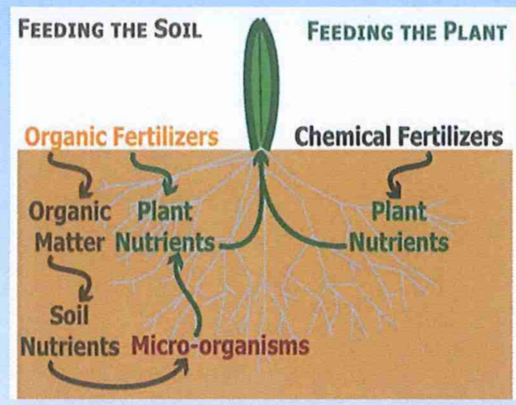
Good afternoon.
It is clear that there is a need to reduce the amount of nutrient loss from the Lake Rotorua catchment and thereby reduce flows of N and P into the lake.
My evidence should help you understand that this is possible without reducing the farming area or the productivity from farms.

Should we refocus fertiliser spend and emphasise efficiency more than cost per kg of N,P,K & S?

- Farmers can reduce N and P loss from their farms by reducing the inputs of soluble P and N fertilisers but that often comes with a reduction in productivity.
- Improvements in fertiliser nutrient efficiency using modern technologies are increasingly common globally.
- The NZ the fertiliser industry remains focused on Single Superphosphate and Urea
- We could place more emphasis on efficient use of the nutrients
  - Nutrient cycling
  - Methods of plant uptake
  - Reduced losses from soil to water



Currently fertiliser value is mainly perceived to be getting maximum kg of nutrients on the ground for the $ spent.
A better approach would be to place emphasis on farm productivity and the value of the farm outputs when valuing the fertiliser inputs.
Modern technologies provide ways of optimising the use of nutrients, reducing losses and enhancing nutrient cycling and plant uptake

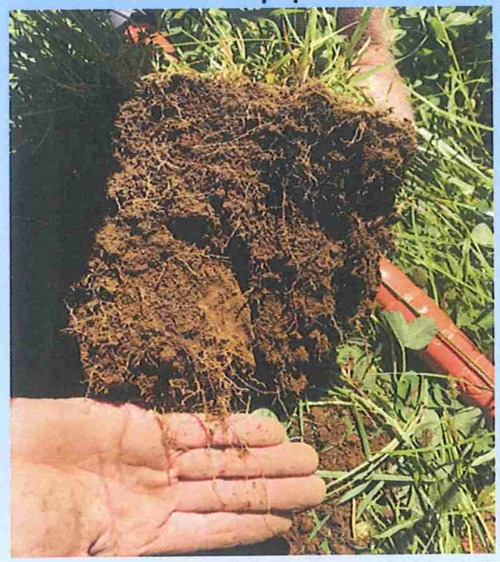
Just as in animal and human nutrition we are only beginning to understand the importance of microbes in the acquisition and delivery of essential vitamins and minerals.

Regular applications of soluble nutrients on pasture. Typical pasture soil profile.

- Shallow root system
- Very high levels of undigested plant material in top 75 mm
- Only a fraction of the soil profile is being used for nutrient and moisture transaction by the pasture.

Common situation on NZ farms to see pastures with shallow roots and lots of organic matter in the top 50 to 75 mm of the soil profile.
Pastures not using much of the soil profile.

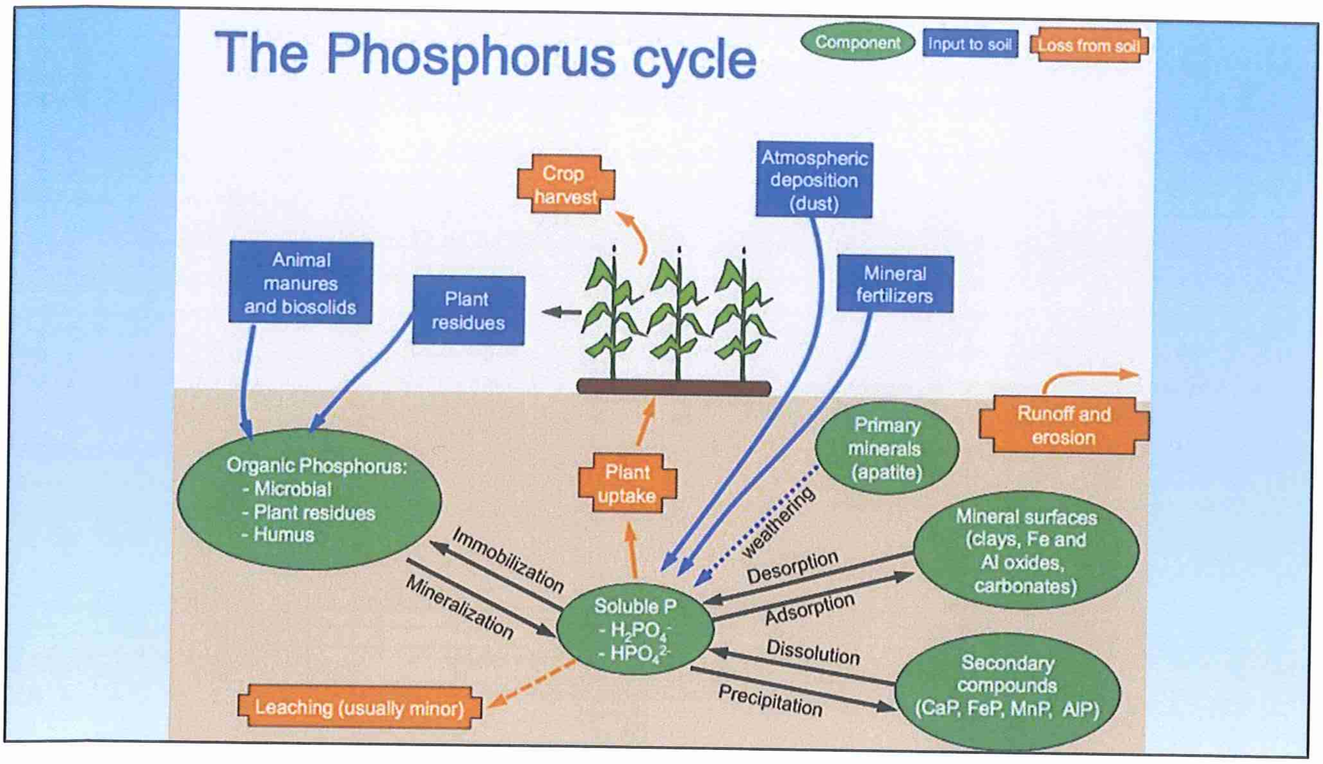
Same soil, climate and pasture. Different fertiliser approach.



