



**microbiology
laboratories
australia**
agriculture • forestry • environmental

**What we do
How can we help you?**

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Managing Director

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PhD MSc BSc
Director, Analytical Services and Research





What we do




We help **people** in agriculture grow **healthier** crops, more **efficiently** by better managing **soil microbiology**.



What we do



More **efficient** use of inputs
More **consistent** outcomes
More **profit**
Relax and enjoy your work



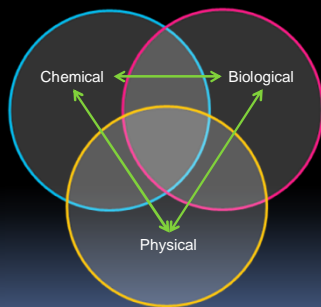
How we can help you



Information to make better soil management decisions



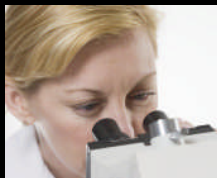
Soil – The Basis for Productivity



How we can help you



Microbiology analyses


- Focussed on outcomes
- Advanced techniques
- Extensive range
- Continual R&D



How we can help you

Talk to us later about how we might help **you** specifically






**Introduction to soil microbes,
measurement & management**

Dr Ash Martin PhD BSc (For) Hons Managing Director	Dr Maria Manjarrez-Martinez PhD MSc BSc Technical Director
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Outline

1. What is microbiology?
2. Overview of soil microbiology
3. What can soil microbiology do?
4. How to manage soil microbiology
 1. Measure
 2. Manage
5. Q&A



What is microbiology?

- Organisms that are too small to see with the naked eye

Complexity

- Prokaryotes
 - Bacteria *
 - Archaea
- Eukaryotes
 - Fungi *
 - Protists
 - Protozoa →
 - Algae *
 - Nematodes

* Some colony-forming or multi-cellular organisms can be seen with the naked eye. E.g., actinobacteria/mycetes, filamentous fungi, algal blooms.

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Soil Microbiology – Where?

- Everywhere, but
- Most prevalent in the rhizosphere

Soil Microbiology – How?

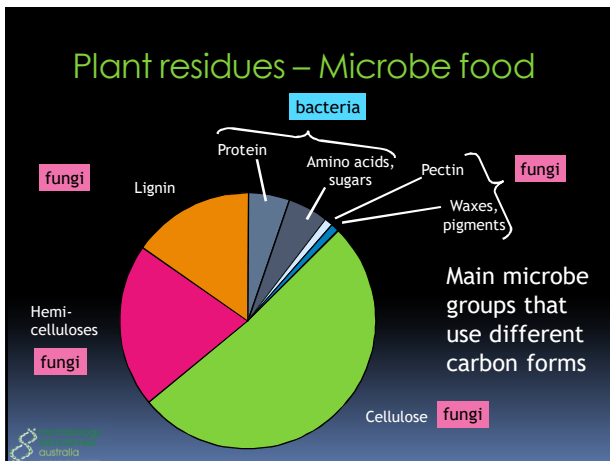
Uptake of molecules into microorganisms

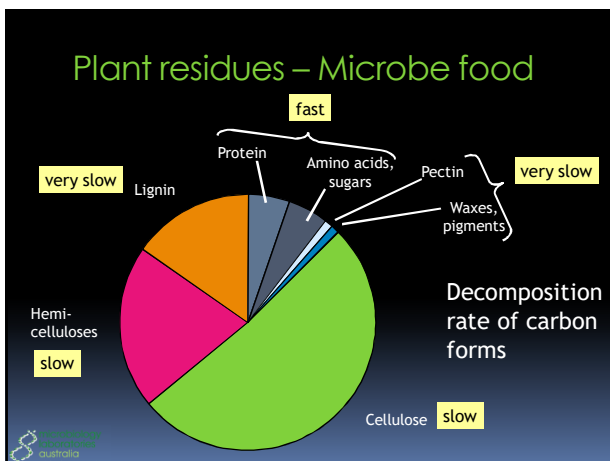
Large molecules
e.g. cellulose, starch

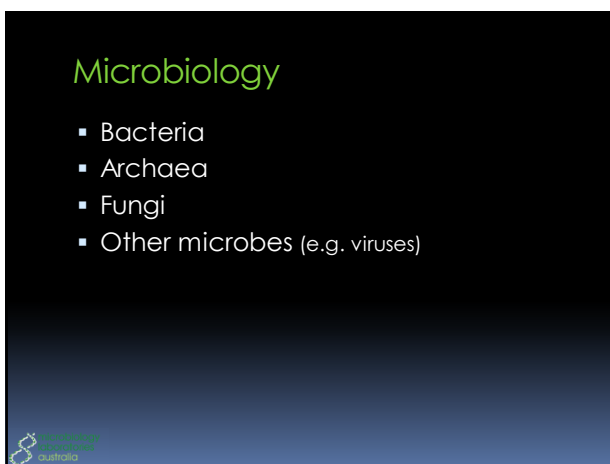
Small molecules
e.g. sugars, amino acids

