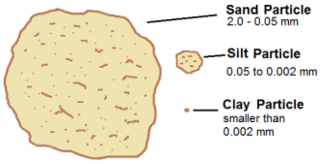
The Importance of the fungal Kingdom to healthy soils.

(Dr Mary Cole, Agpath P/L; 0413 013 247)

Soil without microbes is sand, silt and clay. It is the glues produced by bacteria that hold together the grains of sand, silt, and clay to form micro-aggregates. It is the fungal glues and mycelium that bind the micro-aggregates into macro-aggregates that gives soil its structure.



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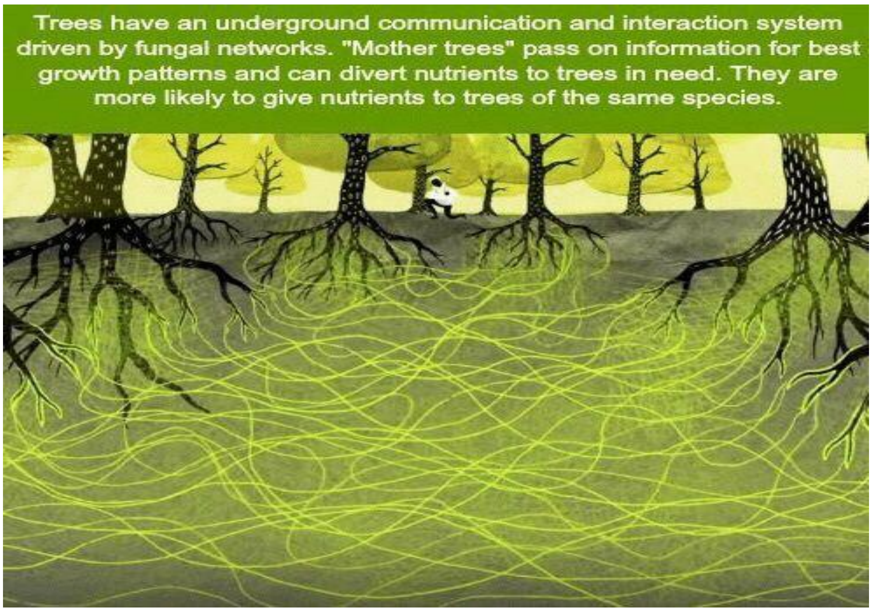
Sand, silt & clay	+	Organic Matter	=	Soil

It might come as a surprise that the largest living organism on the planet is a fungus. This beautiful organism is a mushroom called *Armillaria ostoyae* found in the Malheur National forest in Oregon, USA. Molecular profiling has established that this fungus covers an area of approximately 965 hectares and growing with an estimated biomass up to 35,000 tonnes of mycelium, soil and diseased plant roots (Schmitt, CL & Tatum, ML (2008) USDA The Malheur National Forest Location of the world's Largest Living organism – the Humongous Fungus). Australia has its own endemic species of *Armillaria* causing considerable damage to the native forests but not as large as the one described.

Many organisms make up the soil food web including bacteria, fungi, protozoa, nematodes, earthworms, beetles, micro-arthropods and others. Together they form passages and build airways for water and air to penetrate the soil for feed plant roots.

Bacteria and fungi are the primary colonisers of organic matter from which they capture nutrients such as calcium, nitrogen, iron, potassium, phosphorus, etc into their cells. These cells are fixed to soil particles preventing them from being leached away. It is then the next level of predators that feast on the bacterial and fungal cells releasing the nutrients in plant available form. In this highly democratic soil society, the plant excretes foods for the bacteria and fungi from their roots. This is a highly complex web of interactions. Plants are involved actively with the soil biota through their chemical communication with other plants and microbes shaping their environment to benefit all soil life. One can consider the soil a superhighway of chemical signalling and fungal networks assuming it is not impacted by modern agricultural practices. Modern agriculture destroys the superhighway completely! Tillage destroys mycorrhizal fungal networks that result in decreased phosphorus uptake by and availability to the plants.

Forest soils and natural grassland ranges constitute major carbon pools in the context of the global carbon cycle. Mycorrhizal fungi in forests are mostly ectomycorrhizal. This biomass contributes significantly to the formation of soil organic matter. The Biomass of ectomycorrhizal hyphae is comparable with the fine root mass (Wallander et al, 2001,2004).



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In a forest that is not too damaged, each tree is connected to all the others in a network that allows distribution of messages about invading insects or disease organisms. This allows the trees to alter their chemical behaviour to better protect themselves against attack.

The fungal networks provide water, phosphorus, microelements and nitrogen in exchange for food such as carbohydrates. The Fungal kingdom members do not photosynthesise so rely on plants to provide this fungal food in a direct exchange relationship. It is not just within plant species that mycorrhizae associate, but it is known now that different tree species help one another with nutrients via the fungal superhighways.

This same superhighway is used to warn plants that a pathogen or damaging insect is in the vicinity and likely to cause damage. Within hours plants have signalled the pending danger to neighbouring plants allowing them time to activate their natural defence systems to defend against attack.

This arbuscular mycorrhizal network exudes a glycoprotein called glomalin that was discovered by Sarah Wright in her PhD research in 1996. Glomalin stores and sequesters over a longer period more carbon than does humus in the soil. Nutrients are stored and water retention is much higher in undisturbed soils where the superhigh is intact. The fungal network collects plant available phosphorus for plants by effectively acting as an increased root system for plants allowing them to source phosphorus from a greater volume of soil. At the same time, the fungal hyphae exude calcium oxalate which moderates the soil pH in the rhizosphere of the plants.

The use of synthetic phosphorus negatively impacts the ability of mycorrhizal fungi to mineralise phosphorus from the soil. Mycorrhizal fungal populations can be improved by removing synthetic phosphorus from farming management and minimising soil disturbance and increasing at every opportunity the amount of organic matter in the soil. Each of these activities increases soil fertility, improves aeration; gives better water holding capacity to the soil; makes available more nutrients in forms that can be immediately used by the plants, and finally, increases plant productivity.

As agricultural scientists it is incumbent on us to understand the role of soil microbes in the overall productivity of all soils, not just agricultural soils, and to become aware that synthetic chemistry is destroying our most valuable resource for future life of Earth – the Fungal Kingdom.

Wallander, H., Nilsson, L.O., Hagerberg, D., Baath, E. 2001. Estimation of the biomass and seasonal growth of external mycelium of ectomycorrhizal fungi in the field. *New Phytologist,* 151:753-700.

Wallander, H., Goransson, H., Rosenberg, U. 2004. Production, standing biomass and natural abundance of 15N and 13C in ectomycorrhizal mycelia collected at different soil depths in two forest types. *Oecologia* 139:89-97.