Why are soil minerals so important and how can we use biofertilisers to remineralise our land?

We come from bedrock. Iodine for our teeth, fingernails of zinc, cobalt to coat our tingling nerves and beating heart, all built from the rocks and stones beneath our feet. The enzymes needed for our immune systems to function optimally rely on a full complement of trace elements such as molybdenum or selenium. This is one of the differences between food as fuel and food as medicine. We achieve deep nutrition by eating food rich in minerals, grown in soils full of biology.

Yet we have become accustomed to the 'new normal' of poor soils, demineralised food and consequent ill health. Our land, our crops and ourselves have an 'inner hunger' on a physiological level, born out of incomplete mineral nutrition, as described by Bob Cannard in his excellent podcast. He urges us to strive for the 'physical completeness and tranquillity that can arise from the freedom of internal hungers'[1].

Industrial agriculture has stripped our minerals and vitamins from our food, only to offer them to us in the form of 'health supplements' on the shelves of pharmacies. Our food should have the ability to heal as well as fuel our bodies. Biofertiliser production is emerging as an important tool in the remineralisation of our soils, mimicking the epic journey of soil bedrock through to biologically available minerals. To understand this we need to get some dirt under our fingernails!

Take a spade and scrape off the leaf layer of a healthy soil and you will see a rich dark layer of detritus and fibrous roots. You are looking at duff, the layer of soil rammed full of microbial activity twixt plant and soil – this is God's compost.

Dig deeper into the dark brown layer past root hairs and sweet smelling aerobic soil. Press your nose to the soil and breathe in the peaty smell with a hint of mushroom. Deeper still and you hit a paler, cooler, wetter world. Here amongst the tap roots and earthworms are streaks of yellow and blue. Dig deeper and in a good deep soil you are waist deep in the earth and the smell is of iron; the mind wanders to thoughts of creation and mortality. And finally the spade jars in your hand. You have hit bedrock. And here in the dark, wet, secret places live microbes evolved to anaerobic ferment! This is where geology becomes biology, as bacteria slowly digest the minerals in the bedrock through the dance of life, reproduction and death. They are digested again and again, passing through generations of bacteria, protozoans, on and on up the soil food web until they are fully biologically available as building blocks to make fingernails, teeth and a heartbeat. This is the natural pathway for our dietary minerals.

Instead we have chosen an industrial agricultural monoculture that grows cereals year after year on the same fields without rotation, mining the soil of its minerals. We have tried to mitigate the inevitable drift towards decreased yields through the use of fertilisers in a salt form such as Diammonium Phosphate, whose action oxidises the soil, burning up the organic matter holding minerals in an available form for the plant.

Misconceptions about minerals

Our approach to soil fertility, particularly in the fields of organics and permaculture, suffers from two main misconceptions. The first is that we should concentrate only on building soil organic matter, through compost or other organic additions. Whilst the addition of compost to soils is almost always a benefit, it is the full range of minerals that turbocharges photosynthesis, enabling plants to produce excess sugars and lipids that are exuded into the soil. We can therefore feed the soil by feeding plants, turning the organic maxim of 'feed the soil not the plant' on its head.

The importance of trace elements – the minute but essential mineral component of a healthy soil – is described by Liebig, the German chemist, in a fable known as 'Liebig's barrel'. He stated that a barrel made of staves of differing lengths would only fill with water to the height of the lowest stave. He saw soil fertility similarly; out of the full range of minerals needed for perfect growth, the mineral lacking the most would limit all other mineral uptake by the plant. A lack of just one mineral therefore has profound consequences. In practice, most of our soils, particularly unglaciated soils, are lacking in minerals and we are accustomed to rates of photosynthesis that are throttled back to idle, or tick over at best.

The second misconception is that chemicals are the devil's business! It is easy to think that if you make good compost, it creates good all round soil nutrition, and to leave it at that. However, major nutrients such as magnesium sulphate, calcium carbonate and a host of trace elements are required for optimum growth, but have been maligned as they are often only available in their raw chemical salt form. We tend to shun the work of the early pioneers of soil chemistry such as Liebig, the father of industrial agriculture, and Julius Hensel, who worked with empirical science to understand the interactions of plant and nutrient. We can now adapt this work to our understanding of biological processes, natural systems and holistic management to create a step change in regenerative farming. This is where biofertilisers play an important role.