Pass through the membrane

too big to pass through membrane







Bacteria

- Single-celled
- Different life strategies
- Different food preferences
- Different functions



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Microbiology - Diversity



Bacteria – Strategists

- Occupy different places in root zone
- **r strategists** – 'Party Animals'
 - Gram negative
 - E.g., *Pseudomonas*
 - Thrive in places with high nutrient availability
 - E.g., root hair zones
 - Prefer good conditions
- **K strategists** – 'The Quiet Achievers'
 - Gram positive
 - E.g., Actinomycetes
 - Gain hold in places with low nutrient availability
 - E.g., older root parts
 - Can tolerate adverse conditions better
 - E.g., drought

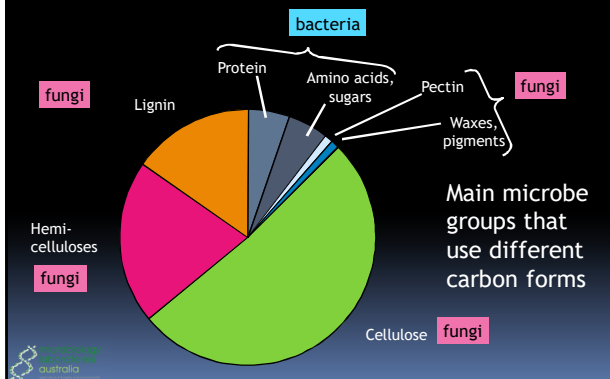


Bacteria – Life strategies

- Community make-up influenced by:
 - Food (energy) source
 - Simple vs complex carbohydrates
 - Other molecules (e.g., denitrifiers, methanox)
 - Environment
 - pH, moisture holding capacity, mineral nutrient availability, structure, etc.
 - Microbial interactions (microbe-microbe)
 - Synergistic
 - Antagonistic

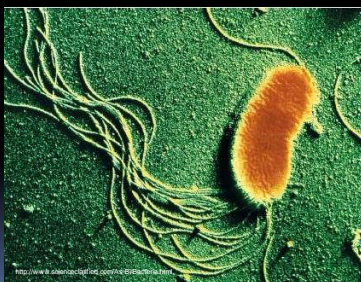


Plant residues – Microbe food



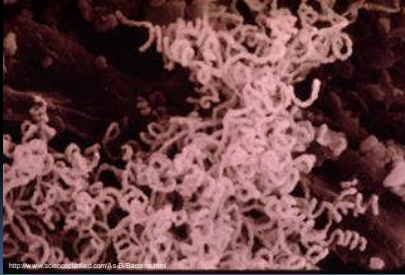
Bacteria - Example

- Pseudomonas fluorescens* (P-solubilising)



Bacteria - Example

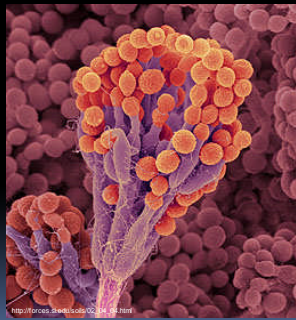
- *Actinomyces* (break down organic matter)



<http://www.microbiologylaboratories.com/A&B/Bacteria.html>

Fungi

- Single celled
 - Yeasts
- Multi-celled
 - Moulds →
 - Filamentous fungi
- Very diverse
 - Life strategies
 - Foods
 - Functions



Fungi - Yeasts

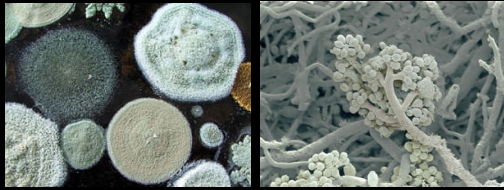


- ↑ By eye
- ↑ Magnified
- Immotile (do not move)
- Growth limited in dry conditions



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Fungi - Moulds

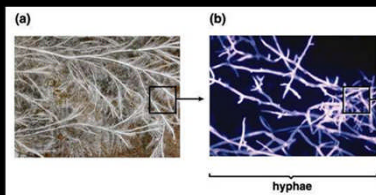


- ↑ By eye
- ↑ Magnified
- Expand to find food source
- Growth limited in dry conditions



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Fungi - Filamentous



- ↑ By eye
- ↑ Magnified
- Rapidly explore area to find food sources
- Can remain active in dry conditions

