Nurture sands to stimulate soil microbes

Many producers neglect sandy soils believing they have poor yield potential and are not worth valuable fertiliser inputs. But as this article shows, encouraging microbes in sandy soils by retaining crop residues can lift yield potential, while improving structural stability.

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Stimulating the soil biota population in sandy soils by increasing soil organic matter can deliver substantial production benefits in a relatively short time.

CSIRO research within the Mallee Sustainable Farming Systems project shows better management of sandy cropping soils can help stabilise soil structure, reduce nutrient loss via leaching and erosion, lift the supply of nutrients and suppress soil-borne plant diseases.

Lifting crop and pasture dry matter production on sandy soils and retaining above- and below-ground crop residues will boost soil organic matter, which soil microbes require as an energy source.

Access to more energy encourages soil microbes to multiply and decompose crop residues quickly releasing valuable plant nutrients such as nitrogen.

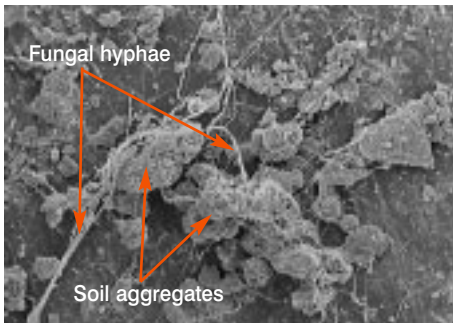
Soil structure

Good soil structure depends on the presence of aggregates which remain stable during cycles of wetting and drying. Aggregate size and stability controls the amount of surface soil lost to wind erosion.

Wind erosion is a particular threat to sands in the landscape, which lack the benefits of clay-based aggregation.

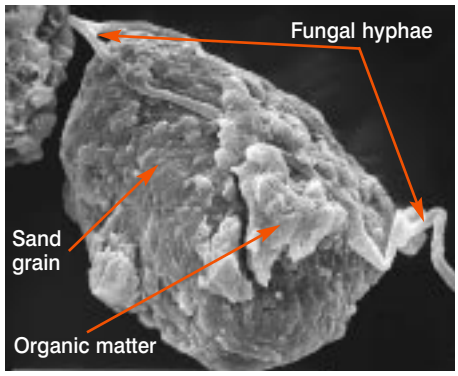
At a glance

- Improving the populations, diversity and activity of soil biota can lift crop production and stabilise soil structure significantly.
- Of all soil types, sands have the best potential to benefit from better microbial management.
- Better microbial management of sands will deliver the benefits of improved soil structure, reduced nutrient leaching, increased nutrient delivery to plants and improved suppression of soil-borne plant diseases.



Photos: CSIRO Land and Water

Soil microbes play a critical role in sustainable crop production. Sand particles and small soil aggregates (pictured) are held onto decomposing wheat stubble by fungal hyphae. Without soil microbes such as fungi, soil aggregation would not be possible.



Pictured are sand grains colonised by fungal hyphae and coated with organic material. In sands, nutrient turnover is rapid because organic matter is not bound up in soil aggregates but instead remains open to degradation by soil microbes. Increasing soil organic matter in sandy soils can result in a relatively quick release of plant-available nutrients.

The physical nature of sandy soils enables soil biota to access and decompose available organic matter quickly.

The lack of soil structure in sands allows soil microbes ready access to small particles of organic matter dispersed throughout the soil.

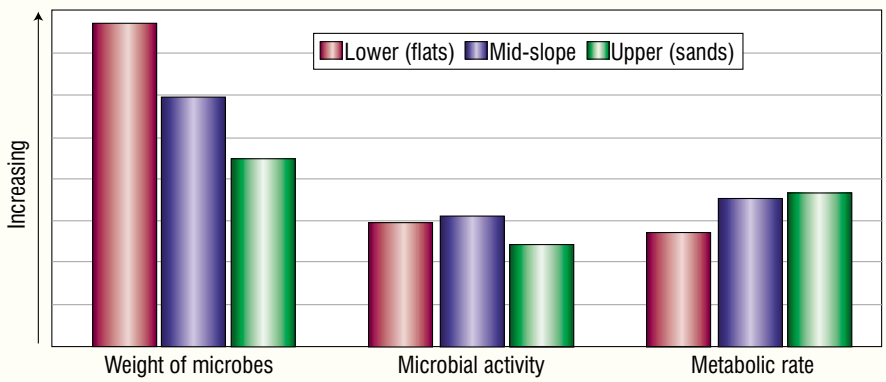
In contrast, soil microbes in clay and loamy soils are intimately bound within large aggregates of soil and organic matter, which offer protection from environmental extremes and predation.

