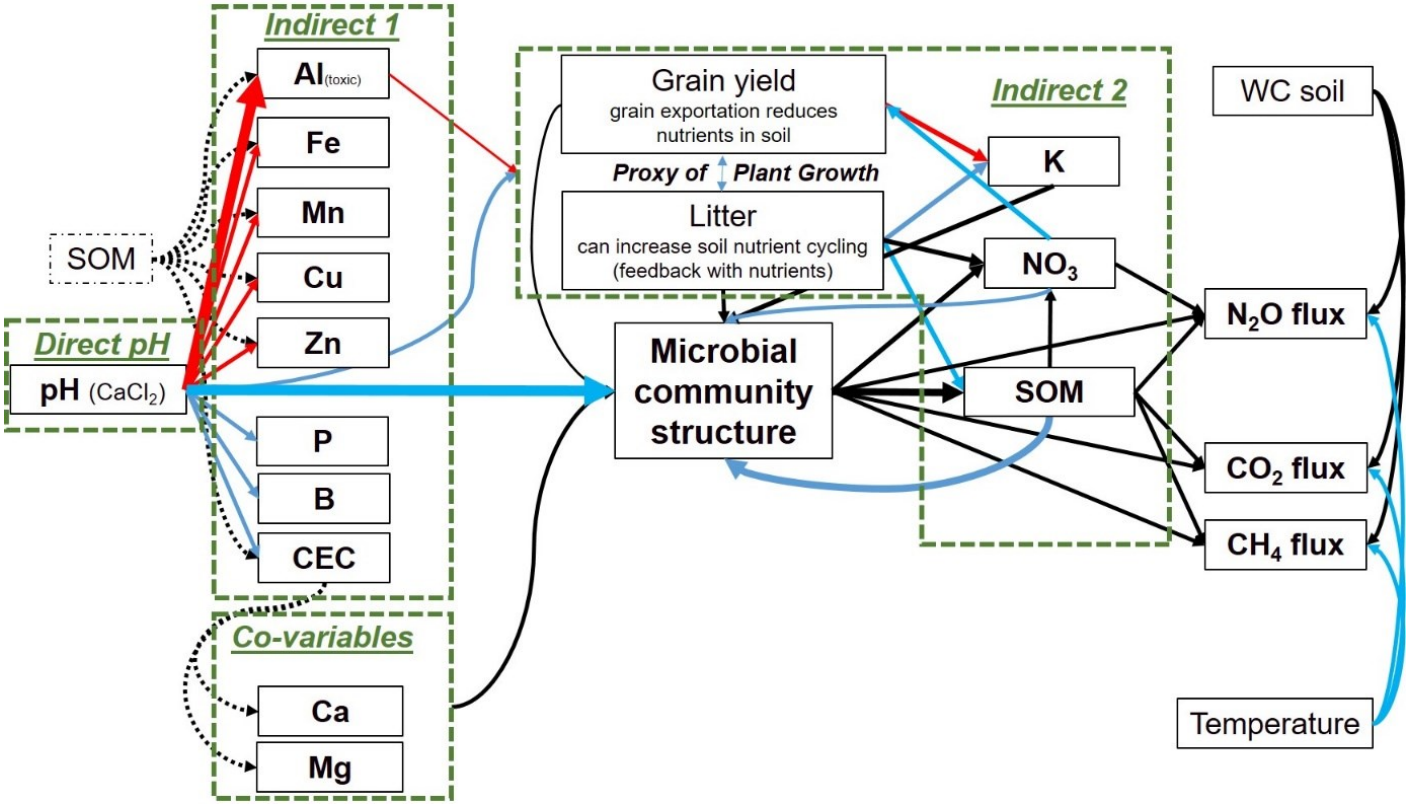

Figure S1-A Overall theoretical diagram of expected interactions in the pH range between 4-6 with the microbial community structure. Boxes represent soil variables and the arrows the interactions (soluble Al^{+3} is toxic for plant roots and some bacteria; Fe, Mn, Cu, Zn and B are nutrients that in high concentrations may be toxic; and P, K, Ca, Mg and NO_3 are nutrients rarely toxic to plants). In this study, the gradient was produced by liming application, with expected direct effect on pH, and Ca and Mg values. The indirect effects are the "spill-over" effect of the pH in the other soil and plant variables. Indirect effects 1 is mainly related to the solubility of elements, while indirect 2 is related to these effects on plant growth and nutrient cycling. SOM is abbreviation for soil organic matter, CEC, for cation exchange capacity, and WC, for water content. Temperature and WC are considered in this diagram only for the survey day of greenhouse fluxes (proxy for microbial activity).

Soil pH can have direct and indirect effects on soil microbiota (Figure S1-A). Direct effects are related to the proton concentration that affects microbial membranes, nutrient transporters and proteins stability and enzymatic activity [1-3]. While the indirect effects are related to nutrient availability (e.g. Fe, Cu, Mn, Zn, P, N, S and B), the availability of toxic elements (e.g. Al), and the effects on plant growth that drives organic inputs and chemical changes in soil [3-5].

The direct effects of pH are very like related to the H^+ potential that affect microbial membranes and nutrient transporters and metabolism; different prokaryotic species have different optimum pH and strategies to handle acidity [1, 3]. For example, acidophilic microorganisms usually have proteins with increased negative surface, and changes in the phospholipids membrane, at same time activing pumping H^+ out of the cells [2]. These organisms that are highly adapted for acidic conditions are likely to be outcompeted by other organisms better adapted to other pH ranges when pH changes (e.g. following liming) [6].