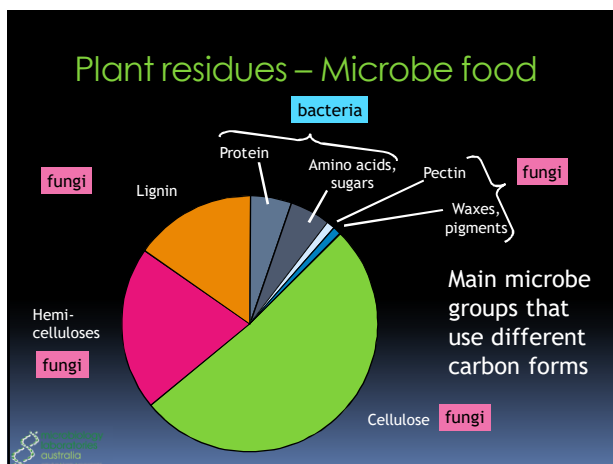


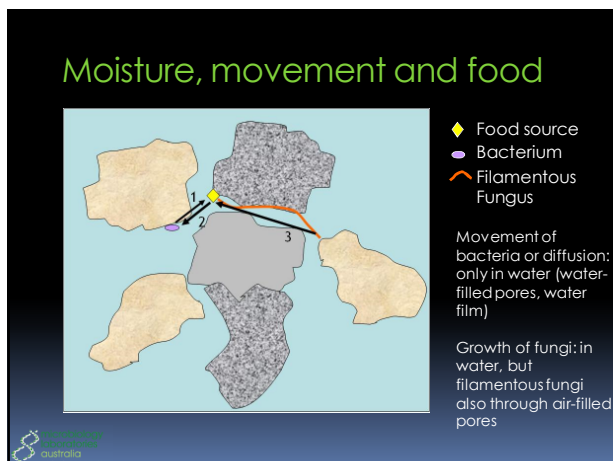
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Fungi – Life strategies

- Occupy a different 'niche' to bacteria
- Bacteria
 - Mostly degrade simple, soluble substrates (sugars)
- Fungi
 - Main decomposers of complex, solid, recalcitrant substances (e.g., cellulose)
 - Produce enzymes (e.g., cellulase)
 - Enzymes release sugars → taken up by fungi
 - These sugars are also used by bacteria (∴ niche differentiation not strict)







Fungi - Functions

- **Decomposers** – main role of fungi
 - Saprophytic – can get carbon from environment
 - Facultative – can get carbon from both environment and living plants
 - Non-pathogenic, e.g., ectomycorrhizal fungi
 - Pathogenic, e.g., *Rhizoctonia*
- **Symbionts**
 - Non-saprophytic – must get carbon from living plants
 - Arbuscular mycorrhizal fungi (AM fungi, a.k.a. VAM)

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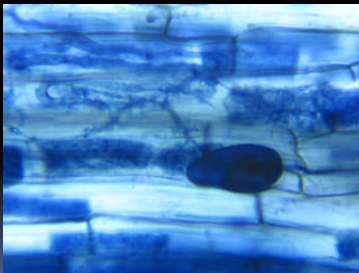
Arbuscular Mycorrhizal Fungi

- Arbuscular mycorrhizal fungi (VAM)
 - Must live in association with plants
 - Receive carbon from plants as sugars
 - Provide mineral nutrients to plants (esp. P)
 - Produce glomalin – long-lived carbon-rich soil exudate
 - Different to saprophytes and pathogens
 - Plant genes unique to AM colonisation and nutrient transfer
 - Specialised structures within roots
 - Usually beneficial to plant nutrition and growth



Microbiology - Fungi

- Arbuscular mycorrhizal fungi (AM fungi/VAM)



What Can Microbiology Do?

- More consistent outcomes
 - Despite adverse seasons (e.g., drought)
- Improve soil structure
 - Water stable aggregates
- Increase nutrient availability
 - Solubilise nutrients - e.g., *Pseudomonas*
 - Cycle nutrients - e.g., N cycle
 - Translocate nutrients - e.g., mycorrhizal fungi
- Suppress disease

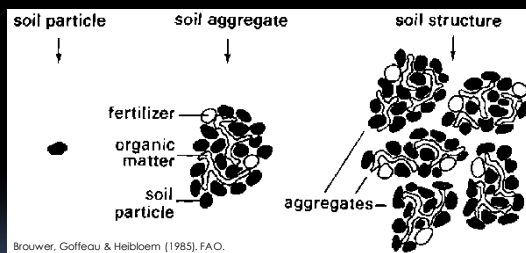


What Can Microbiology Do?

