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Responses of lucerne (Medicago sativa L.) and rhizobia to copper-based fungicide application in two contrasting soils

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For more than 120 years, salts of copper (Cu) have been used in viticulture to prevent damages by fungal diseases. Due to restrictions in the use of synthetic fungicides and mineral fertilizers, organic viticulture depends on Cu as well as on biological nitrogen fixation. Here, we conducted an eco-toxicological pot experiment with an acidic, sandy soil and a calcareous, loamy soil and incrementally increasing fungicide application rates from 0 to 5000 mg Cu kg-1 soil. Lucerne (Medicago sativa L. cultivar. Plato) was grown in the pots for 3 months under greenhouse conditions. Acetylene reduction assays performed with harvested nodules showed no response to elevated soil Cu concentrations indicating that the nitrogen fixing capacity of rhizobia was not compromised by Cu in our experiment. Nevertheless, the nodule biomass was very sensitive to Cu and strongly decreased due to reduced amounts of fine roots and less energy supply by the plant. Legumes are known to be Cu-sensitive, and our contribution also showed a decrease in harvest by 50 % (EC50) at 21 mg kg-1 plant Cu tissue concentration in the acidic soil and at 30 mg kg-1 in the calcareous soil. This corresponded to diffusional fluxes measured by diffusive gradients in thin films (DGT) of 202 and 368 fmol cm-2 s-1, respectively. DGT measurements showed that in the acidic soil, Cu was 2 to 10 times more available for plants, depending on the concentration applied, than in the calcareous soil. A modeling approach for estimating the effective concentration (EC) by including the DGT-estimated plant Cu content and the pH produced more accurate values (NRMSE of 21.9 to 20.1 %) than EC directly estimated from DGT.