Soil fumigation and effects on soil biological communities

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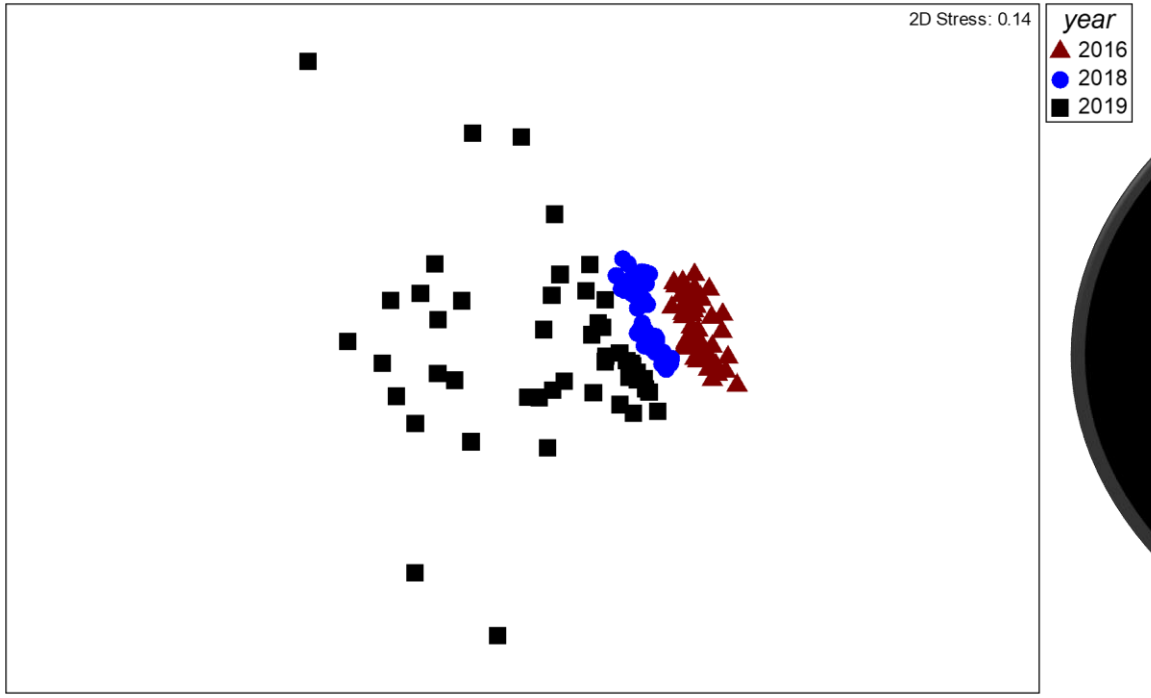
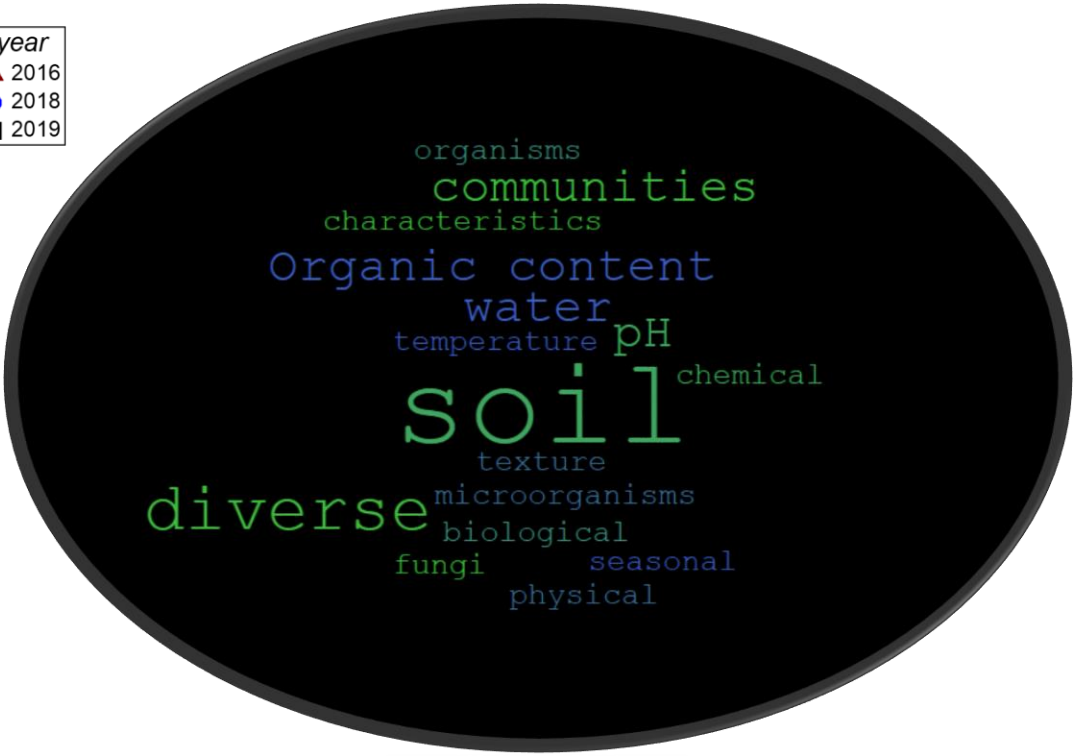
Soil biology is complicated

