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Impacts of Human-use Antifungals on Symbiotic Soil Fungi in the Agro-environment

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Unsustainable agricultural practices which degrade soil quality and reduce crop production are a threat to increasing food demand globally. Reusing municipal biosolids and promoting arbuscular mycorrhizal associations in crops to reduce synthetic fertilizer use is practiced in regenerative agriculture but exposes soil to man-made chemicals, including partially metabolised pharmaceuticals, that enter wastewater treatment works. Here, we evaluate the impact of pharmaceuticals on arbuscular mycorrhizal (AM) fungal function. Mycorrhizal spring onion and lettuce were grown in agricultural soil spiked with three antifungal azole pharmaceuticals at environmentally relevant concentrations and used a combination of radio and stable isotopes (14C, 33P, 15N) to track carbon for nutrient exchange between the AM fungi and the plants. We used DNA sequencing to define the microbial communities within crop roots and soils in both treatments and chemical analysis to quantify the presence of antifungals in soil and plant organs.

When exposed to antifungal pharmaceuticals, no significant impacts on root colonisation by AM fungi were observed. However, bi-directional exchanges of AM fungal-acquired phosphorus and plant-fixed carbon between symbionts were reduced in all crops alongside changes in bacterial and fungal community composition. Specifically in spring onion roots, there was a significant decrease in fungal (ITS) alpha diversity and this trend followed for lettuce, although it was not significant. These changes support the results from our nutrient tracing observations which revealed that phosphorus assimilation by spring onion via AM fungi was significantly reduced in the presence of the antifungals. Comparatively for lettuce, the results show that this crop did not respond so dramatically, although there was a general decrease in phosphorus transfer.

Our results indicate that pharmaceutical antifungal agents have a direct impact on AM function, impacting the wider soil microbiome. This is likely to have wider effects on soil health and function in agroecosystems. Our research emphasises the unintended consequences and threats posed by emerging contaminants in soils in terms of impacts on AM fungal function and microbial community composition. This emphasises the pressing need for further research and regulation across potential contaminants of soil systems to determine wider impacts of circular agriculture practices.