Microbial diversity – can it feed the world?
Gupta V.V.S.R., CSIRO Agriculture (Tel: 08-83038579; Email: gupta.vadakattu@csiro.au)
https://www.youtube.com/watch?v=Rp-MKhWSN8M

Let us travel from the magical plant world aboveground to the mysterious and unseen microbial life belowground.

Productive and sustainable agriculture needs healthy soils. Soil health depends upon the life that you can't see with the naked eye. Belowground and underneath the crops there is a diverse life that is vital for food production, soil and water quality, climate regulation and that also has cultural value for people – an overall healthy ecosystem.

This unseen life has given us the life-saving antibiotics

Biota in soil are diverse in terms of size and abundance. Some of them are large enough that we can see with naked eye, for others you need a regular microscope (school room) and there are others you can only see using powerful microscopes (electron microscope). Microorganisms are a key members of soil biota food-web.

Microorganisms may be small in size but make up in numbers with more of them in one teaspoon of soil than all the human populations.

They are diverse and multifunctional; they help plants overcome a variety of biotic and abiotic stresses to plant growth. Microbes help plants thrive in wide range of environmental conditions.

This multifunctionality comes from their diversity. We all have family trees - Soil Microbes have a much more complex family tree. The diversity in microbe communities is very important to their resilience in function.

- The jobs microbes do can be resilient under all sorts of environmental conditions as long as the diversity of microbial communities in maintained.

This is the Omics era, we can now unravel the genetic diversity of the unseen world in our soils and their inner workings. Bacteria, Fungi and viruses are the three major groups of microorganisms with 10 to 100 million microbial genes in a gram of soil. More diversity in a gram of soil than the above ground diversity in the whole of the Amazon basin. The omics tools give us power to know 'who' is there, and how management and plant type can modify what they do; which means we can manipulate.

The growing demand to increase food production is becoming critical. By 2050 global food production needs to double to what it was in 2000 to meet the food needs of world's population. The dramatic increases in crop yields from the new varieties during green revolution have plateaued.

There is a large yield gap (>50%) between what is attainable with current technology and that is actually achieved. WHY?? Diseases, nutrition, lack of water… Climate variability adds another uncertainty to the efforts to reduce this gap and improve food production. Harnessing the power of microbes can help us achieve this!

The word microbiome is used to describe the collection of microorganisms in an environment creating a mini-ecosystem. There are 10 times more microbial cells (10^{14}) than human cells in our body (10^{13}). Like the human gut and its close interaction with microbes, roots and rhizosphere are the action-points for plant-microbe interactions. Plants like humans have an intimate and long standing relationship with microbes. Plants provide shelter and sugars to microbes and intern microbes provide nutrients and protection from pathogens and environmental vagaries. A diverse group of *endophytic bacteria* are found in side every plant.

This close association between plants and microbes is and can be influenced by management and plant and variety type. Through management we can modify the composition of soil microbiome and thus giving plants access to a desirable microbiome. Through management we can also make a better home for microbes.

- Plants selectively influence and enrich certain members of soil microbial community by stimulation and recruitment of beneficial microbes. We are now finding out that there is a continuous talk between plants and microbes through various type of signals.

Nitrogen is the key limiting nutrient to all crops. Increasing fertilizer costs are a critical economic bottleneck for farmers especially in developing countries. The annual Global fertilizer industry is worth $100 billion. How can we reduce the amount of fertilizer used without reducing yields. This is where a specific group of microbes – Diazotrophs - could come to the rescue.

Research at the Waite campus has shown that there is a diverse community of diazotrophs present in Australian soils (e.g. >120 genera in Australian soils). Another interesting point is that perennial pasture grasses harbour a diverse community in all parts of their plant and are fixing nitrogen and supplying it to plants. The question we can ask is how can we encourage this beneficial interaction in new crop varieties?

Soilborne pathogens are a major constraint to agricultural production; 10-50% yield losses or $400million in every year in Australia. There are no chemical or varietal resistance options available. Research in SA and overseas has identified the presence of biological disease suppression that removes or reduces disease development even in the presence of the pathogen. Recent research using omics tools has identified that DS is a product of a diverse (phylogentically and functionally) group of microbial community. The presence of specific groups of bacteria and fungi gives plants have a more diverse consortia to utilize / exploit. Once developed the extensive connectivity between the groups also gives resilience across seasons. Live and let live i.e. pathogens can be present but couldn't cause diseases.

Another constraint to agricultural production is droughts and lack of sufficient rainfall. Exciting new research on plant-microbe interactions (at the Waite, in collaboration with researchers in India and research in Canada and USA) suggest that we could 'bio-fortify' plants against abiotic stresses such as droughts. With the aid of new *omics* tools we can now understand how some microbes, particularly endophytes, help plants withstand stress during the periods of lack of water and recover when right conditions arrive. Researchers around the world are looking for right combination of plant-microbes in all types of environments (like arid regions) and with different plants.

We can better harness the Microbiome for to meet food demand

The new *omics* tools have opened the doors to unravel the true depth of microbial diversity and its capability allowing us to exploit it for food production and improving ecosystem health. There are lots of similarity between human-microbe and plant-microbe interactions. Soon farmers could get a microbiome report for their soils which will give them options on what to do. Research can help develop crop variety-microbe combinations for farmers to choose. We could even 'immunise or biofortify' crops to upcoming stresses. It is exciting times to be researching in microbiology – we can do something about helping humankind.

It is exciting times to be a microbiologist – There are enormous possibilities for you to do something about helping humankind.