Soil is a system: parts cannot be understood in isolation

Biological communities are shaped by their environment:

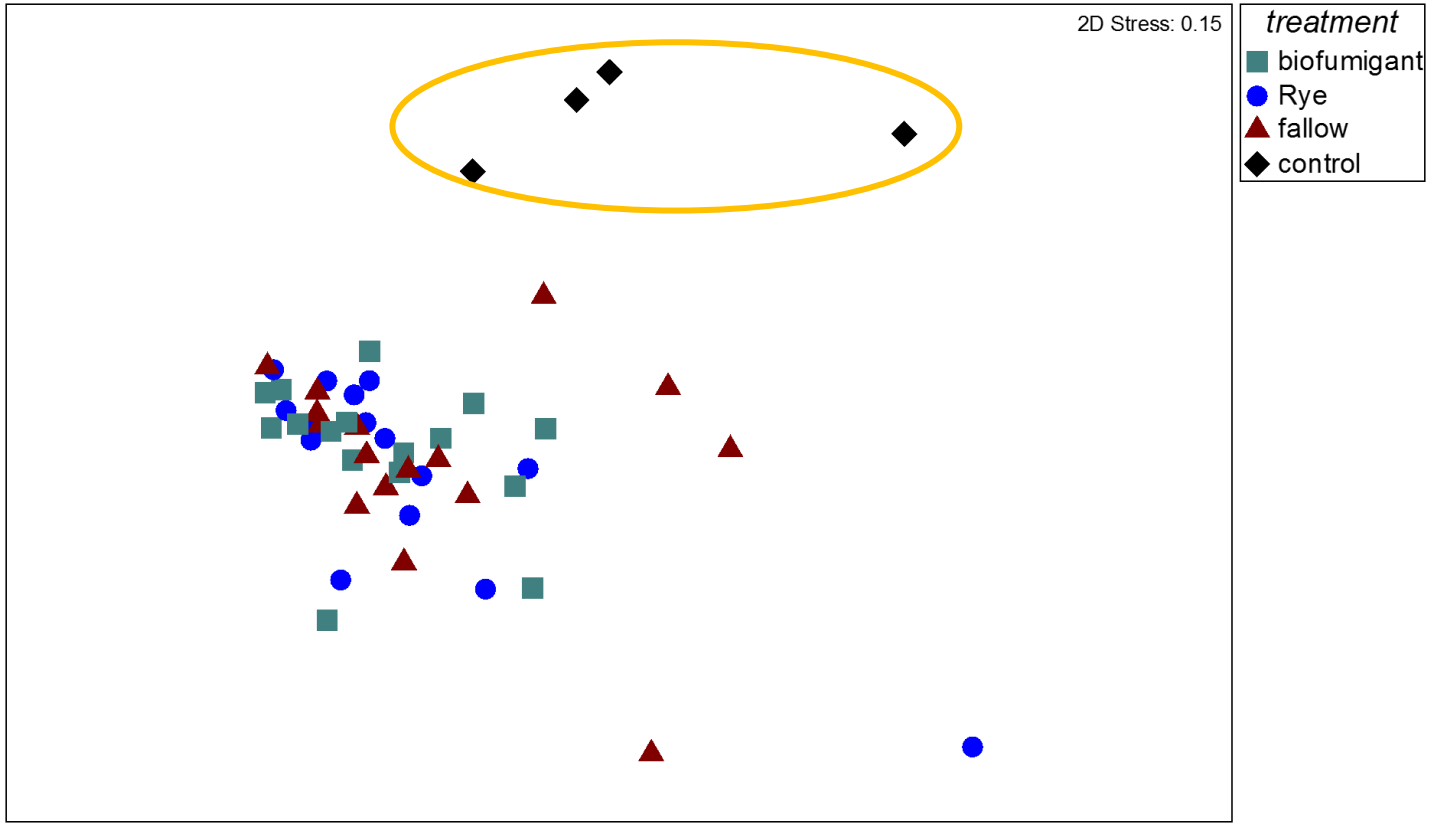
What organisms are present, and what they are doing depends on the soil





