The importance of Soil Biodiversity for the use of resources

Introduction:

'Upon this handful of soil our survival depends. Husband it and it will grow food, our fuel, and our shelter and surround us with beauty. Abuse it and the soil will collapse and die, taking humanity with it.'
Vedas Sanskrit Scripture, 1500 BC.

The functions performed by soil organises are essential to human society and the natural world. Specifically, soil biodiversity has been seen to influence all the main regulatory services including, regulation of water quality and composition in agricultural and natural ecosystems (Turbe et al., 2010). Agricultural sustainability lies within the framework of which resources are being renewed or remain available at levels to attain such production (Brussaard et al., 2007). One way to ensure agricultural sustainability is met is to understand the importance that soil biodiversity (SBD) has when it comes to use the of resources, such as water and nutrients. Soils host a diverse community that supports and regulates ecosystems, thus affecting resource use efficiencies (Mujitar et al., 2019). This links directly to SDG 15, "Life on Land", as it aims to "halt and reverse land degradation and halt biodiversity lose", which can often arise through the misuse of resources that harm the biodiversity of soils (UN, n.y.). More specifically SBD relates to more than one of the SDG 15 targets (targets 15.1, 3, and 6). Soil organisms, include bacteria, fungi, soil arthropods and invertebrates and thus they all play essential roles in soil processes. For example, soil communities help the nutrient uptakes by plants and organisms, and organisms such as earthworms, can improve soil aeration and water infiltration (Pulleman et al., 2012; Orgiazzi et al., 2016). SBD houses a multitude of importance; however, the organism underground remains largely unexplored, thus we will highlight the importance of understanding SBD for the use of resources and practises that can affect it.

Nutrients:

Soil biodiversity is essential to providing key ecosystem services, such as nutrient cycling, and in agriculture, nutrients are of the utmost importance. Soil organisms are critical for plant growth and production, by cycling nutrients (Bach et al., 2020). For example, the availability of nitrogen (N) for plant uptake is dependent of microbial process present in soil, such as N fixation (N2(gas) into bioavailable form (NH3)) (Kuypers et al., 2018). Furthermore, it has been found that 80% of all land plants rely on partnerships with mycorrhizal fungi, which deliver nutrients directly to plants (Wang et al., 2006). Nutrient use efficiency is one way SBD helps to increase agricultural sustainability of an area. In a study undertaken by van der Heijden et al., 1998, they showed that increasing the arbuscular mycorrhizal diversity hyphal length causes plant phosphorus (P) at vegetation level to increase and soil P to decrease. This highlights SBD importance to nutrients as the mycorrhiza allows for more a more efficient exploitation of soil P (Brussaard et al., 2007). Furthermore, Brussaard et al., 2007, also found that under N limitation, treatments with soil fauna present showed a significant higher N use efficiency than without soil fauna. If SBD is negatively impacted this can affect the agricultural yield, as smaller and less taxonomically diverse soil communities lead to lower plant productivity, less N turnover and greater leaching of P. Therefore, reduced resources, not just in the crop yield, but also an increased loss of nutrients from the agroecosystem. The mismanagement of agricultural practices can directly affect SBD as stated and thus cause large nutrient deficiencies in the developing world in crops and human societies (Mujitar et al., 2019). A high diverse SBD allows plants to optimise their nutrient uptake, thus it is important to enhance the biodiversity of our soils and implement practices that do not harm the soil, as the nutrients benefits the plants and humans.

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Water:

The importance of SBD does not only lie within SDG 15, but also in SDG 6 and 14 (clean water and sanitation, and life below water). As water passes through soil, the pore space causes the water filtration and thus allows chemical and biological interactions between the water and the organisms. Where these processes occur, the water is cleaner and thus benefits people and aquatic life (figure 2) (Bach et al., 2020). SBD plays are large role in biological soil water use, however many of the organisms also facilitate physical and chemical interactions between water and soil matrix (Bardgett et al., 2001). A species-rich soil increases the water use efficiency in upper soils where roots are concentrated and thus leads to a higher total biomass (Brussaard et al., 2007). Furthermore, as seen in nutrient use efficiency, a more diverse mycorrhizal community leads to a higher vegetation biomass. Here, diverse mycorrhizal fungi communities are effective soil stabilises and thus affect moisture retention in the soil, which means root systems can scavenge water more effectively (Brussaard et al., 2007). In Burkina Faso, increased termite foraging in restored forests increased water infiltration over crop fields and bare ground; this can help alleviate flooding during high rainfall and increase soil moisture (Kaiser et al., 2017). Using SBD to increase water infiltration also increases opportunities for plants and soil organisms to use dissolved and suspended nutrients, such as nitrates and phosphates, thus reducing nutrient run-off into surface water and ground water (Bach et al., 2020). Water resources are essential and thus having a diverse SBD, as shown, can lead to a high biomass and safer environments for not only plants but also human civilisations.

