Managing soil life for crop production ?

Paul Gosling

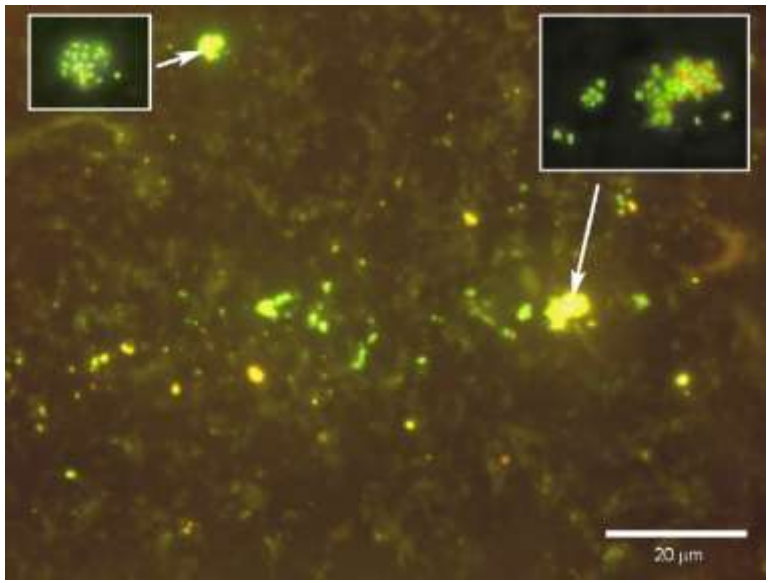
THE UNIVERSITY OF WARWICK

Soil life – what do we know?

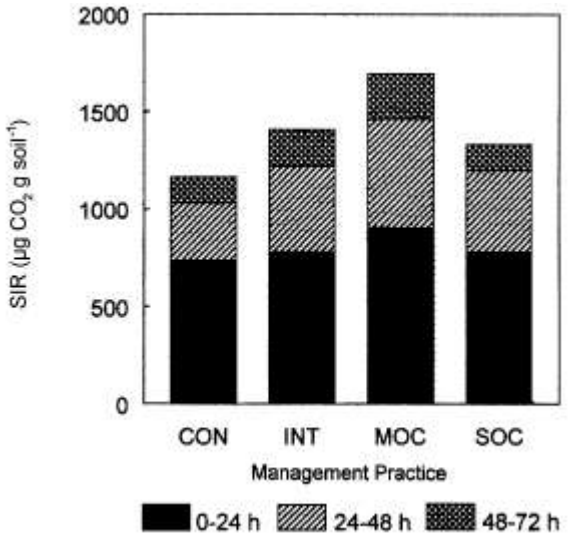
- Diverse – bacteria, fungi, actinomycetes, algae, protozoa, archaea, nematodes etc.
- Numerous – 6 billion bacteria in one gram of soil
- High biomass – can exceed weight of grazing animals
- Multifunctional – organic matter decay, nutrient cycling, N fixation, symbioses, pests and disease, ecosystem engineers

Soil life – what do we know?

- Most are inactive, they have nothing to eat
- Soils have a very high surface area 1x, 2x a tennis court per gram



Colonies of FISH-stained bacteria in an undisturbed sandy soil (Eickhorst & Tippkotter 2008)



Substrate induced respiration in organic and conventional soils (Shannon et al 2002)

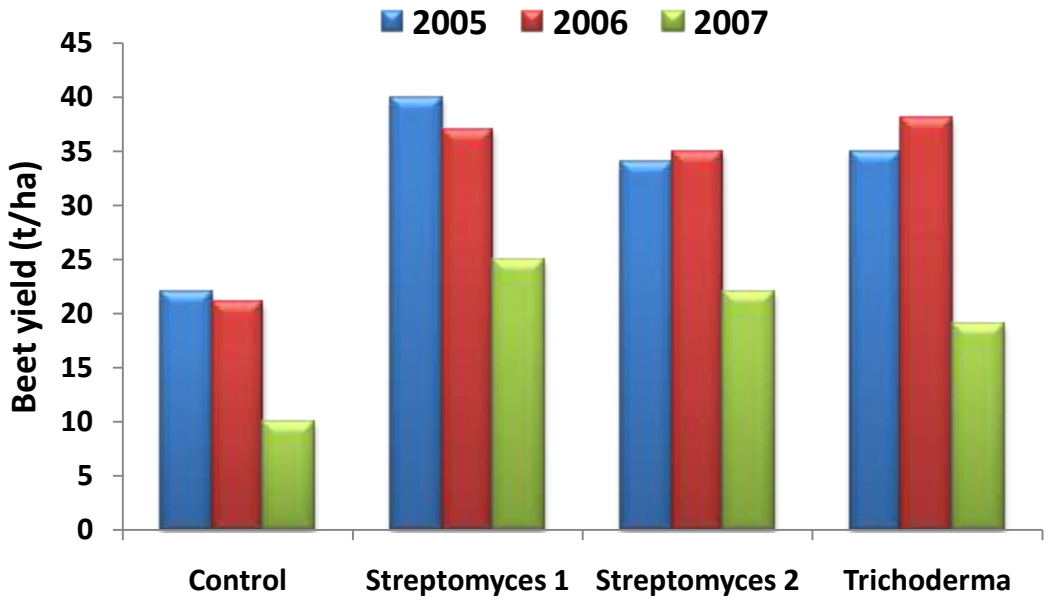
Can we manage soil life to improve yields and/or sustainability?