Managing the soil causes change

Biological communities under the fence-line were significantly different to those in all cover crop rotations



Fumigation in the soil

Biofumigants and chemical fumigants both have compounds that are toxic

Biofumigation starts when biofumigant crop, or other product, incorporated into soil

- Enzymes convert glucosinolates to isothiocyanates (ITC) which can be toxic
- These compounds move through the soil whilst organic matter is decomposing

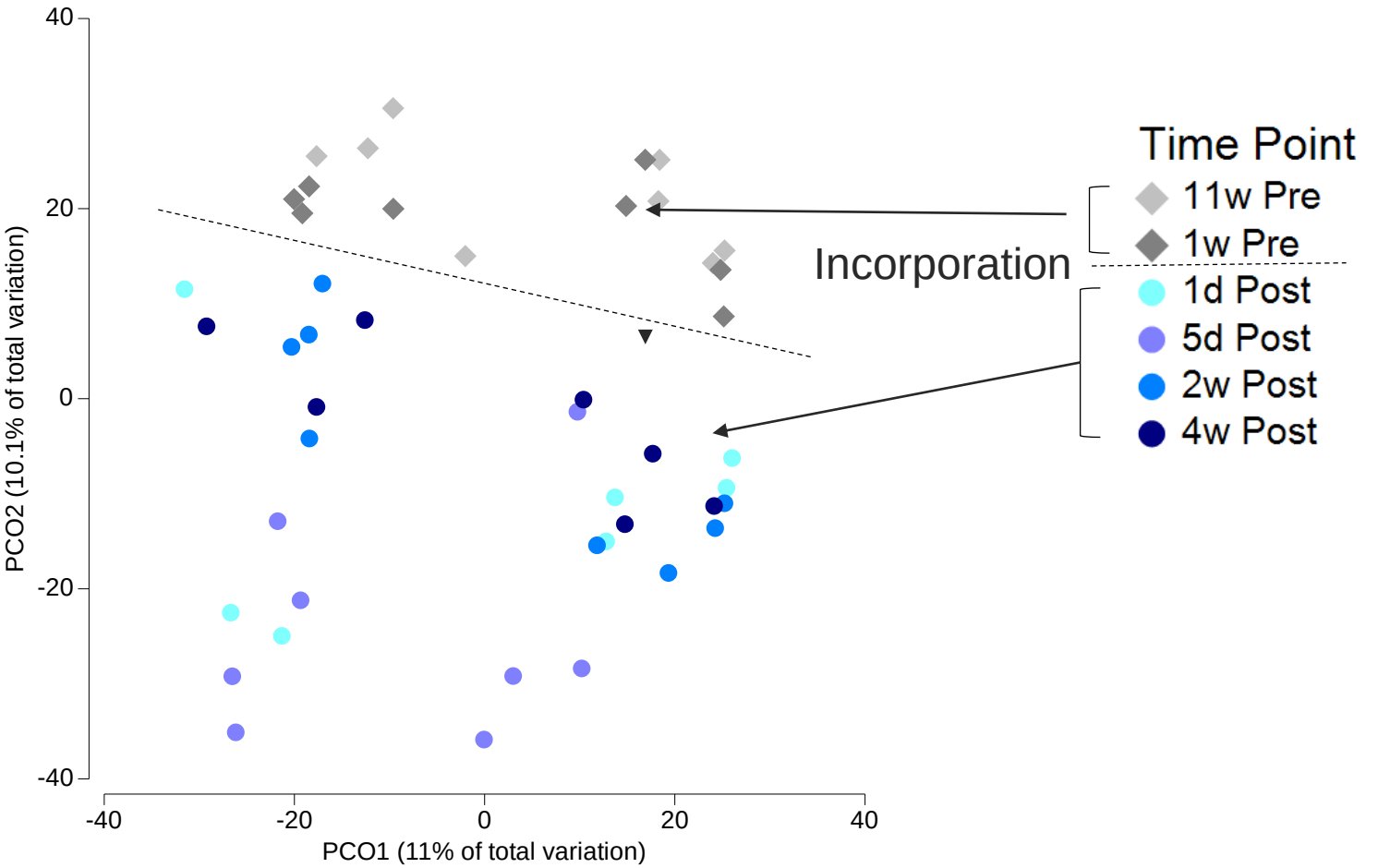
Organic matter → Stimulates soil food web