- Less thatchiness
- Deep root systems
- Deeper darker topsoil or "A" horizon
- More porosity. Air and water movement is enhanced.
- Less nutrient loss.
- More nutrient storage (soil organic matter and microbial biomass)

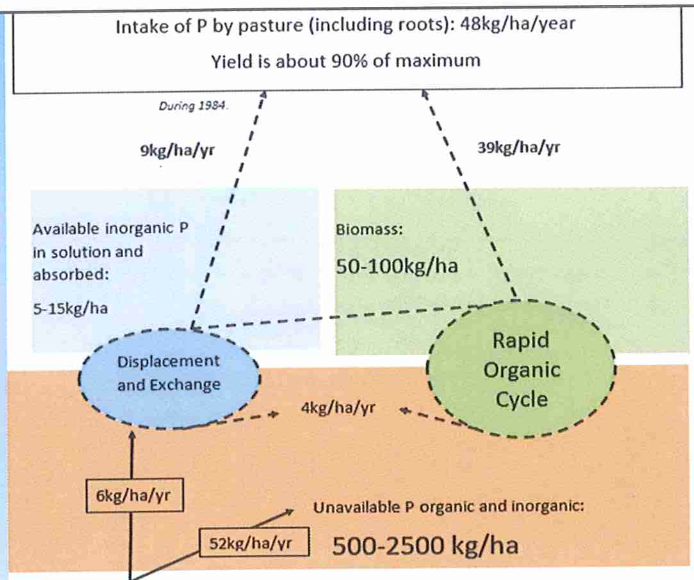
When we enhance soil biological activity with our fertiliser programme by using insoluble P fertiliser and regular applications of lime and humic acid we find biological activity increases and pasture root systems exploit more of the soil profile. We therefore have a much bigger soil volume from which to draw nutrients and water. We have a more efficient system that leaks less nutrient.

So lets look at the nutrient cycles as we understand them currently and see what we can learn from them.



The soluble P in soil at any time is maintained by a constant flux and some sort of equilibrium between P that is involved in the organic matter and microbial biomass and the P that is stuck to soil particles. Most of this movement is mediated by soil biology.

P loss from the farm is mainly through soil loss and P that is stuck to soil particles. Therefore the lower soil levels of soluble and weekly bound P that we have while maintaining optimal pasture production the lower the P loss will be.



INPUTS	Kg/ha/yr
Fertiliser	22
Dung	20
Litter and roots	16
TOTAL	58

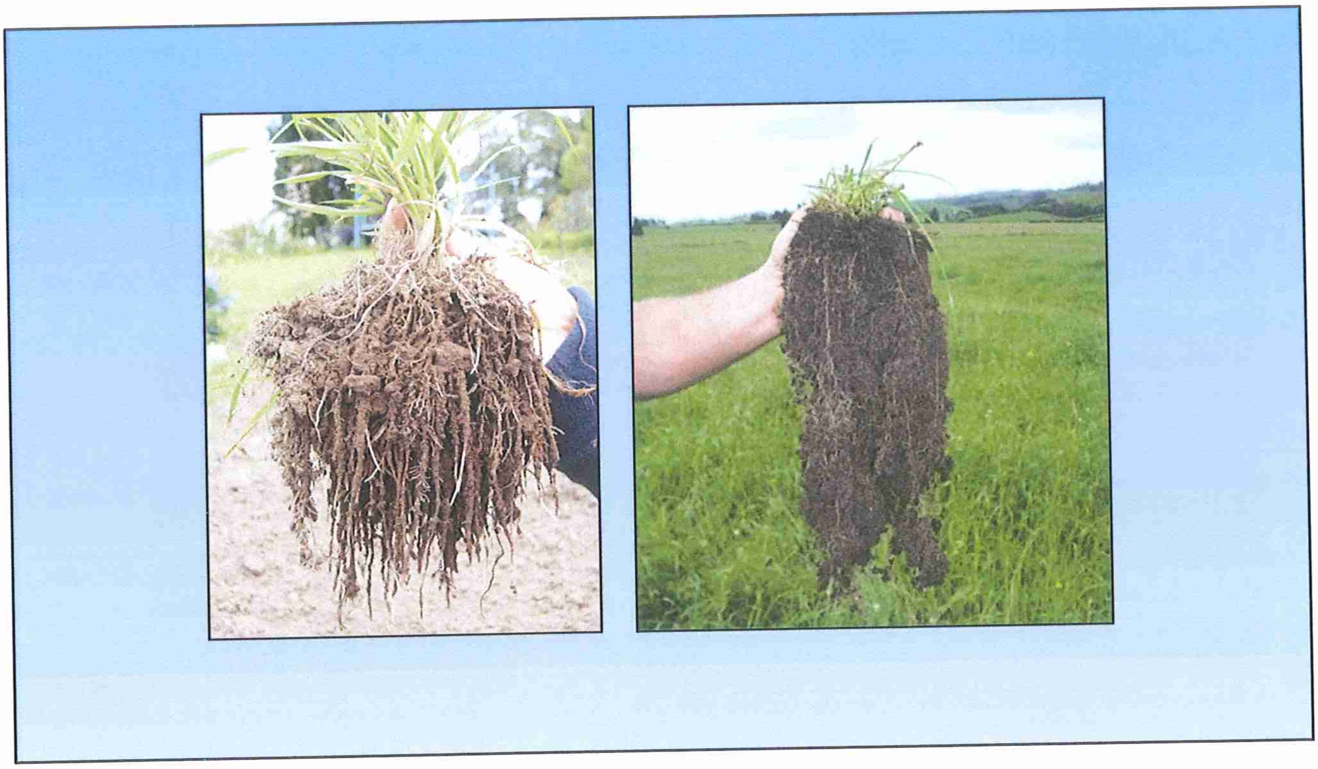
LOSSES	Kg/ha/yr
Animal produce	5
Dung Transfer	5
Erosion, runoff, insoluble P in dung and in P rock	6
Immobilised by soil and leached	4
TOTAL	22

During was able to quantify the sizes of the P pools in a New Zealand pasture system.