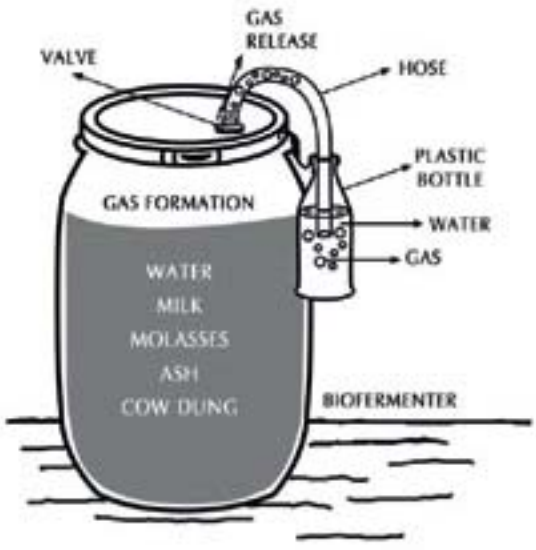
Biofertiliser is a critically important tool in the kit, enabling farmers and growers of any scale to produce high quality biological fertiliser that combines the power of a balanced soil biology to build the soil food web, with the full array of trace elements and soil minerals. It can be produced on the kitchen table or at scale and applied from a hand sprayer or helicopter. Think what you may about the scale of our modern farms, we need bridging technologies like this to enable mainstream agriculture to transition to agroecological methods. We need to do this at scale if we are to turn soil carbon emissions from industrial farming into stable soil carbon.

What is biofertiliser?

Biofertiliser is a biologically active fertiliser concentrate, providing a wide range of microbiology, mostly as spores, and solution rich in proteins, enzymes and vitamins formed during the fermentation process. The solution can be fortified with minerals, either generally through the addition of rock dust, or specifically through the addition of mineral salts. Biofertiliser is made by breeding up microbes in solution under anaerobic conditions. Cow dung or native microbes from the forest floor form the source of biology for the brew. Into this we add molasses as an energy source, milk or whey for a source of protein and to 'steer' the brew towards a lactic fermentation, and water as a carrier. Finally, the ferment is enhanced with minerals as the ferment matures.

Like most ferments such as yoghurt or cider, this process can be as simple or as complicated as you want it to be. The basic principle is easy, and the modifications to make ferments that suit your soil, crop or livestock take more perseverance and skill.

The tools are cheap – for a garden you need a demijohn with an airlock, or for larger scale you need a 200 litre plastic barrel with a homemade airlock. Biofertiliser is diluted down at the point of spraying onto the crop between 5 and 10%. So a demijohn of biofertiliser will do 4 litres × 10% dilution = 40 litres. I can spray my veggie patch with 2 litres with a hand sprayer, so the one demijohn will do me 20 applications, or most of the summer at 1-2 week intervals between sprays.



Drum with fermented biopreparation (note the gas bubbles in the bottle)

Controlling pathogens

Jairo Restreppo filling biofertiliser barrels with whey

But what about anaerobic environments producing pathogens such as *E. coli*? Our early compost tea days at Ragmans taught us that oxygenated is good and anaerobic is bad. Surely we would be breeding the bad guys in our anaerobic ferment? It's true that there are possibilities for anaerobic ferments to go wrong, but they usually make quite a statement – like putrid aroma or vivid colouring. The trick with getting healthy ferments is to source clean, fresh ingredients, and to create the right environment for beneficial microbes such as bacillus subtilis and lactobacillus to thrive. These are aggressive beneficial microbes that devour food sources that *E. coli* need to survive.

There are simple tricks for controlling pathogens, not least our own sense of smell that intuitively distinguishes the aroma of a loaf of bread or fresh yogurt from that of rotting food. While we may worry about anaerobic and aerobic microbes, in reality most bacteria are facultative, meaning they can thrive in both anaerobic and aerobic environments, E. coli being a prime example. The trick is to maintain an environment, whether it is aerobic or anaerobic, that favours beneficial microbes.

One way to think of biofertiliser is to think of it as a cow's rumen, only made out of a plastic barrel (and less beautiful). The evolution of soil biology and ruminant stretches back through the ages with microbes transiting from anaerobic ferment on four legs to an aerobic life within the soil. We have a simple understanding of the myriad of biological transactions within this stomach of a gently chewing flatulent cow, two of which are particularly wondrous – chelation and sporulation.

Juanfran's lab

Photos: Ragmans Farm

Chelation and sporulation

Chelation has its roots in the word Chela, meaning claw or pincer in Latin. In terms of biochemistry, it is the process whereby the electrical bonds holding minerals in an unavailable state are changed through a series of biological or sometimes inorganic reactions.

