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Contributions of soil microbes and soil organic matter to plant productivity in tropical savanna soils under different land uses

Geofrey Soka[1] and Mark Ritchie[2]
[1]Sokoine University of Agriculture, College of Forestry and Wildlife, Wildlife Management, Morogoro, Tanzania, United Republic of (gsoka@suanet.ac.tz)
[2]Department of Biology, Syracuse University, 107 College Place, NY 13244 USA

Arbuscular mycorrhizal fungi (AM fungi) and soil organic matter (SOM) can be important factors in soil fertility, cycling of nutrients, and plant productivity. It is still unclear whether greater AM fungi abundance is advantageous for plant productivity under nutrient-poor tropical soils despite the relatively common lack of phosphorus (P) and the purported benefit of AM fungi in obtaining and exchanging P with plants for carbon. We explored whether AM fungi and/or SOM augmented plant productivity in different field soils to test the hypotheses that AM fungi were important contributors to plant productivity and that the contribution by AM fungi is higher on soils with lower organic matter and presumably lower nutrient availability compared to soils with higher organic matter. We conducted a factorial experiment in the greenhouse with potted soils of either high or low organic matter (SOM) collected from each of three different land uses, grazed by wildlife in a protected area (Serengeti National Park, Tanzania), grazed by livestock, and cropland. Half the soils were sterilized to remove soil microbes, including AM fungi. Two grass species, Zea mays and Themeda triandra, were grown for 12 weeks in 8 replicates of each soil type and sterilization treatment. About 52.4% and 62.6% of Z. mays roots grown in non-sterilized soils were colonized by AM fungi in low and high SOM, respectively, and 38.1% and 46.7% of T. triandra roots grown in non-sterilized soils were colonized by AM fungi in low and high SOM respectively. Overall, the production of both plant species was significantly higher on control soils than sterilized soils, indicating that AM fungi likely contributed to productivity, and on soils with higher SOM. However, the separate contribution to the productivity of SOM and soil microbes varied significantly among plant species and soils from different land uses. Zea mays productivity increased most strongly to higher SOM, and declined with sterilization in agricultural, but not livestock or wildlife grazed soils. In contrast, T. triandra production was largely insensitive to SOM or sterilization except on wildlife-grazed soils, where it increased most strongly in unsterilized soils. Soil microbe impacts on productivity, therefore, may be driven more by host plant species than by lower nutrient supply, as associated with lower SOM. Furthermore, the results suggest that efforts to enhance productivity in uncultivated lands should perhaps focus on altering plant species composition, while efforts to enhance productivity in agriculture soils might not depend on beneficial soil microbes or additional fertilizer but instead on effective crop rotations to reduce soil pathogens.