- Total P (organic and inorganic) between ½ tonne and 2 ½ tonne per Ha
- Less than 20% of the plant uptake of P is likely to come from displaced or exchanged P in soil solution
- More than 80% of P the pasture requires is likely to arise from the rapid organic cycle. If we can improve this then we are likely to get better efficiency from our P resources.
- Annual fertiliser inputs of P required to maintain optimal pasture production are small compared to the total pool of P in the soil (often less than 1%)

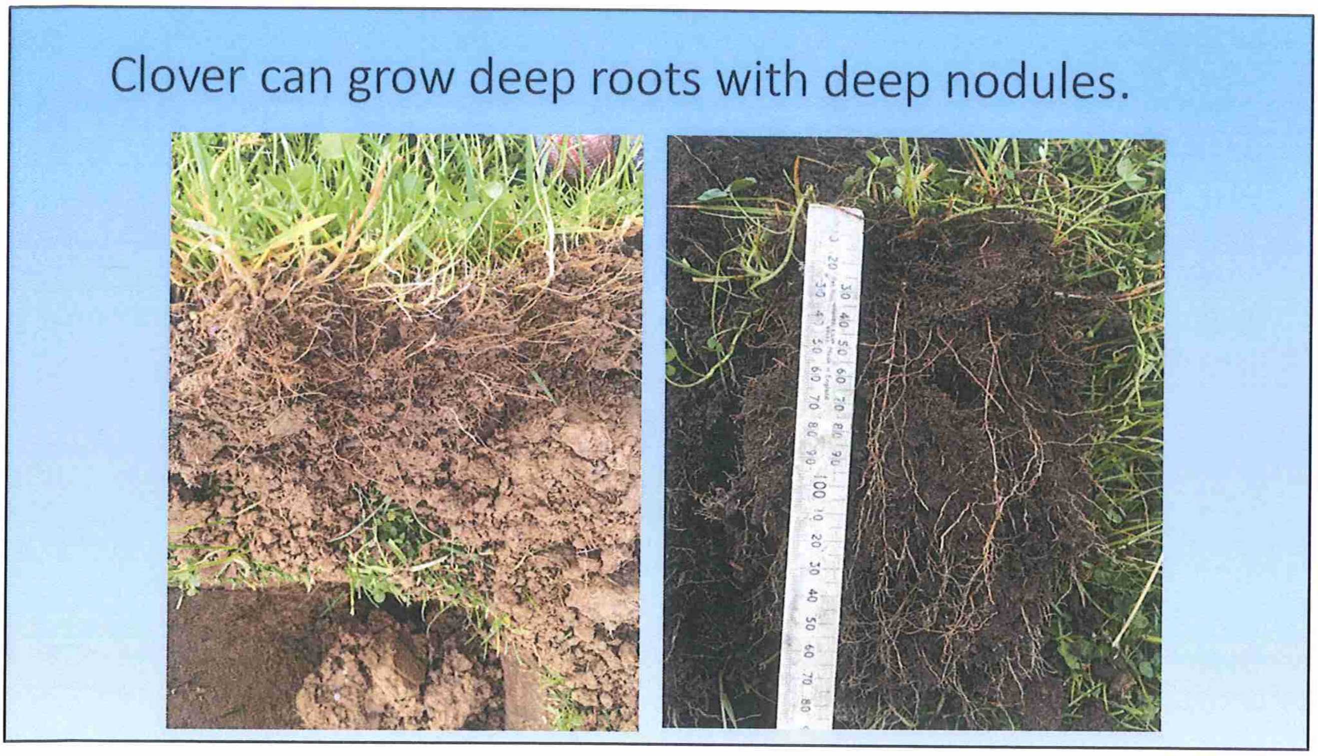
Fungi and bacteria associated with the roots facilitate P uptake for most plants. As well as water and other nutrients and secondary metabolites.

In this photomicrograph the root hairs are the tiny roots (barely visible to the naked eye) that are involved in nutrient and water uptake.
The fungal mycelium is wrapped around and penetrates the roots.
Plants send carbohydrate (sugar) to the mycorrhizae and the fungus delivers this to bacteria out at the tips of the mycelium.
The fungi delivers back water and nutrients that the helper bacteria and the fungi have obtained from soil.