The indirect effects are rather complex. Soil pH is buffered by the soil colloids (clays and organic matter) and CEC. This also implies that a pH change in soil is expected to co-occur with a change in cation composition; usually the concentrations of Ca and Mg, the two most highly correlated co-variables with pH in soils worldwide [5]. Both elements are plant and microbial nutrients and are linked with several cellular and physiological processes [3, 5]. At the same time, increasing pH can precipitate cations, e.g. Al, Fe, Mn, Cu, Zn, thus reducing their biological availability (Figure S1-B). Consequently, these elements also act as buffers to soil pH changes [5].

We separated the indirect effects of pH into two main groups (Figure S1-A). The first group is related to the solubility of Al, Fe, Mn, Cu, Zn, P, B and to soil CEC (Figure

S1 B). Soluble Al^{+3} is known to be toxic for plants [7], and some studies previously reported potential negative impacts of Al in microbial communities [8-10]. Effects of Al toxicity in bacteria include Fe deficiency induction and metabolic disorders; however, overall effects on microbial cells are still largely unknown [11, 12].

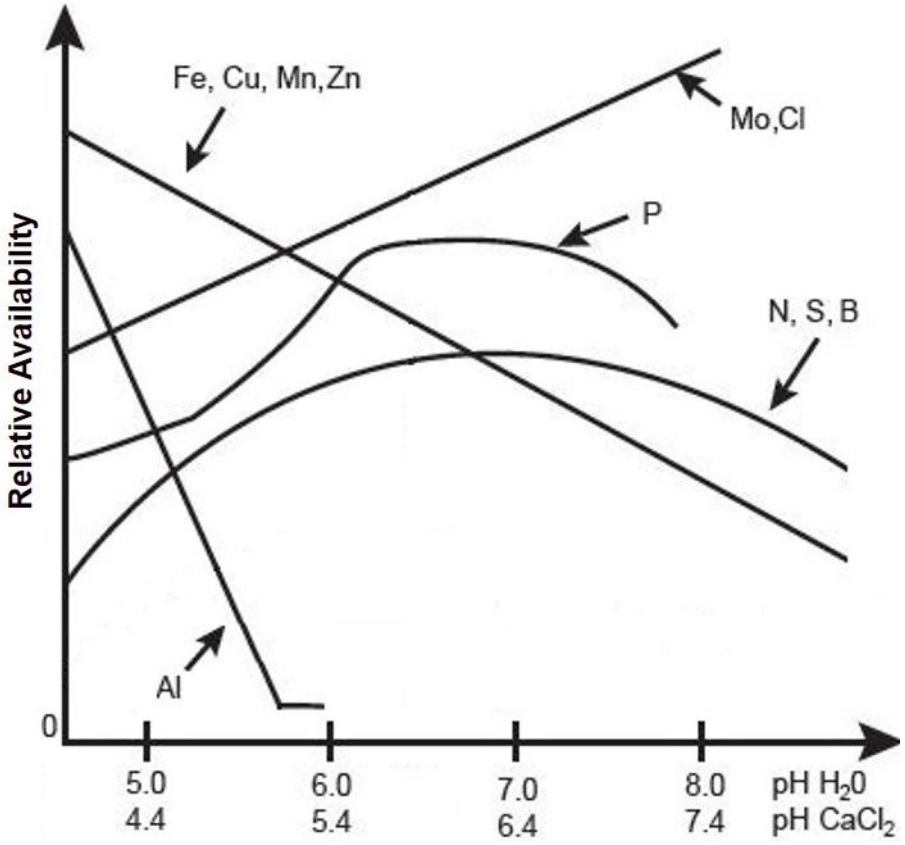

Figure S1-B Effect of pH in the relative availability of important ions related to soil fertility (Fe, Cu, Mn, Zn, Al, Mo, Cl, P, N, S, B). Adapted from Malavolta [13] and IPNI-Lopes [14].

Effects of Fe, Mn, Cu, Zn, B, and P were previously reported on bacterial studies [10, 15, 16]. Even though these elements are nutrients when available in optimal concentrations, they can be toxic (at variable thresholds for different microbial groups), and different microbial groups also have different strategies for their uptake and detoxification [3, 12, 17]. The role of iron in soil microbial communities is complex,

involving interactions with soil and plants [4, 18]. Mn, Cu, Zn and B are important micronutrient linked to enzymatic activity, but in excess Mn can inhibit enzymatic activity [19], Cu can be toxic [20], Zn can cause metabolic disorder [21], and B may impair protein synthesis in microorganisms [22]. P is an important microbial nutrient and its role is widely studied in soils [23]. The last factor in indirect effects 1 is soil CEC, that is the result of the colloid (clays) surface charges, and thus may interact with microbial cells and biofilm formation, and can influence cation availability [3, 24].

The second group of indirect effects is related to plant growth and other soil parameters. Due to all the above mentioned factors, pH can change plant biomass accumulation and grain production, and thus affect the nutrient dynamic in soils. Plants can compete for nutrients with microbial communities [25], and nutrients from different depths in soils can be exported by the harvest or cycled to the soil upper layers through plant litter [26]. Plant litter accumulation on the soil surface can especially increase SOM, K and N in the top soil, and these are also known drivers for microbial community structures [26, 27]. Moreover, plants that grow in very acidic soils (pH<5.5) may produce organic exudates to reduce the toxicity of Al^{+3}, and after changing soil pH, plant exudates and litter composition can change and may also influence the microbial community [4, 7, 28, 29].

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