Aggregation enables separate and distinct community groups of microbes to form throughout the soil and can mean pathogenic or disease-causing micro-organisms develop in isolation from the beneficial microbes that help keep diseases at bay.

In addition, organic matter is protected from degradation and as a consequence nutrient turnover can be slow.

In sands, nutrient turnover is rapid because organic matter is not bound up in soil aggregates but instead remains open to degradation by soil micro-organisms. This means, increasing the amount of organic matter in sandy soils can result in a relatively quick release of plant-available nutrients.

FIGURE 1 Soil microbes and position in the landscape



Microbial activity is relatively low in sandy soils compared with loamy or clay-based soils close to the valley floor (mid-slope and lower flats). Lifting the organic matter content of sandy soils can stimulate microbial growth — leading to increased nutrient availability, a more stable soil structure and increased disease suppression.

Source: CSIRO Land and Water.

In addition, the nutrients from organic matter and inorganic fertilisers are temporarily tied up in the microbial biomass, preventing them from leaching beyond the root zone.

Nitrogen mineralisation

Results from CSIRO research at Waikerie, South Australia, show how adopting a high input, intensive cropping regime on sands can increase nitrogen mineralisation and reduce nitrogen leaching.

Nitrogen mineralisation increased by more than 50 per cent from 20 kilograms per hectare per year under a low input pasture–wheat system to more than 35kg/ha/year under the high input, intensive cropping system.

In addition, nitrogen leaching was reduced by more than 60%.

Disease suppression

Because most microbial populations (both beneficial and pathogenic) in sands are concentrated near plant residues, pathogenic micro-organisms have to interact with the rest of the soil biota, particularly during the 'off season' when the host plant is missing.

As a result, in sands, pathogenic microbes are forced to compete with other micro-organisms for carbon and nutrients while also withstanding antagonistic soil microbes and predation by soil fauna.

Pathogens also need to negotiate other soil microbes and reach seedlings at the ideal time to cause infection.

In the absence of healthy soil biota, disease inoculum from infected plants will have the 'upper hand' and could cause higher levels of the disease.

But with improvements to microbial functions and overall plant health, pathogens will have less impact and disease levels will be low.

Research on the severity of rhizoctonia root rot at Avon, SA, showed disease suppression levels could be modified over time to the point where complete control of the disease could be achieved.

Improved disease suppression was related to increased carbon inputs (stubble and roots) to the soil from higher yielding crops and increased cropping frequency.

Increased carbon inputs result in changes to the composition and activity of the soil microbial community causing more competition for soil resources which, along with predation and inhibition of pathogens, lead to increased suppression of many soil-borne fungal diseases.

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Sandy soils

Sandy soils have less total and biologically-available organic matter than heavier soils in the landscape.

But even though sands generally hold less soil water than heavier soil types, more of this water is available for soil biota and plants because sands suffer fewer problems with subsoil constraints.

The poor structure of sands means soil microbes can access and breakdown soil organic matter more easily than is possible in heavier, more structured soils, in which organic matter is bound within large soil aggregates. In addition, soil microbes in sands have fewer places to hide from soil fauna predation and dehydration.

Under low-input cropping systems, fewer crop residues are available on sands compared with heavier soils and consequently there is less carbon to promote the build-up of soil microbial populations.

Increasing the input of organic matter on sands by retaining crop residues and intensifying the cropping system will lift the activity of soil microbes and provide production benefits.