isothiocyanates → Toxic to some organisms

Chemical fumigants only have toxic effect: no additional organic matter

Biofumigation results in short term changes to soil communities

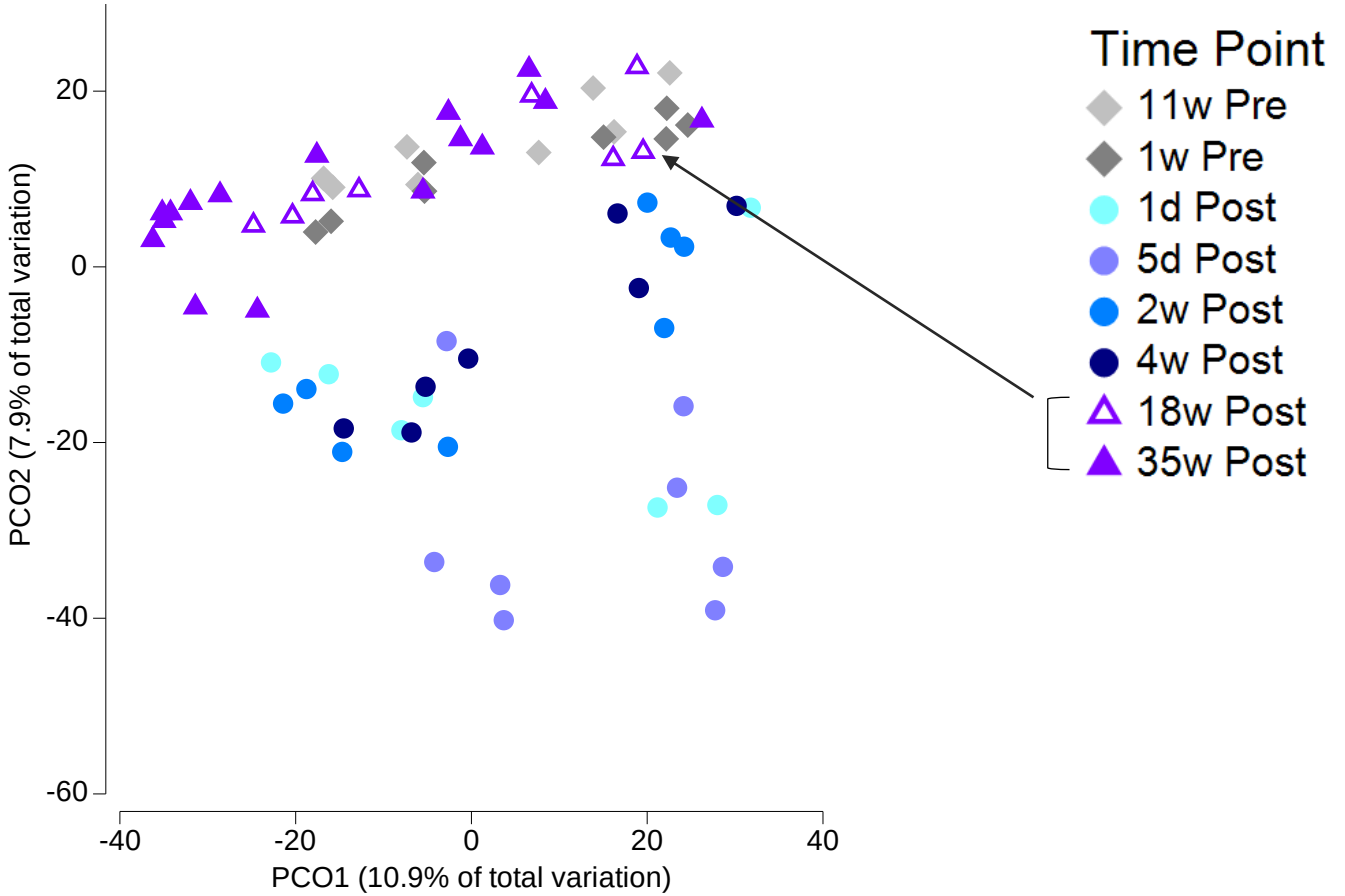
Within days, the soil communities have responded to the increased organic matter, including GSL & ITC