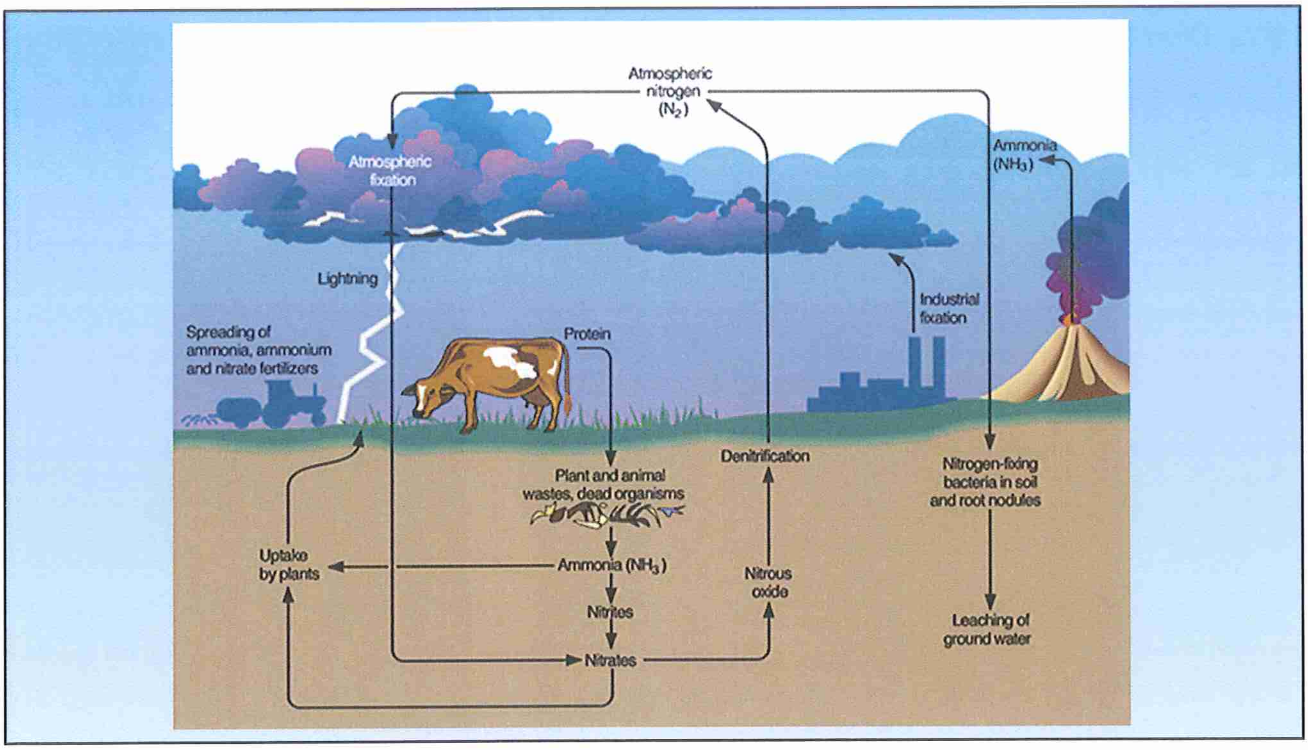


Healthy/strong mycorrhizal associations with pasture plants.

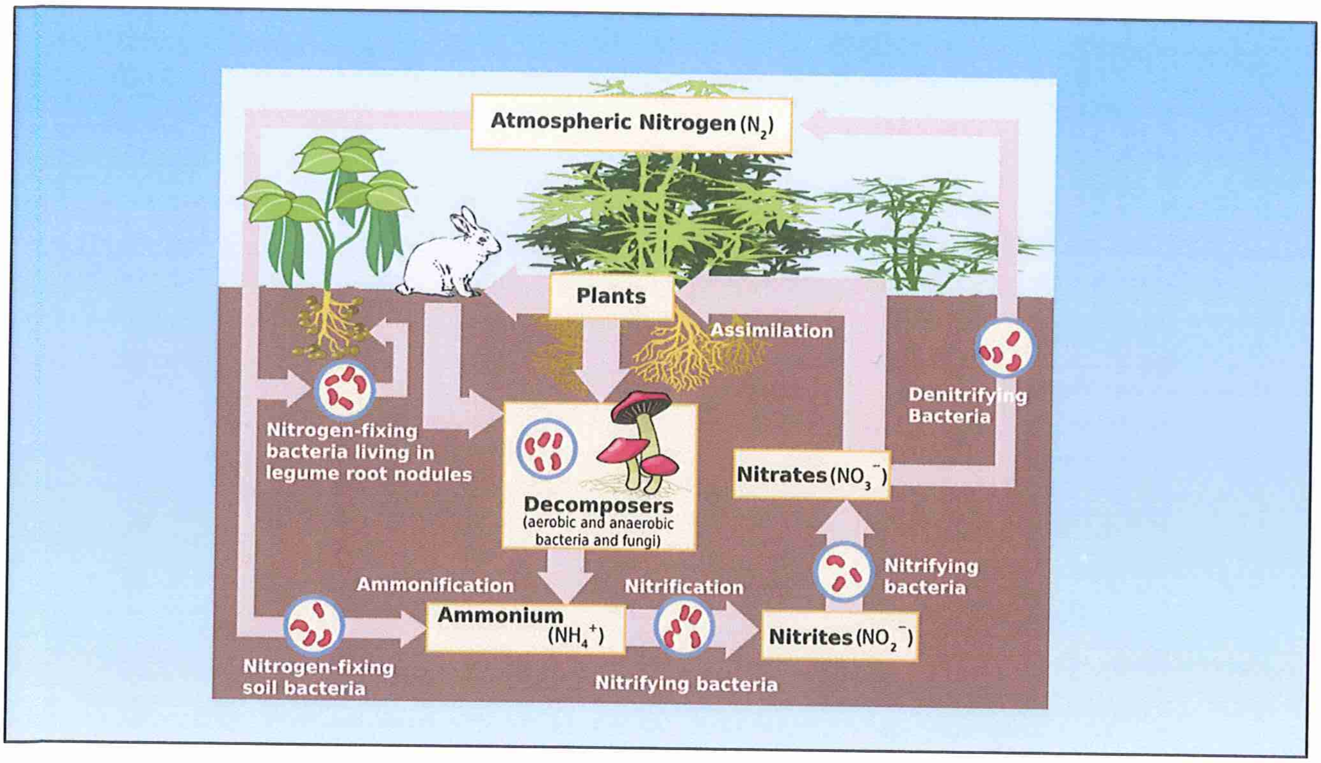
- Associated with strong plant root growth.
- Discouraged when soluble P or soluble N is applied.
- Thrive when small amounts of humic acid are applied with P fertiliser
- Nitrogen fixing organisms and phosphorus solubilising organisms also present.



Its easy to see that if we compare the pasture on the RHS with that on the LHS we could expect more efficient use of resources such as soil moisture and plant nutrients where the root system is exploring a bigger soil volume and there is likely to be a more active nutrient cycling process taking place.



This nitrogen Cycle is for Taranaki farms.
We have the mountain, cows and Kapuni.
Air is 78% nitrogen so there is plenty of N in a healthy well aerated soil.



You can see all the transformations of nitrogen in soil are done by fungi and bacteria.