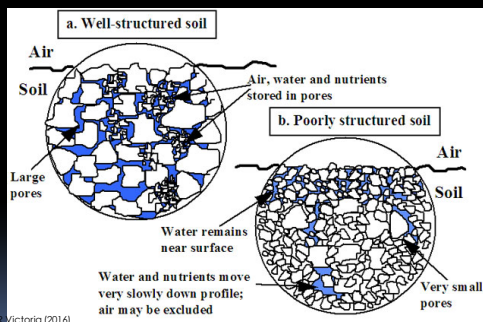
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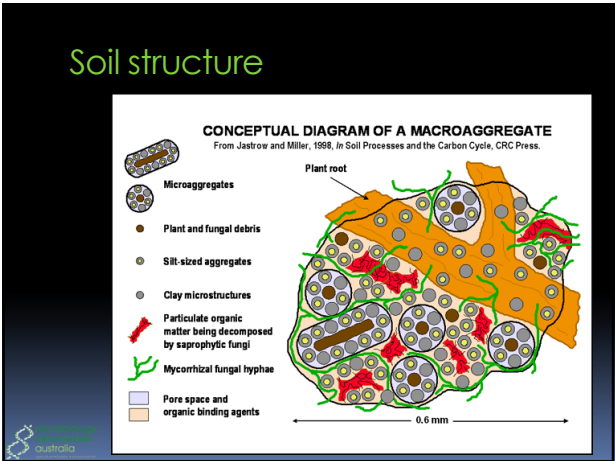


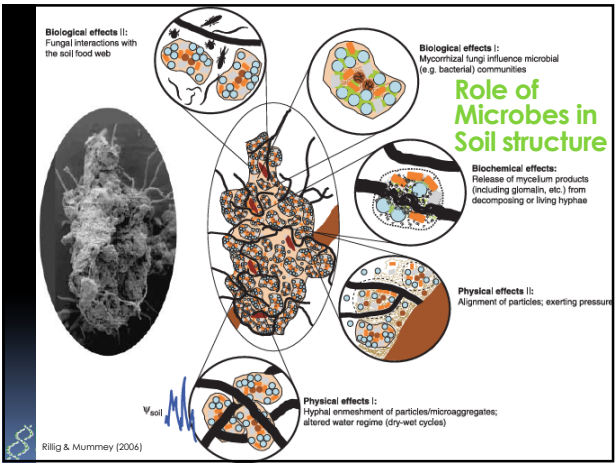
Soil structure – What is it?

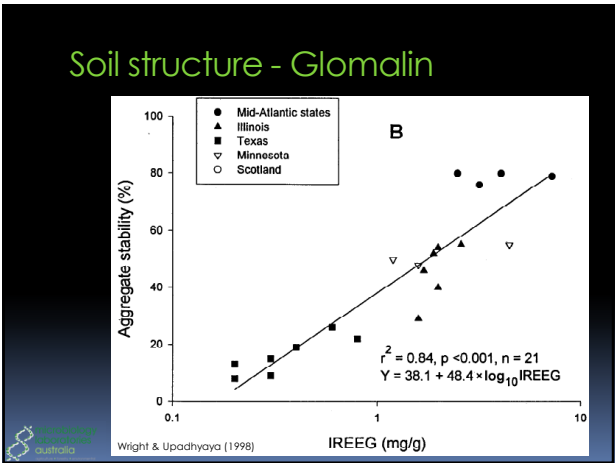


Soil structure









What Can Microbiology Do?

- More consistent outcomes
 - Despite adverse seasons (e.g., drought)
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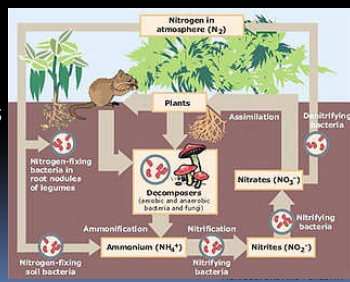
What Can Microbiology Do?

- More consistent outcomes
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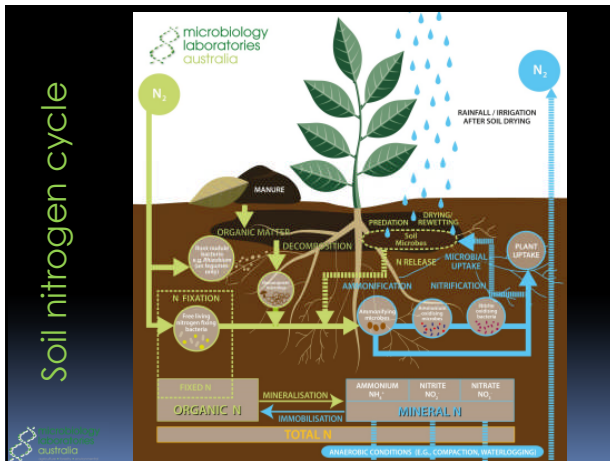