Longer-term these communities are stable

After 18 weeks, the communities begin to resemble the pre-incorporation communities

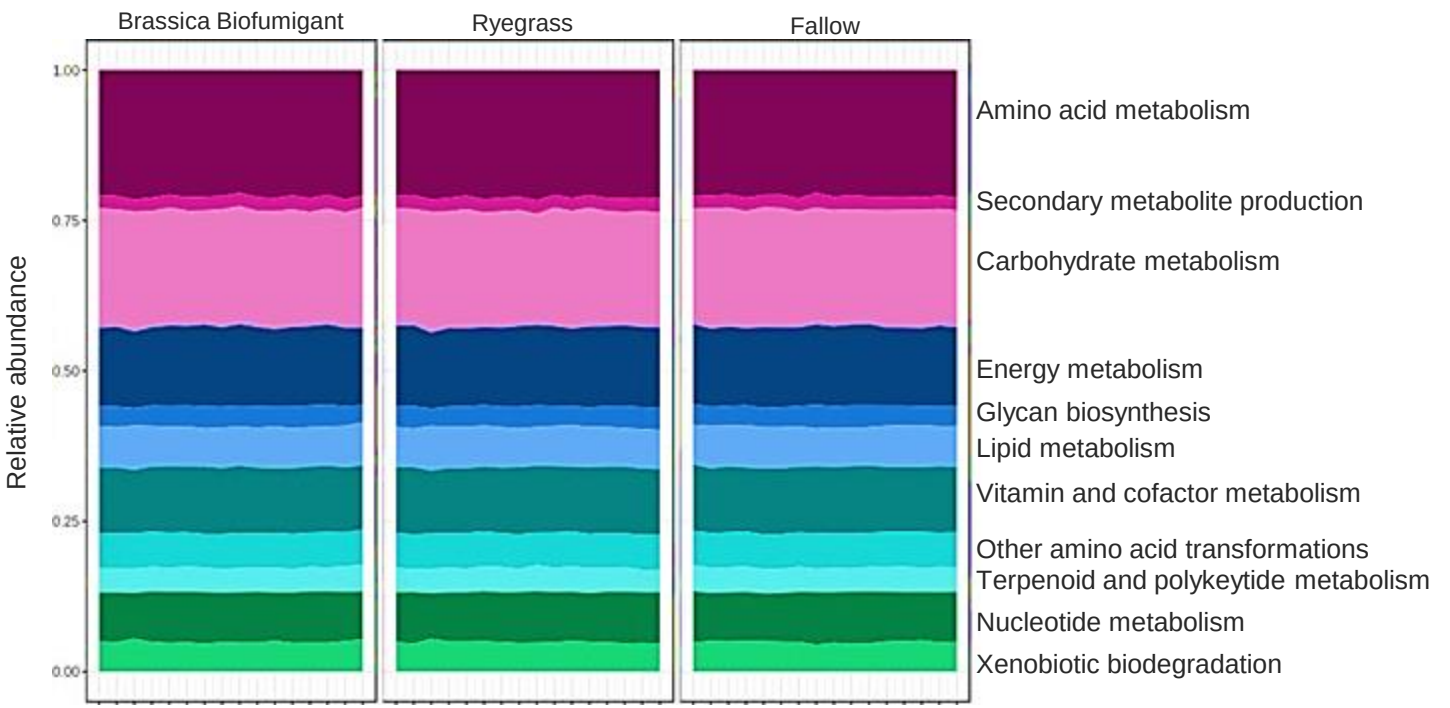
By 18 weeks, things are mostly back to ‘normal’ in the bacterial communities… the changes are more persistent in the fungal and eukaryotic communities



