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Mycorrhizal inoculation and application of Fe correction in the soil for ameliorating grapevine performance in a copper-contaminated soil

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Copper-based fungicides are commonly applied in vineyards to control fungal diseases that can severely affect grapevine productivity. Continuous application of this type of fungicides contributes to Cu accumulation in surface horizons of the soil, which can generate toxicity problems in plants, regardless of being an essential nutrient. Several strategies have been proposed to immobilize or counteract the effect of soil contaminants, such as plant inoculation with arbuscular mycorrhizal fungi (AMF). However, depending on the element concentration, this may not be sufficient to avoid its excessive accumulation in belowground and/or aboveground organs. Since Fe is known to have an antagonistic interaction with Cu in plants, Fe application, as an amendment, in vineyard soils, could be a good strategy to avoid excessive Cu uptake by grapevines growing in Cu-contaminated soils. However, little information is available on the combined effects of both strategies.

In order to reveal the possible beneficial effects of plant mycorrhization and Fe application in Cu-contaminated soils on grapevine growth and nutrition, a mesocosm experiment was established under controlled conditions. Two-year-old plants, previously inoculated or not with two different AMF, were grown in pots filled with 6.5 kg of an Arenosol collected from a wine-growing region. These plants were subjected to three soil treatments: 1) soil contamination with Cu, where the grapevines were watered with a solution containing 5.89 mg/L $CuSO_4$ to ensure that the soil in each container reached 300 mg Cu/kg; 2) soil contamination with Cu + Fe addition, where the plants were watered with a solution that contained the same amount of $CuSO_4$ plus 0.38 mg/L of $FeNaEDTA{\cdot}3H_2O$ to achieve 100 mg of Fe/kg soil; and 3) non-contaminated soil watered with deionized water. Four months later, at the end of the growing season, plant vegetative growth as well as leaf and root nutrient contents were analyzed.

Grapevines inoculated with AMF demonstrated a good level of tolerance to high Cu concentrations in soil, as they presented significantly higher root biomass than non-inoculated plants and Cu was mainly accumulated in the roots avoiding its translocation to the aerial part. However, when the Cu-contaminated soil was amended with Fe, a significant decrease was observed in root biomass in all mycorrhizal inoculation treatments and Cu was accumulated in grapevine leaves. Contrastingly, Fe application helped to avoid the excessive increase of Mn concentrations in leaf

and roots that is commonly induced in Cu contaminated soils, which can be detrimental for grapevine growth.

These results demonstrated that mycorrhizal inoculation is a suitable strategy to promote grapevine growth in Cu-contaminated soils. However, special attention needs to be taken when applying amendments to correct Cu contamination, as the mycorrhizal status of plants may alter the expected outcome.