



A meta-analysis to understand the effects of fungicides and bactericides on carbon and nitrogen cycling

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Fungi and bacteria play a central role in the cycling of carbon (C) and nitrogen (N), which has been frequently assessed by manipulating their abundance in soil with application of fungicides and bactericides. We conducted a meta-analysis using 61 publications related to fungicide and bactericide effects on soil and microbial properties. We observed that most of the fungicides and bactericides had significant negative effects on microbial biomass C and N. However, fungi and bacteria had mixed effects on soil respiration, N pools and transformation processes. Some fungicides caused the highest positive effects on available NH_4^+ and ammonification, while the largest negative effect on nitrification was caused by a bactericide. Available NO_3^- was little affected by most biocides, while N_2O emission was reduced by most biocides. Application of fungicides had neutral effects on respiration, NH_4^+ , and ammonification in agro-ecosystems, but had positive effects on these parameters in forests. The effect sizes of available NO_3^- and nitrification in response to bactericides were positively related to soil pH, while they did not vary with soil pH in response to fungicides. Interestingly, effect sizes of available NO_3^- and nitrification in response to bactericides were negatively related to soil C content, with no clear relationship for the fungicide effect sizes. Our results suggest that most fungicides and bactericides inhibit microbial growth and respiration, but that they have mixed effects on N cycling. Biocides need to be carefully evaluated for unintentional side effects, such as an increase in C and N availability due to decomposition of microbial necromass or of organic biocides themselves, before they can be used in assessing the role of fungi and bacteria for C and N cycling.