In our biofertiliser ferment, minerals from rockdust or from chemical salts are unshackled from their strong molecular bonds through the endless digestion and re-digestion of microbes and are now held 'loosely' in organic acid compounds such as tartaric or malic acid. They are therefore more available to pair up at a molecular level, making their way into the biological food chain. This is what we mean by biologically available. Our anaerobic ferment, or biofertiliser, like the anaerobic regions deep down where soil meets bedrock, is particularly suited to this process; geology meeting biology, plugging Liebig's leaky barrel.

Our next wonder is sporulation! The basic principle is that when a particular microbe experiences a benign environment, it reproduces at a spectacular rate, but when the environment becomes more hostile, microbes cope by adopting dormant forms of life such as spores or cysts that allow them to survive in the most extreme conditions. This sporulation is nature's way of taking the smallest expression of life into suspended animation.

When times are good again the spores, a minute parcel of DNA holding the key to future generations, will wake from their sleep and reproduce once more. This is how soil biology can cling onto life under a glacier for 100,000 years only to come to life again in the meltwaters. It is what gives soil biology its remarkable resilience.

Good biofertilisers will then have a wide range of spores generated as the ferment passes through different stages of aeration, acidity, and nutrition, ready to awaken when they find themselves sprayed onto soil or plant. Many of them are adapted to both anaerobic and aerobic conditions. These biofertilisers also have a range of minerals that have chelated in the ferment. Another ingredient they also have is the 'waste' solution left behind as microbes break down into their spore form. This solution is rich in enzymes, amino acids and minerals, forming a potent fertiliser and growth stimulant.

Knowledge for small farmers

The commercial biofertiliser market is expanding rapidly, with many distributors now joining the market with products 'selected' and 'screened' to provide a consistent product. The issue is not whether or not this technology works, it is more how can we adapt it so that it serves small farmers, and does not become yet another agricultural input that we become dependent on.

The fight to keep the true knowledge of agriculture in the hands of small farmers has many champions – one of these is Jairo Restrepo, a Columbian scientist who has worked in the informal sector for decades, teaching and demonstrating the benefits of biofertilisers and a range of other self-reliant technologies. His work is to give farmers confidence to make their own agricultural products, which he argues are as good if not better than commercial brands. He gives recipes for preparations in his excellent book T*he ABC of Organic Agriculture*[2], but he also urges farmers to learn the science behind these recipes so that they keep control of their own destiny.

There are vast numbers of farmers in South America making and using biofertiliser on their own farms, some at scale. The conversion to organic agriculture that occurred in Cuba in the '90s was partly due to the adoption of biofertilisers. We are not, however, advocating biofertilisers as a silver bullet! They are simply tools that sit alongside good soil care, and plant and animal husbandry. Apart from using the ferments themselves, they have brought a new hunger at Ragmans to go back to the science behind our approach to land. We find ourselves thumbing through soil chemistry textbooks!

We need to up our game as organic growers! We need to reclaim the scientific knowledge of the eighteenth and nineteenth century agricultural pharmacists and stand it alongside indigenous knowledge and the holistic knowledge of biologically active soils, that we have developed over the last thirty years. We need to bring this approach back to agricultural colleges on our own terms and develop the science behind this new modern agriculture in a way that puts farmers back in the role of innovators, rather than operatives following spray regimes from an ever more directive agricultural supply industry.

Matt Dunwell and Juanfran Lopez

For those interested in learning more about biofertilisers please have a look at our website. We have a one day course, taught by Juanfran Lopez in November, and Jairo Restrepo will be visiting the UK in July 2018 to teach a six day course at Ragmans Farm: www.ragmans.co.uk

Matt Dunwell has run Ragmans Lane Farm, a 60 acre farm using permaculture principles for 26 years. Over this time he has hosted courses taught by Patrick Whitfield, Bill Mollison, Starhawk, Jairo Restrepo and many others.

Juanfran Lopez is manager of the research programme at Ragmans Farm. He aims to build on a conventional scientific approach to make knowledge more accessible to all farmers and growers, so that they can understand how to build locally adapted healthy systems.

This article is based on a talk given by Juanfran Lopez and Ruben Borge at the Oxford Real Farming Conference in January 2017.

First published in Permaculture magazine issue 92, Summer 2017 (https://www.permaculture.co.uk)

1 Bob Cannard http://sustainableworldradio.com/natural-processfarming-with-bob-cannard/#

2 available from www.ragmans.co.uk