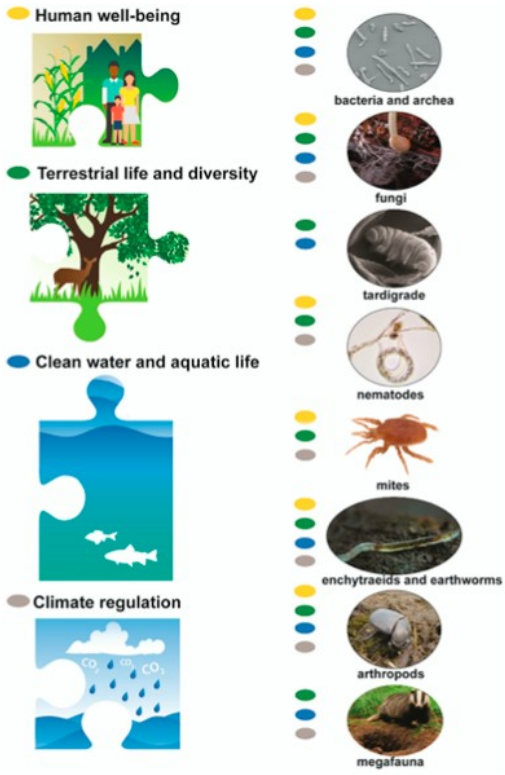

Figure 1: Taken from Bach et al., 2020, showing how soil organisms support multiple ecosystem services, which underpin global sustainability agendas.

No-till farming:

There are many agricultural practices that harm the quality of the soil or that can be even lethal to soil fertility, such as the use of chemicals or deforestation, all of which affect the resources: water and nutrients. However, there is a common practice that is one of the biggest contributors to degrading the soil: tilling. Tilling consists in turning over the most superficial part of the soil in order to aerate and warm the soil, but even if this is good in the short term, it can have very bad consequences in the future. Because of this practise millions of microbes and arthropods are displaced from the soil, which in the long term will result in a lifeless and chemical-depending soil (Spears, 2018). No-till farming is an alternative that brings the opportunity of increasing the crop yield at the same time of reducing the input costs and the degradation of the soil (Pittelkow et al., 2015). Dominguez et al., 2010, further emphasise the impacts of tillage by showing how even reduced tillage systems still host less soil biodiversity than natural ecosystems, thus affecting the nutrients and water resources of the system. As tillage negatively impacts soil organisms with larger body sizes, annual tillage sites are found to have reduced SBD and have a shift towards small-bodied communities

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compared to fields managed with no-tillage (Postma-Blaauw et al., 2010; Bach et al., 2010). As stated, less taxonomically diverse soils lead to a numerous of nutrient deficiency problems for the soils and for the plants themselves. In addition, no-tilling practises not only sustain a healthy soil offering clean and better ecosystem services, but also saves water, enhance carbon sequestration while decrease greenhouse emissions and ensures food security (Somasundaram et al., 2020). Therefore, no-till farming becomes a key for achieving SDG15 (Life on land) but is also important for others SDG's as SDG2 (Zero Hunger) and SDG13 (Climate Action), between others. For these reasons, the no-tilling agricultural practise is recommended by the Voluntary Guidelines for Sustainable Soil Management, published by the United Nations Food and Agriculture Organization in 2017 (FAO 2017). However, no-till farming is still facing many challenges as for some countries is being difficult to adapt from the traditional practises. Therefore, to ensure the water and nutrient properties of soils aren't alternated for the worse a no-till approach needs to be adopted

Conclusion:

In agricultural systems, the harmony between water and nutrients is an essential relationship in sustainably utilizing the resources of the land to meet our own nutritional needs, while minimizing our impacts in doing so. This emphasises the importance of maintaining a diverse biological community within the soils of agricultural lands when it comes to SDG15, and thus the importance of respective practices that ensure these communities are preserved. Maintaining the soil biodiversity is needed for the use of resources as it streamlines the usage of nutrients and water in resource limited environments and to maintain a healthy natural cycle of the ecosystem dynamics within the soil. Preventing erosion, facilitating nutrient uptake, limiting the degradation and acidification of lands, as well as waterbodies affected by agricultural run-off are among the many important factors being positively impacted by preserving the natural biodiversity of agricultural soils. Measurements such as practising no-till farming help preserve this diversity, and thereby restrict the use of chemical fertilizers polluting land areas and waterbodies affected by run-off. If we are to sustainably feed the future human population and ensure that no person goes hungry, our biological friends of the underground need to be recognized as assets and provided with a healthy natural habitat in which they can continue doing what they do best.

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