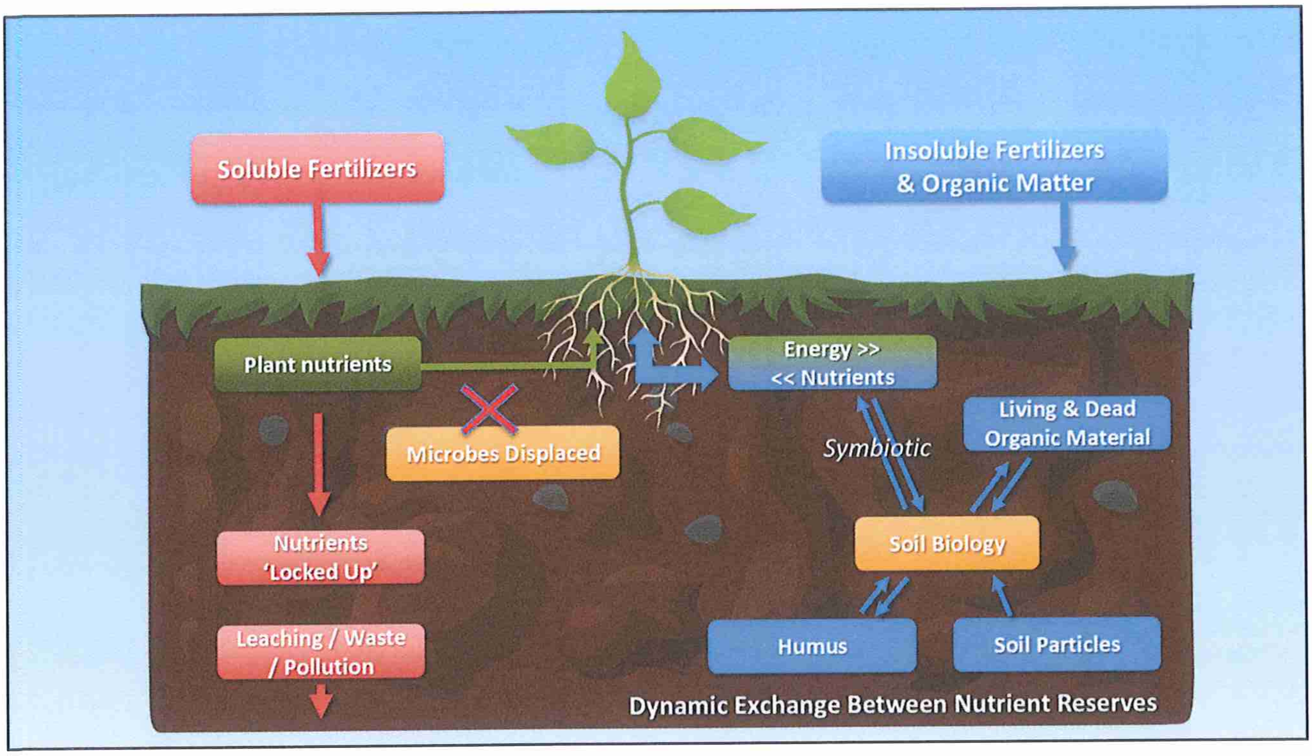
Every time we apply N fertiliser we will disrupt the activity of these microbes:

Reduce the legume content of pastures. Grasses will dominate legumes increasingly as apply N.

Reduce the amount of N fixing done by rhizobia. Rhizobia strains remain the same but their ability/propensity to fix nitrogen diminishes with increasing N fertiliser applications.

Response to N fertiliser applications reduces over time.

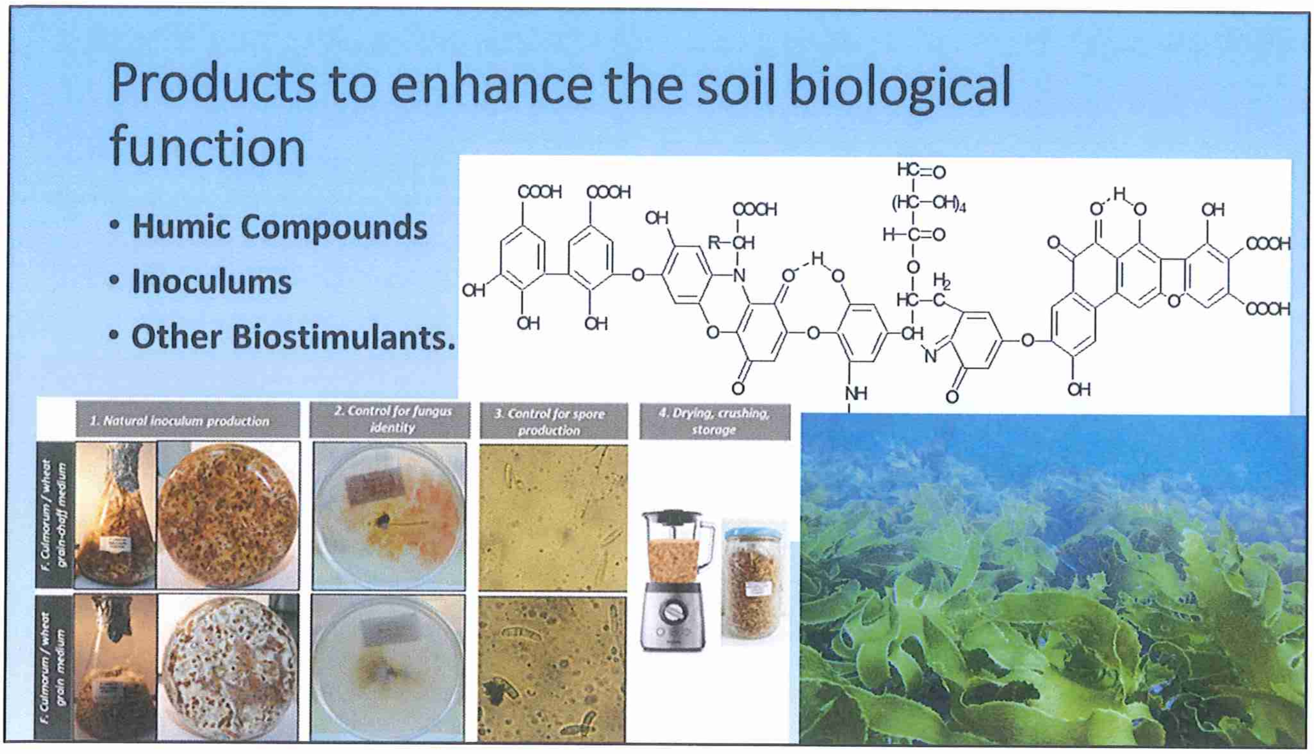
Need to apply increasing amounts of synthetic N to get the same response from pastures.