Similar trends observed in microbial functions

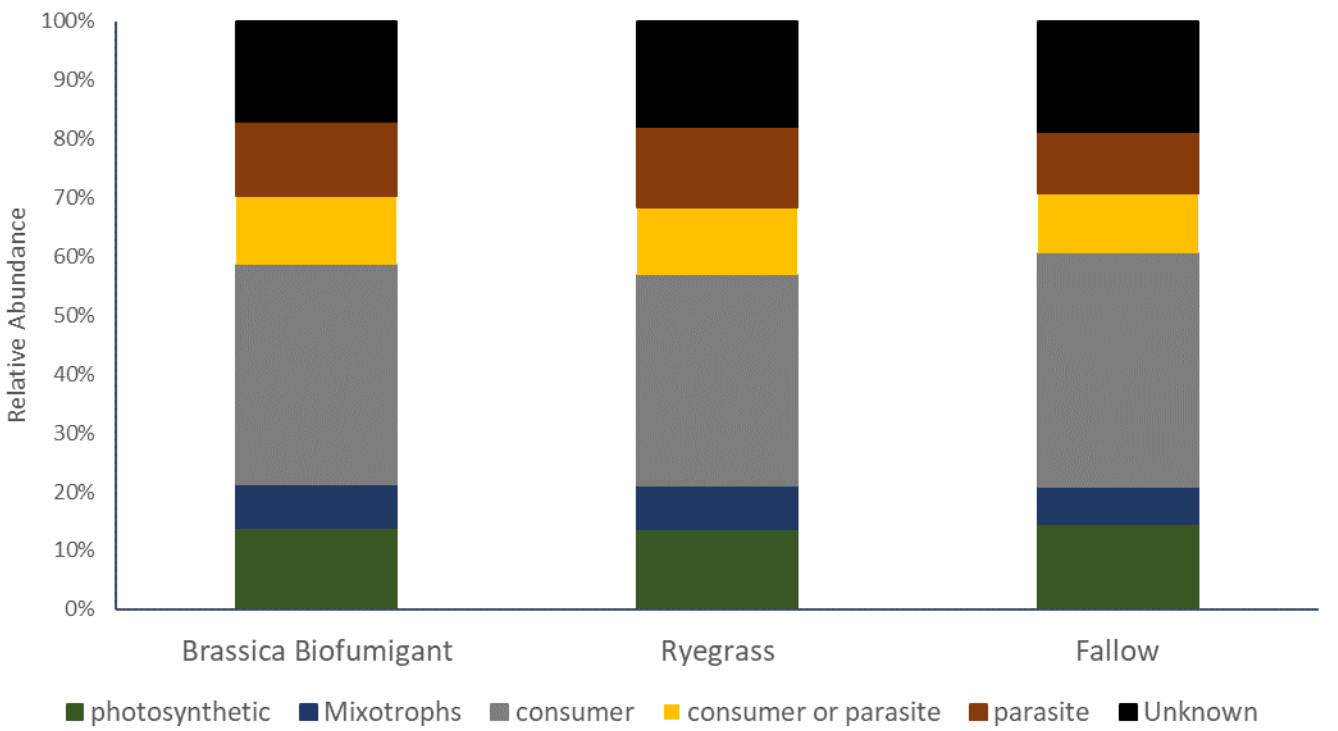
Predicted functions of soil bacterial communities similar in all treatments

Similar analysis carried out on potential function based on genetic markers showed the same trend in this soil



Predicted functions in microbial communities 35 weeks after incorporation of cover crops in a vegetable system in NW Tasmania

And in function of protists



Predicted functions in soil protist communities 35 weeks after incorporation of cover crops in a vegetable system in NW Tasmania

Biofumigation effects on soil biology

Generally, in time-series studies, biofumigation effects only last for weeks to months

- Other papers also report short term changes in biological communities that decrease over time
- Effects of biofumigants due to isothiocyanates affecting soil fungi and bacteria plus the effect of additional biomass
- Some changes are beneficial to plants: Siebers et al found that although overall diversity decreased, the bacteria that remained tended to be plant growth promoting

Chemical fumigation ecosystem effects

Chemical fumigants also produced short-term changes in soil biological communities

Effects of chemical fumigation are often larger than biofumigation

- E.g. Wei et al 2016 found changes only in chloropicrin not biofumigant treatments