Specific targeted interventions

- Biopesticides e.g, *Trichoderma* to control *Rhizoctonia*
- *Rhizobium* for exotic legumes e.g. Sweet clover
- Mycorrhizas to improve P uptake and control disease
- Plant growth promoting rhizobacteria – antifungal activity, nitrogen fixation, phosphate solubilization, plant hormone production

What can be achieved?

- Some specific applications may be highly effective



Control of *Rhizoctonia solani* in sugar beet. (Sadeghi et al. 2009)

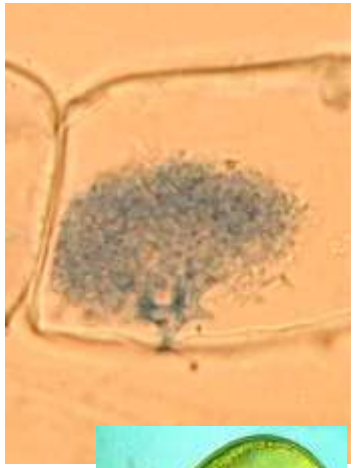
General enhancement of activity of soil life

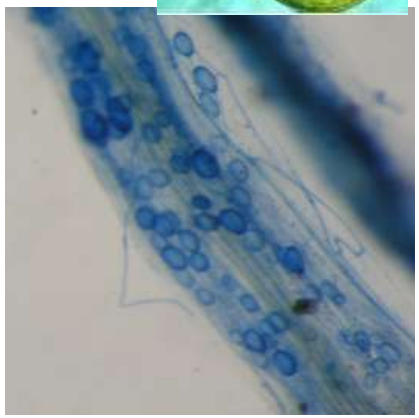
- Application of fresh organic matter
  - crop residues
  - FYM
  - green manures
- Reduction in tillage
- Appropriate rotations
  - e.g. for mycorrhizas

Managing soil life - Mycorrhizas

- Microscopic fungi that form a symbiotic relationship with many crops plants
- Improve access to soil P and some other nutrients
- Can protect against soil borne diseases and nematodes
- Improve soil structure
- Increase drought tolerance

- Defined role, easily produced





- Mycorrhizas have been marketed for many years
- Several products are available on the market
- They are generally approved for organic systems
- They have made little impact – products often perform poorly

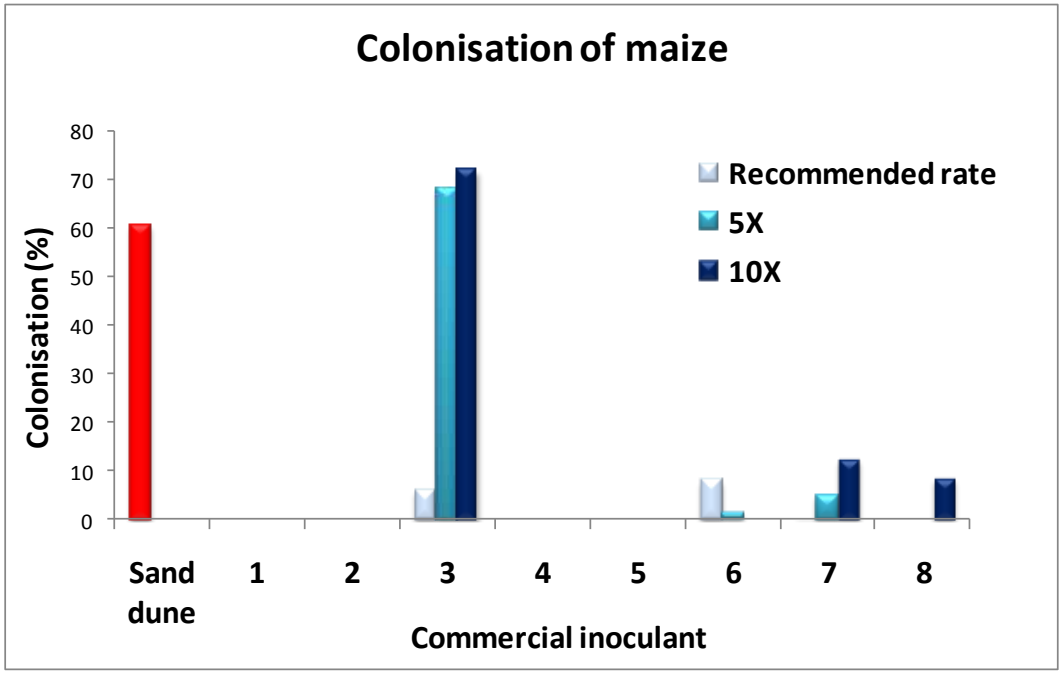
Why do products perform badly?