Currently N, P, K and S applications are based on soil tests which we use to calculate the nutrients required to meet the production plan.

Nutrient delivery to plants is mediated by soil biological activity that we have little knowledge of.
We have named and studied the functions of less than 10% of the organisms that live in healthy soil. (ones we can culture in the lab)

When we are making fertiliser recommendations if we consider not only the pool of available nutrients but also look at the likely nutrient cycling and delivery processes we may be more efficient with fertiliser inputs.
If we maximise nutrient cycling and delivery mechanisms we find it is possible to reduce inputs of soluble P and N while increasing the farms overall productivity.

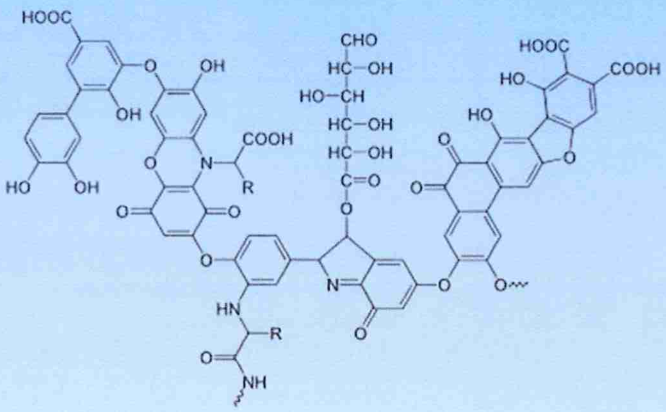


I will describe the humic compounds a bit more next. These pictures show the complex nature of humic compounds, Kelp a common ingredient in biostimulants due to the abundance of plant nutrients, trace elements and plant hormones it contains. The lower left picture is of the lab based steps involved in producing a fungal spore inoculum. Globally there is a renewed interest in research and commercial development of inoculums and bio-stimulants used in conjunction with fertiliser and plant health products.

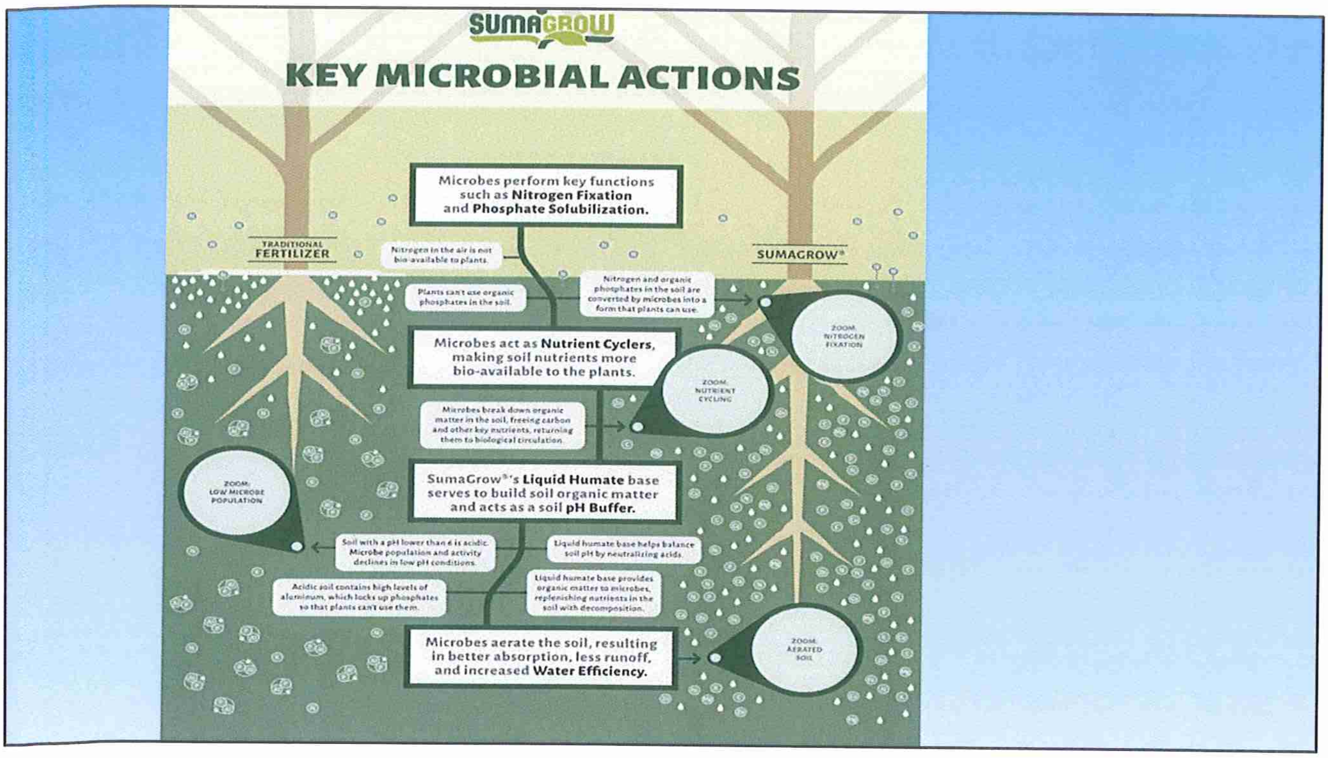
Companies like Monsanto (Bayer) through their partnership with Novozymes for example plan to release this year corn seed with a microbial coating that enhances P uptake of the germinating corn seedlings and thereby reducing the amount of P fertiliser required.