There also tend to be short-term effects on soil microbial communities

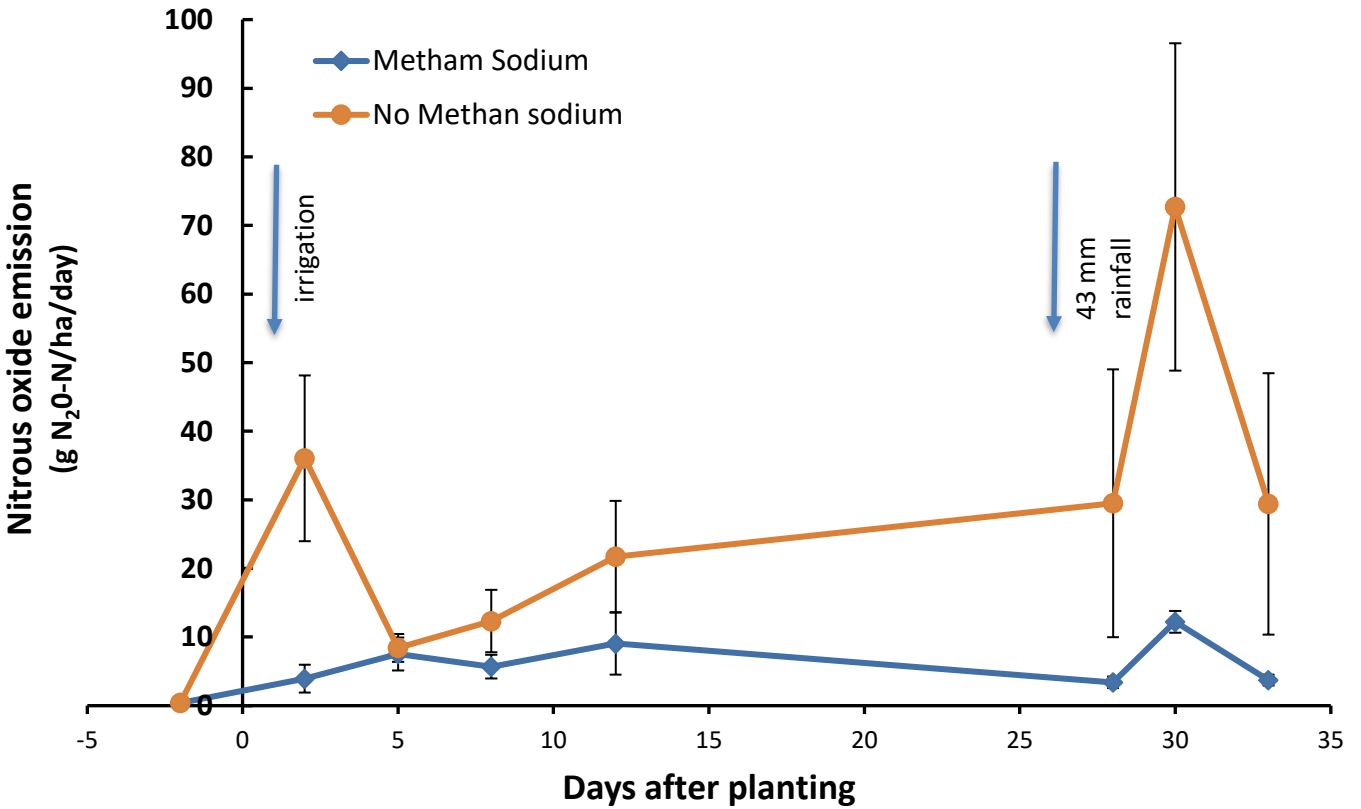
- Eg reduction in biomass (eg Cao et al 2004)
- Eg reduction (@28 days) in Actinomycetes (Fouche et al 2016 – Brennan)

Sometimes this also means they are more effective at reducing disease

However, may also be other considerations besides soil biological communities!