Microbiology – Nutrient Cycles

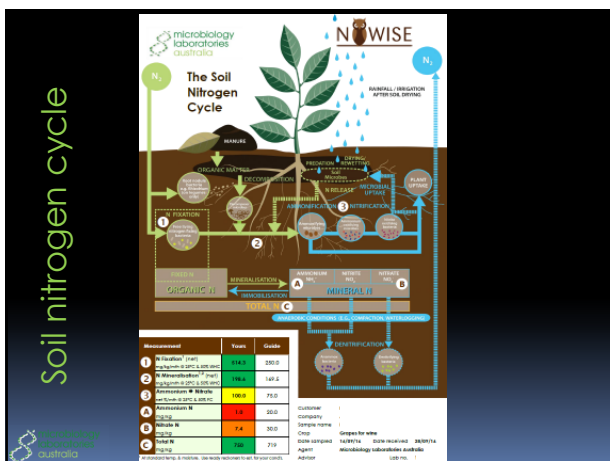
- Microbes play an important role in soil nutrient cycles
- N-cycle
- P-cycle
- Cycles for all other nutrients



Soil nitrogen cycle



Soil nitrogen cycle



Microbiology

- Bacteria
- Archaea
- Fungi
- Other microbes (e.g. viruses)

But...

Microbiology

- Bacteria
- Archaea
- Fungi
- Other microbes (e.g. viruses)

But...

How do we manage them?



Managing Microbiology

- Step 1:
Measure them
- Step 2:
Find out whether levels are 'good' or 'bad'
- Step 3:
Employ management practices to improve them



Managing Microbiology

- Step 1:
Measure them
- Step 2:
Find out whether levels are 'good' or 'bad'
- Step 3:
Employ management practices to improve them



Why measure microbiology?

- To manage it
- Improve sustainability (= profitability)
 - More efficient use of inputs
 - Maintain or increase outputs (yield)
 - Dry years
 - Consistency
- Identify problems
- Analyse management practices
- Stewardship



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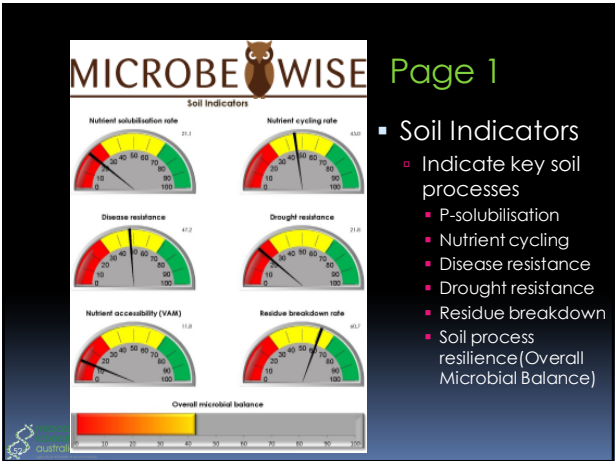
- Methods commonly used in research science
 - Adapted for commercial use
- Balance between accuracy, cost & practicality
- Repeatable
- Readable reports
 - Relevant information
 - Concise
 - Easy to understand

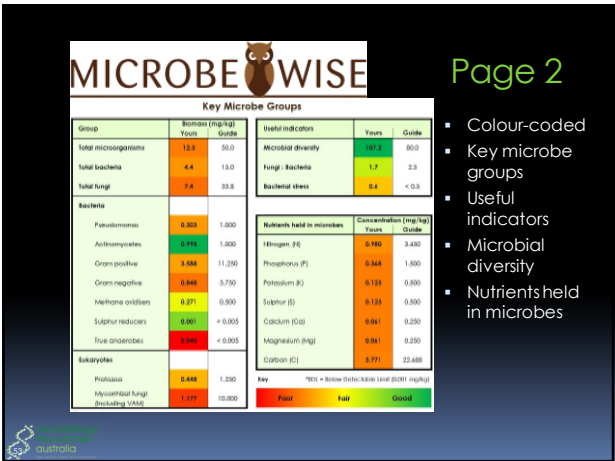


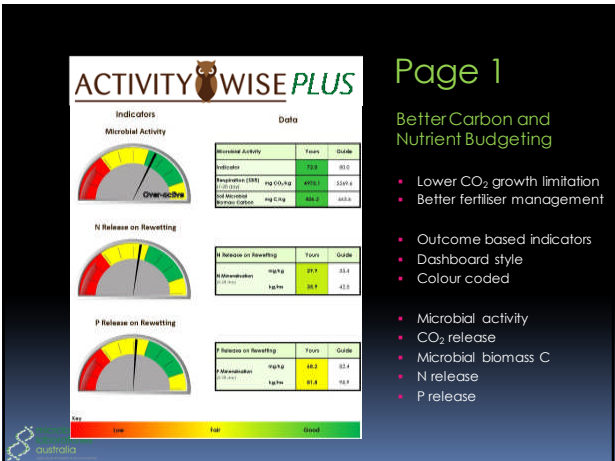
Test Groups

1. General – Microbe Wise
2. Activity – Microbe Activity Wise/Plus
3. Hybrid Nutrient – N Wise & P Wise
4. Mycorrhizal – VAM Wise & Glomalin Wise
5. Pathogens – CropSaver
6. Other – ID Wise, Worm Wise & Nem Wise