Humic Compounds

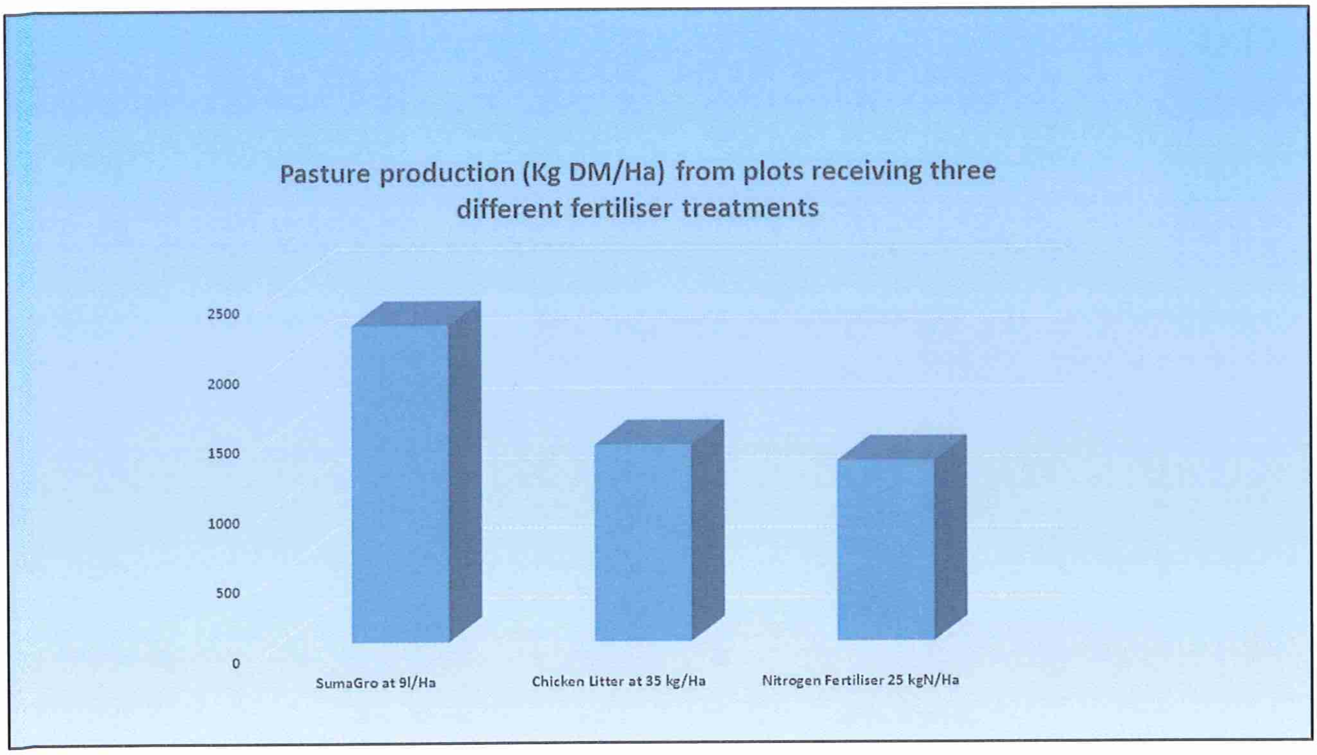
- Chelate soluble fertiliser nutrients like N and P
- Provide nutrition for microbes
- Stimulate plant root growth
- Improve efficiency with which fertiliser nutrients are used
- Increase P availability in soil
- Detoxify soils.
- Reduce Al and Fe activity in soil



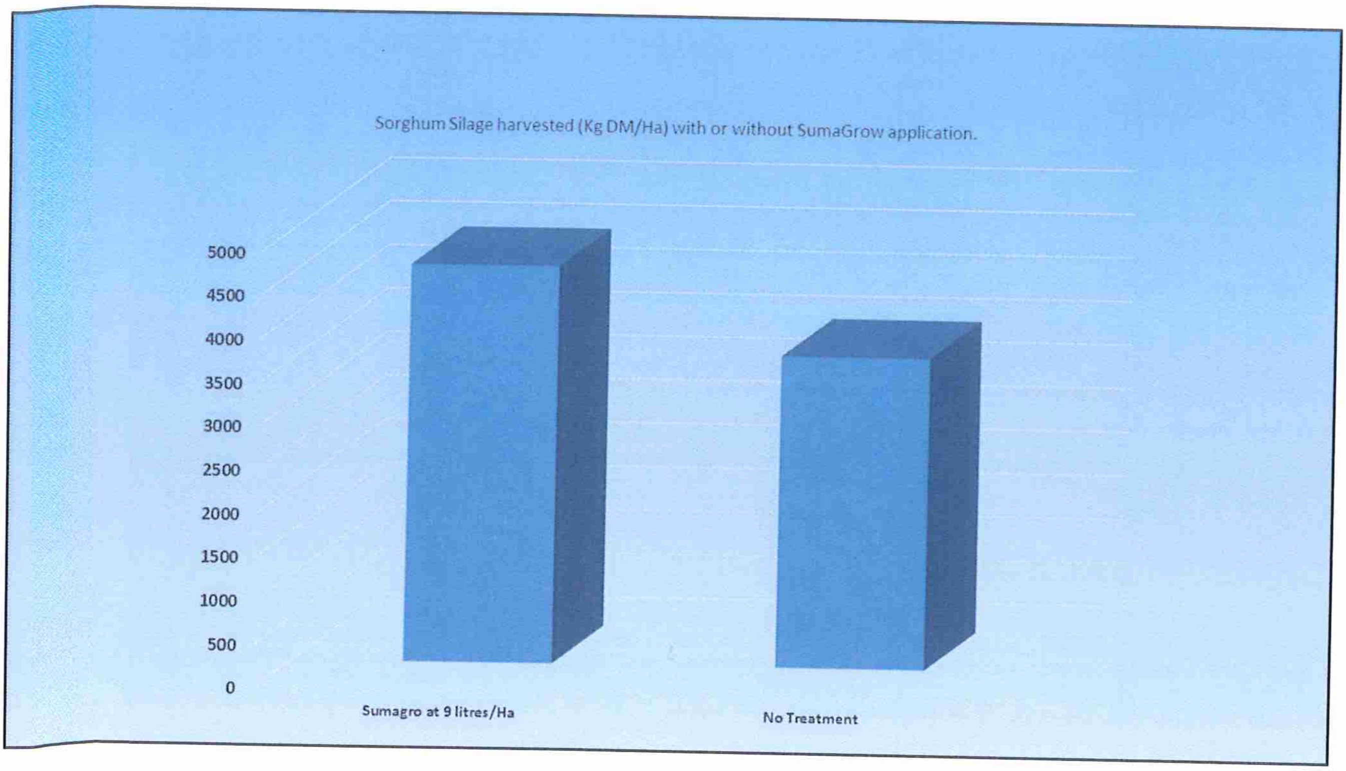
Include Sugar, carbohydrate source for soil microbes; Peptide Groups that are involved in plant stress resistance; Quinoid Groups that are involved in plant root development; Carboxylic acids, involved in water and nutrient movement and also detoxification; Phenolic compounds involved in water and nutrient retention.



