SOIL MICROBES AND DROUGHT: GRAZED SYSTEMS

Microbial function and adaptation in response to climate change driven drought and the resulting effects on plant production and nutrient cycling

Microbes are important for many soil processes that contribute to the production of food and fibre on which humans rely. Under climate change, there is likely to be an increase in the intensity and frequency of drought in New Zealand but little remains known about how drought affects soil microbes. Therefore, we conducted a literature review to assess what we do and do not know about the effects of climate change driven drought on soil microbial function and adaptation and how this might affect plant production and nutrient cycling.

We assessed a broad range of literature that considered how microbes respond to drought and how that affects carbon, nitrogen and phosphorus cycling in soils under pastoral grazing. We reviewed the interaction between microbes and soil water repellency and how plant production and pathogens might behave under drought. Further, we evaluated how advanced genetic techniques could contribute to understanding the effects of drought on microbial community composition and the ability of microbes to cycle organic matter. Finally, we also investigated possible mitigation strategies to lessen the effects of drought on soil microbes.

Drought effects on soil microbes

During drought:

- Microbial function decreases and reduces C, N, and P cycling
- Microbial community structure is altered
- Soil water repellency may worsen the effects of drought
- Pathogen disease expression varies
- Nutrient cycling and plant production will decrease

The persistence of drought effects on microbes will be affected by the duration, intensity, and timing of drought and the subsequent rewetting phase.

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What don't we know about the effect of drought on microbes?

We found a lack of information applicable to New Zealand and identified a large number of areas that need more information to able to adequately understand and prepare for future climate change driven drought events. For example, we don't know how and to what extent soil water repellency will increase the negative effects of drought. There may also be a trigger level of soil moisture above which the negative effects of drying and re-wetting are avoidable. However, further work is needed to determine these trigger values, and they are likely to be soil and land use specific. We also do not fully understand how microbes will respond to nitrogen (urine or fertiliser) or phosphorus additions during drought periods and how these combined factors influence pasture production or weed invasion.

In the bigger picture, while there was information on how reduced soil moisture, increased temperatures, and elevated CO_2 might effect microbes, they were often assessed separately. These factors will often occur together in future climate change drought scenarios but experimental data that have assessed all three of these factors at once are very rare. Further, as short- and long -term experimental results vary, more work assessing the effect of drought over the long-term is needed to increase understanding of drought effects on future soil health and plant productivity.

What can pastoral grazing systems do to prepare for climate change driven drought?

The most obvious solution to drought is irrigation, which is commonly used in dairy production. However, this is not always a viable option and is rare in other pastoral landuses like deer or sheep and beef production due to lower profit margins, more difficult topography and reduced access to surface water resources.

Increasing the soil organic matter contents of soil will increase the amount of water a soil can hold as well as feed microbes and plants to maintain their growth in drought periods. Further, preventing or remediating water-repellent soil conditions will also decrease the effects of drought on soil microbes. Such strategies will be site– and soil-specific, and more research is required to understand the root-source of water repellency.

There are strategies that are more directed at helping plants survive drought conditions, including spraying plants with chemicals to increase their drought tolerance. Also, the development of more drought resistant plants is also an option being explored by many researchers around the globe. A move towards more diverse pasture systems with greater rooting depth may also be a strategy for drought resistance in pasture swards.

The introduction of biofertilisers (fertilisers that include specific microorganisms that can enhance drought tolerance of plants, e.g. mycorrhizal fungi) is also being researched internationally but results remain inconclusive in New Zealand.

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