ACTIVITYWISE PLUS

Comments

Microbial activity

The microbial activity in your sample was good. However, it could be increased by adopting management practices that promote microbial activity. It would be a good idea to consider the addition of organic matter to your soil. If you add a lot of organic matter, the activity of the microbes will increase. It is important to note that the activity of the microbes will increase with the addition of organic matter. It is important to note that the activity of the microbes will increase with the addition of organic matter. It is important to note that the activity of the microbes will increase with the addition of organic matter.

N Release on Resolving

N release on resolving is a good thing. However, it could be increased by adopting management practices that promote microbial activity. It would be a good idea to consider the addition of organic matter to your soil. If you add a lot of organic matter, the activity of the microbes will increase. It is important to note that the activity of the microbes will increase with the addition of organic matter. It is important to note that the activity of the microbes will increase with the addition of organic matter.

P Release on Resolving

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Comments, recommendations and explanations

- Results in context
- Colour coded
- Educative
- Flexible recommendations
- Works with your program

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NO WISE

The Soil Nitrogen Cycle

Measurement

Measurement	Units	Scale
1. N-fixation (g/m ²)	g/m ²	0-100
2. Nitrification (g/m ²)	g/m ²	0-100
3. Denitrification (g/m ²)	g/m ²	0-100
4. N-fixation (g/m ²)	g/m ²	0-100
5. Nitrification (g/m ²)	g/m ²	0-100
6. Denitrification (g/m ²)	g/m ²	0-100

Outcome based indicators

Indicator	Units	Scale
1. N-fixation (g/m ²)	g/m ²	0-100
2. Nitrification (g/m ²)	g/m ²	0-100
3. Denitrification (g/m ²)	g/m ²	0-100
4. N-fixation (g/m ²)	g/m ²	0-100
5. Nitrification (g/m ²)	g/m ²	0-100
6. Denitrification (g/m ²)	g/m ²	0-100

Page 1

Optimise N fertilisation

- Comprehensive 5 page report
- Takes into account:
 - free-living N fixation
 - N mineralisation
- Hybrid microbe/nutrient test
- Outcome based indicators
- Colour coded
- Ready reckoner for your soil temp & moisture
- Ammonium, Nitrate and Total N, Total C, C:N ratio
- N fixation rate
- N Mineralisation rate
- Ammonia to nitrate conversion rate

PO WISE

Soil Phosphorus (P) Indicators

Net P Solubilisation

P Fertiliser Availability

Soil Phosphorus (P) Data

Measurement	Units	Scale
1. Net P Solubilisation (g/m ²)	g/m ²	0-100
2. P Fertiliser Availability (g/m ²)	g/m ²	0-100
3. Net P Solubilisation (g/m ²)	g/m ²	0-100
4. P Fertiliser Availability (g/m ²)	g/m ²	0-100
5. Net P Solubilisation (g/m ²)	g/m ²	0-100
6. P Fertiliser Availability (g/m ²)	g/m ²	0-100

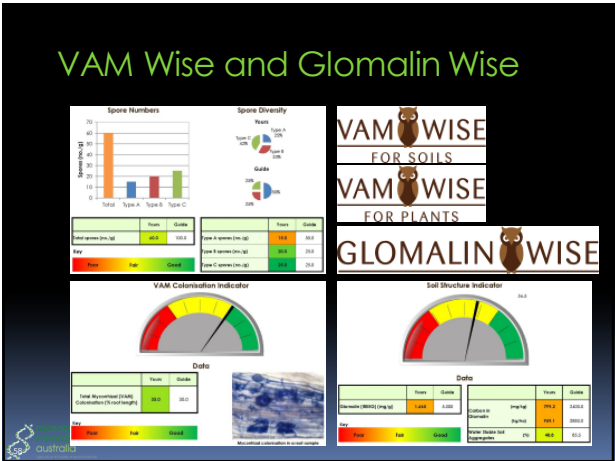
Calculation Table to Help Optimise P Fertilisation