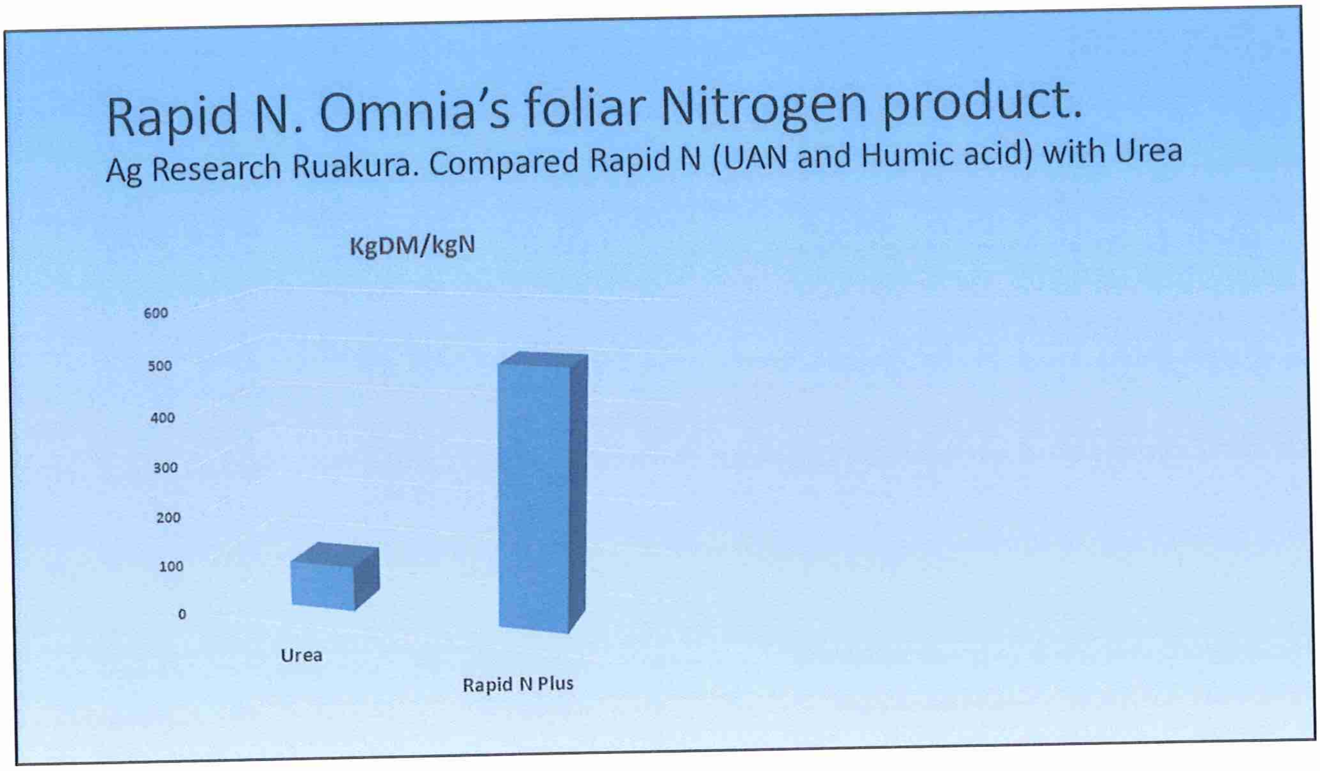
SumaGrow; Polymicrobial inoculum developed in Michigan State University and released as a commercial inoculum in 2010.
Worldwide trials on crops and pasture demonstrate the use of this product in growing more crops or pastures with less N, P, K and S fertilisers.
N fixing bacteria, P solubilising fungi, microbes that mobilize and mineralise plant nutrients present in the soil but not plant available.



This was a trial run by US researchers where they were grazing beef on mixed legume and grass pastures. Replicated plots were treated with three different fertiliser regimes and pasture growth recorded for a 3 month period.



In this trial at Michigan State University the weight of silage produced from a sorghum crop was measured from plots where Suma Grow was applied compared to plots with no SumaGrow applications.



Many trials and many different products have been used to demonstrate that foliar application of nutrients is more efficient than using solid fertilisers.

In this trial Nitrogen fertiliser in the liquid form UAN with Humic acid and biostimulants like kelp grew up to 10 times more dry matter than solid urea applications.
These researchers found if the influence of the growth hormones in the product were removed there was still on average four times as much pasture produced per kg of N fertiliser using the Rapid N product compared to solid Urea applications.

Nutrient efficient fertiliser results on a farm scale

COMPARISON OF FERTILISER APPROACHES	Farm using Humic acid with all fertiliser. Insoluble P. Foliar N,P,K most of the year	Farms with standard fertiliser approach. Soluble P and all N as solids.
Pasture Harvest (Tonne DM/Ha/Year)	17.2	17.0
Kg N applied/Ha/year	115	250
Kg P applied/Ha/year	20	45
Kg MS/Ha	1600	1600
OVERSEER kg N Loss/Ha/year	32	50
OVERSEER kg P Loss/Ha/year	0.4	0.8

Lets look at farm scale situations then.
Looking at a dairy farm in Canterbury that, for more than 5 years, has employed a fertiliser programme that focuses on building a healthy soil and deep root systems. Compared with the neighbouring farms of similar scale and production system.

It is evident that it is possible to grow as much or more pasture with much lower inputs of phosphate and nitrogen.
This results in a much reduced environmental impact (N and P loss is significantly lower than the neighbouring similar farms)
The soil water holding capacity on this farm has also increased as soil structure has improved.

Last year we proposed to run this sort of demonstration and field trial on dairy farm land in Rotorua under the Low Nitrogen Land Use Fund but unfortunately were not successful with our application.

In Summary.
If we pay attention to soil biological functions (and enhance them whenever we can) we will be able to maintain or increase pasture production while lowering the N loss and P loss and thus reducing the impact our farming operations have on

the environment.