Fumigation can affect particular organisms

Denitrification is reduced in soil treated with Metham Sodium

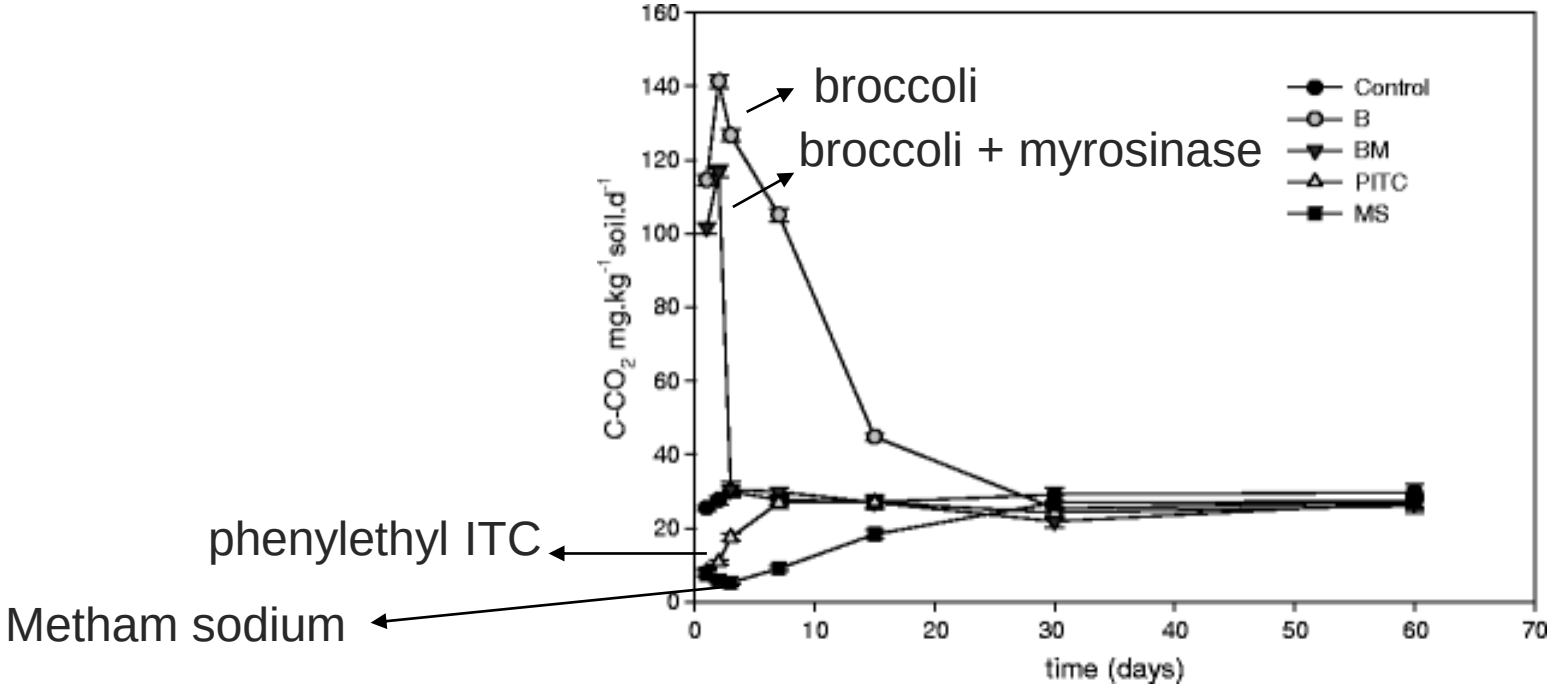


Chemical fumigation compared to biofumigation

Generally, in time-series studies, biofumigation effects only last for weeks - months

Omirou et al 2011 observed:

- Decrease in fungal pathogens only in Metham sodium treatment
- Stimulation of soil biological activity in biofumigation treatments
- Conclusion: changes in biofumigation treatments due to additional organic matter



Inoculation after fumigation

Is it worth the time, expense and effort?

Very little published scientific evidence currently – however is information in other contexts

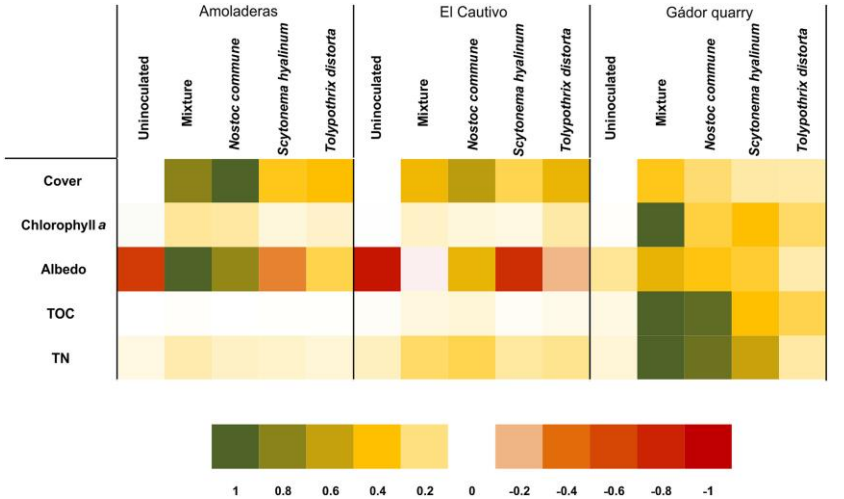
- Is the soil under some kind of stress?
- Do the inoculants have an advantage over existing populations?

Thuerig et al 2009 – re-inoculation with same soil after gamma irradiation

- Some re-establishment of soil biological properties (suppressiveness) but not complete

Roman et al 2018 used cyanobacteria isolated from study soils to improve desert soils

- Increases in TOC and TN in a system that was very poor in C and N and dry.



Roman et al 2018. Land Degradation & Development, Volume: 29: 3184-3193, DOI: (10.1002/ldr.3064)

Fumigation and Soil Biology

- Fumigation, both biological and chemical, can cause short term changes in soil
- Variability between studies: depends on soil and system
- Therefore, need to consider your own context to manage fumigation appropriately