SOIL MICROBES AND DROUGHT: PRODUCTION FORESTRY

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.

Within the literature review we assessed a broad range of data which determined how microbes respond to drought and how that affects carbon, nitrogen and phosphorus cycling in soils under production forestry. 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 drought
- Red needle cast infection will be affected by the intensity, duration and timing of drought
- 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 be 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 specific to soil and land use. With respect to *Phytophthora* infection (red needle cast), more information is needed on the how the levels of drought and the level of red needle cast infection interact in our production forest sector.

In the bigger picture, while there was information on how reduced soil moisture, increased temperatures, and elevated CO_2 might affect 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 the results of the short- and long-term experiments vary, more work assessing the effect of drought over the long-term is needed to increase understanding of drought effects on future

What can the forestry industry do to prepare for climate change driven drought?

While the solution for other production land uses can be irrigation, this is unlikely to be a viable solution for the forestry industry.

Increasing the 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 decrease the effects of drought on soil microbes, and reducing fires in forests will decrease the possibility of water-repellency developing. However, as increasing organic matter can enhance water repellency in some soils further site specific assessments would be required.

The development of more drought-resistant trees is perhaps the best option and is currently underway in New Zealand.

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

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