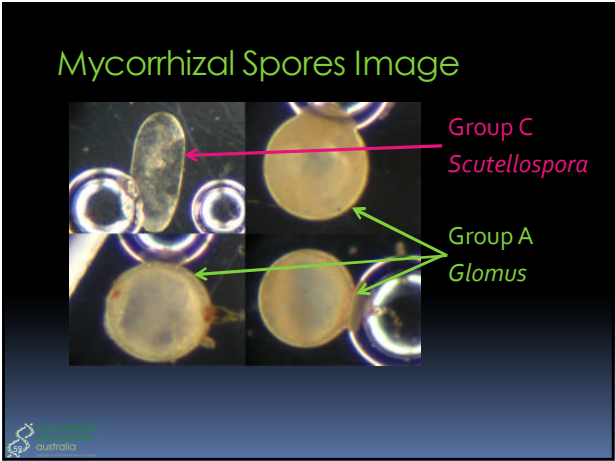
Indicator	Units	Scale
1. Net P Solubilisation (g/m ²)	g/m ²	0-100
2. P Fertiliser Availability (g/m ²)	g/m ²	0-100
3. Net P Solubilisation (g/m ²)	g/m ²	0-100
4. P Fertiliser Availability (g/m ²)	g/m ²	0-100
5. Net P Solubilisation (g/m ²)	g/m ²	0-100
6. P Fertiliser Availability (g/m ²)	g/m ²	0-100

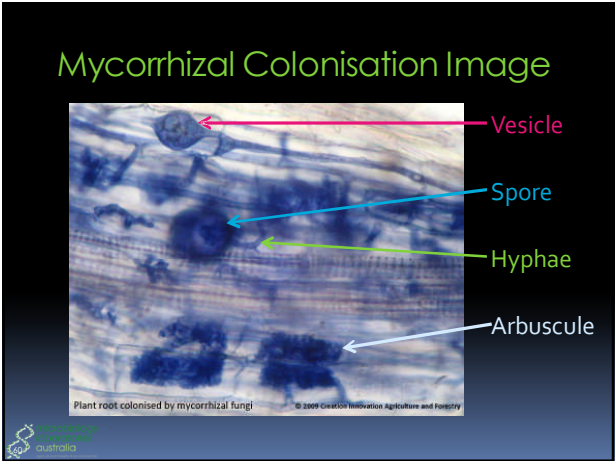
Page 1

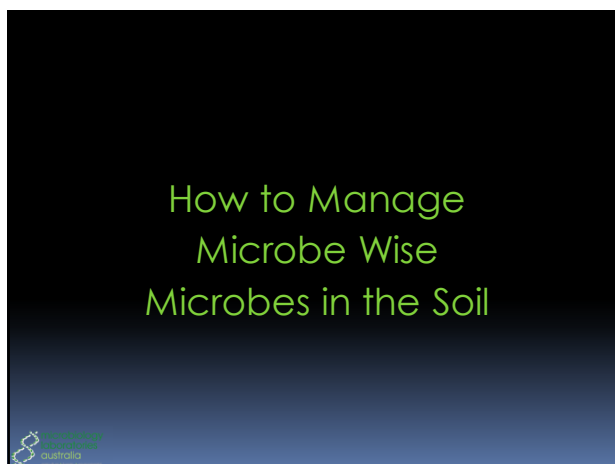
Optimise P fertilisation

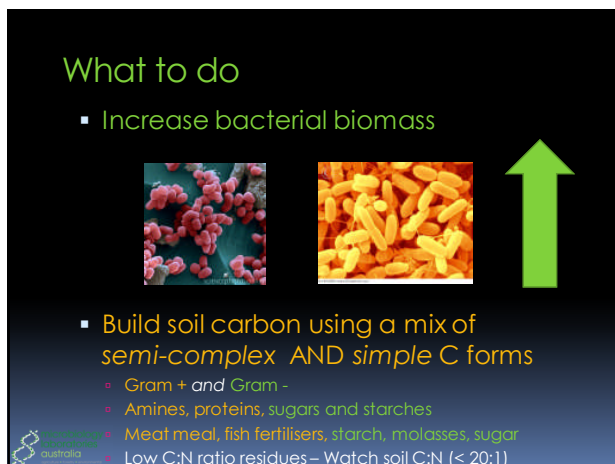
- Takes microbial P solubilisation into account
- Hybrid microbe/nutrient test
- Outcome based indicators
- Dashboard style
- Colour coded
- Plant-available & Total P
- P solubilisation rate
- Net P recovery
- Solubilisation : lock-up ratio

