South West NRM

Case Study

Selecting and testing biological amendments

Main points

- Farmers should understand what different amendments can provide and choose one that is most likely to deliver the desired outcome.
- Amendments should be trialled to assess response by comparing to a 'control' treatment.
- A robust and meaningful indicator should be used in a consistent manner to measure the outcome.
- Complementary management should also be considered.

Soil biology certainly has an impressive résumé. Communities of micro and macro-organisms can help supply nutrients to plants, improve soil structure and suppress pathogens. However, there is a lack of certainty about how farmers can maximise the impact of soil biology.

A lot of information about how to manage soil biology is coming from the marketplace, which now offers a wide range of biological amendments aimed at improving biological function. However, with many amendments not widely tested or used, it is difficult for farmers to decide which product, if any, will help in their situation.

One person with the knowledge and experience to help farmers navigate the world of biological amendments is University of Western Australia Emeritus Professor Lyn Abbott. She believes growers need to firstly look at what is limiting production, then consider which amendments have the mechanism or mode of action to address the limitation.

"In a paper I co-authored in 2018, we reviewed international research and summarised how biological amendments can improve broadacre crop growth. We called these services "modes of action" which include: direct nutrient supply; moderating plant stress such as heat, frost, drought and disease; improving soil structure; improving chemical fertility such as soil pH and cation exchange capacity; and biological function such as nutrient cycling and disease suppression.

"Based on our review of the relevant research, we suggested which biological amendments might be best suited to help deliver these different services."

Biological amendments were categorised into three groups:

- Microbial inoculants ('beneficial microbes'), e.g. rhizobia, arbuscular mycorrhizal fungi, rhizobacteria;
- Biostimulants, e.g. humic substances, hydrolysates and amino acids, seaweed products and chitin/chitosan products; and
- Organic amendments, e.g. manures, composts and their teas or extracts, and biochars.

Microbial inoculants

Inoculants appear best suited to deal with disease stress or where farmers want to improve nutrient supply or nutrient cycling. However, a key consideration is the likely presence of existing microbial populations and the ability of introduced microbes to survive.

"Inoculating legumes with nitrogen-fixing rhizobia is unbelievably beneficial. However, there are lots of other microbial inoculants that aren't necessarily beneficial. For example, we wouldn't recommend mycorrhizal inocula unless soil is severely degraded, because resident communities are already in most agricultural soils. Therefore, inoculation is probably not necessary and could even be detrimental."

Likewise, the survival and growth of rhizobacterial inoculants, which includes phosphorus solubilising microorganism (PSMs), is often questioned, and it's difficult to assess their effectiveness in the field.

Biostimulants

Biostimulants appear to have most potential in terms of helping plants deal with stress such as intermittent drought, heat or frost. In addition, some humic substances (not to be confused with humus, which is a stable form of soil organic matter) have been reported to increase nutrient uptake, chelate micro-nutrients and suppress disease, although effects may vary depending on the parent material.

Seaweed products may also yield responses under nutrient deficiencies and disease stress, while chitin and chitosan products made from seafood processing waste have been used as bio-pesticides.

Organic Amendments

Organic amendments such as composts are perhaps most suitable if farmers want to improve soil structure or address nutrient and moisture retention. Vermicomposts may also help plants stressed by heat, drought or frost, although there have been inconsistent results based on limited assessment in broadacre situations. Many organic amendments also have promise in suppressing disease.

Organic amendments contain variable amounts of nutrients, so a nutrient analysis can help to ensure there is no imbalance compared to crop demand. However, Professor Abbott doesn't see biological amendments as a complete replacement for fertilisers.

"It's about complementing and only adding the amount of fertiliser that you need in relation to what soil organisms provide. By adding biological amendments, you're going to influence the environment of microbes which can enable them to better complement other inputs."

Inoculating legumes with rhizobia is *"unbelievably beneficial"*. Other inoculants could be unnecessary.

Complementary management

While the choice of amendment depends on the limitation you want to address, getting the most impact from the amendment depends on whether all limitations are addressed, or detrimental activities avoided where possible.

For example:

- Soils with low organic matter/carbon content (the main energy source for microbes) may benefit from organic amendments, but may also require complementary mechanisms such as improved nutrient management, grazing management, cover crops or pasture rotations (which tend to build carbon compared to cropping). Farmers should also reduce carbon losses from tillage and erosion (retaining groundcover to protect soil).
- Low soil pH can impair microbial activity, particularly in bacterial populations, so amendments may be less effective if soil pH is below 5.5.
- Excess tillage destroys soil structure, increases the rate of carbon break-down and negatively impacts fungal networks, so should be minimised. However, infrequent strategic tillage that addresses a soil constraint (such as water repellency, compaction or incorporating lime to treat soil acidity) and results in increased plant biomass may have positive effects in some situations.
- Regular use of fungicides will reduce beneficial fungi as well as targeted pathogens, so amendments that offer disease suppression could be trialled. Insecticides can alter the structure of the soil food web, while herbicides may have more transient effects depending on the farming system, e.g. use of rotations.
- High levels of soil phosphorus can decrease colonisation of roots by mycorrhizal fungi, while high levels of nitrogen may limit nitrogen fixation by free-living or symbiotic bacteria. However, low nutrient levels can limit biomass production and reduce the availability of an energy source for many soil microbes. Nitrogen cycling and supply may be increased with some biological amendments and cover crops. Given the risk of nutrient imbalance, use of soil and tissue tests can help to ensure constraints are detected.
- The effect of fertilisers and farm chemicals on soil biology is a common issue raised by farmers. Professor Abbott says that using too much of any input will cause an imbalance, but non-excessive use does not necessarily have a negative effect.

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"If by adding these inputs you get more biomass, there could actually be more soil biological biomass or activity in the soil."

Monitoring progress

Once farmers have considered their constraints and what amendments and/or practices might treat the problem, it is critical to trial and monitor the effect of a treatment to make sure it is worth the investment.

The better the trial is designed (e.g. compare replicates of treated and un-treated areas) and managed (e.g. collect baseline measurements) the greater the confidence in the result. Farmers should also understand that change may occur over a long timeframe (e.g. five years).

Monitoring requires the measurement of relevant variables such as yield, soil structure, organic carbon or nutrient uptake. The Soil Health Institute in the US has endorsed 19 soil health measures considered to be effective and robust indicators. However, they have concluded that biological indicators generally require more research to evaluate their usefulness.

"There's often a chasm between measuring something and understanding what the measurement means. You need to understand whether you can use a measurement in a practical way. Commonly we're just monitoring something, without a clear indication of how to act on the resulting observation.

"The question you can ask is, can the measurement be used to predict something? If it's just a measurement without any capacity to predict and act on, it's probably not useful."

A key point to consider is whether the measure is a good indicator of success or progress towards a desired state or goal.

Another important question is, when, where, how many samples and how often do you sample?

"The answers will depend on seasonal effects, and whether variation occurs between seasons. High variability may require more sampling. But avoid sampling at irrelevant times when the measure is unlikely to indicate something functional.

"The key is to decide on a test and use it consistently. That's probably more important than keeping track of many different tests. Make a decision, monitor over time, be consistent with the monitoring process, and don't worry about all the other things you could be testing."

In summary, farmers should think about what limits their production and consider which amendments or management practices will most likely address these constraints.

Once you have a shortlist of options, trial those you aren't sure about by comparing them to "nil treatment" sites (replicate treatment and nil treatment sites where possible). Finally, find a robust methodology as an indicator of success and use it consistently.

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