Poor knowledge of mycorrhizal ecology

Recently accepted 'truth'	Currently accepted 'truth'
150 species	220 species and increasing
Global distribution	Some have global distribution many do not
Little or no host preference	Strong host preference
Functionally similar	Functionally diverse (within species)
Asexual reproduction	??

Why do products perform badly?

Poor product quality



(Tarbell and Koske 2007)

Comparison of eight commercially available mycorrhizal products

Managing native mycorrhizas?

Beneficial to mycorrhizas	Detrimental to mycorrhizas
Leys	Tillage
Diverse rotations	Bare fallow
Strongly mycorrhizal crops •Alliums, Maize, Potatoes, Clovers	Non mycorrhizal crops* •Brassicas, Chenopodiaceae, (beets), Polygonaceae (buckwheat)
Green manures*	High soil P (?)
Organic matter?	
Weeds?*	

- Organically managed soils usually have higher populations and greater diversity of mycorrhizas
- Horticultural systems?

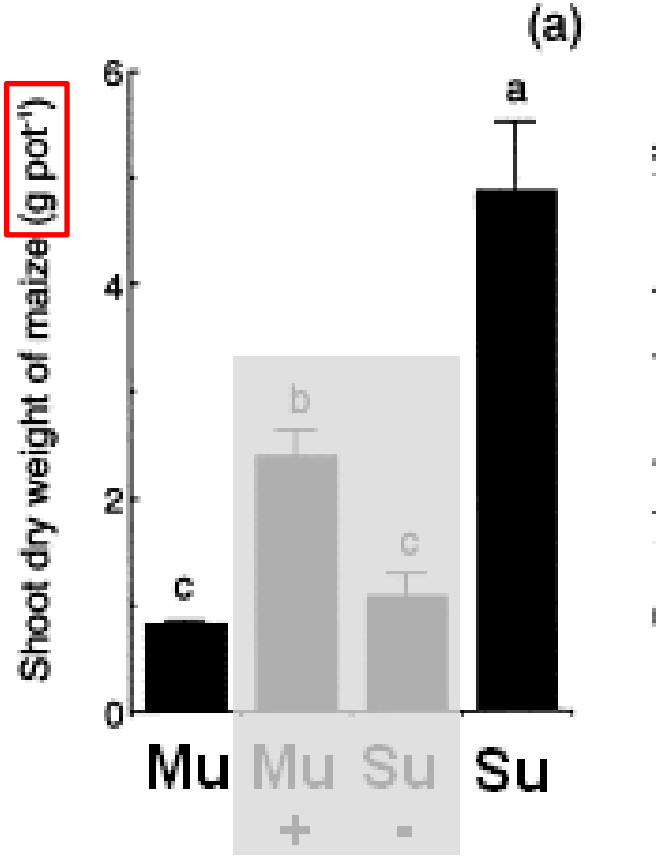
Managing native mycorrhizas?

Rotation effect

Maize after Mustard (non mycorrhizal)

vs

Maize after Sunflower (mycorrhizal)

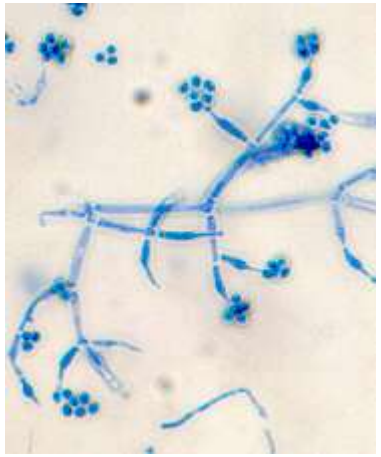


(Karasawa et al 2002)

The future

- Genomics and proteomics
  - Can tell us what genes are present in a bacteria, fungi etc. and what products the genes make
- Metagenomics
  - Can tell us what organisms are present in a soil so we can more easily map the effects of management
- Better understanding of organism biology and ecology

E.g. –*Trichoderma spp.*



- Relevant genes and their expression under different conditions have been identified
- More effective plant cultivar and *Trichoderma* strain combinations have been identified
- Result - new products are more effective than older products and active on a wider range of pathogens

Conclusions?

- There remain huge gaps in our understanding of soil life (biology, ecology, management)
- Molecular biology is opening new doors to understanding
- New better microbial products are appearing
- They will never be a magic bullet
- Organically managed soils are (often) more biologically active anyway