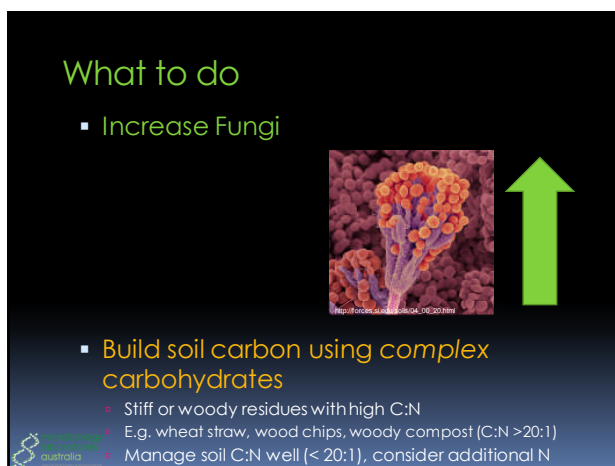






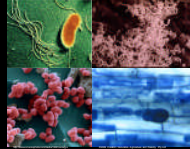






What to do

■ Increase General microbial biomass



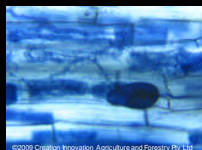
■ Build soil carbon using diverse carbohydrates

- Simple, semi-complex & complex carbohydrates
- Residue mulching/digestion
- High carbon fertilisers/soil conditioners
- Manage soil C:N carefully (< 20:1)



What to do

■ Increase Mycorrhizal fungi (VAM)



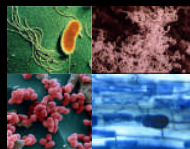
■ Stimulate, inoculate

- Stimulated by increasing soil Carbon
- Avoid over-tillage, over-fertilisation, fungicides
- Inoculate with good quality, verified inocula



What to do

■ Increase microbial diversity



■ Build soil carbon & consider inoculation

- Simple, semi-complex & complex carbohydrates
- Compost, compost extracts, compost teas
- Residue mulching/digestion
- Watch soil C:N (< 20:1)

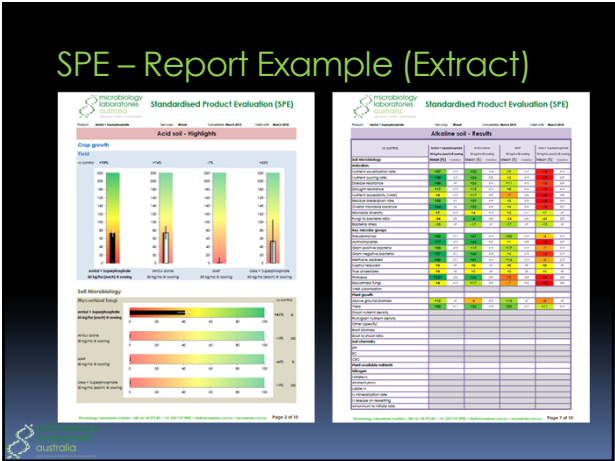


Where common products fit

Product	Microbe Wise Indicators	Product	Microbe Wise Group
	Soil Indicators		
See Pseudomonas, VAM	Nutrient solubilisation rate	Combination (see below)	Total microorganisms
See Total fungi, Actinomycetes, Gram negative bacteria, Protozoa	Nutrient cycling rate	Combination (see below)	Total bacteria
See Pseudomonas, Actinomycetes, VAM	Disease resistance	Humic acids	Total fungi
See Gram positive bacteria, VAM	Drought resistance	Inocula	Pseudomonas
See VAM	Nutrient accessibility (VAM)	Inocula	Actinomycetes
See Total fungi, Actinomycetes	Residue breakdown rate	Starch, fish meal/liquid	Gram positive bacteria
See all microbial groups, Microbial diversity	Overall microbial balance	Glucose, molasses	Gram negative bacteria
	Other Indicators	Manure	Methane oxidisers
Compost, compost extract	Microbial diversity	N/A	Sulphur reducers
Humic acids : Combination	Fungi : Bacteria ratio	N/A	True anaerobes
Combination of factors	Bacterial stress	'Straw brew'	Protozoa
		Inocula	Mycorrhizal fungi (VAM)

Are your products working?

- Standardised Product Evaluation (SPE)
 - Testing system to compare bio-fertilisers
 - Bioassay
 - Standardised, controlled conditions
 - Benchmarks
 - Soil microbiology
 - Plant growth & Yield
 - Any other measurement requested
 - Results compared to
 - Generic fertilisers (e.g. competing brands)
 - Any other comparison requested



Summary

- Measure
- Manage by
 - Plants – presence & type
 - Food (energy) source
 - Simple vs complex carbohydrates
 - Other molecules (e.g., denitrifiers, methanox)
 - Environment
 - Structure, moisture, mineral nutrient availability, etc.
 - Inoculation



Got Questions?



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Thanks for Your Attention!



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