PLANT AND SOIL NEMATODES

MICROBIAL PESTICIDES AND BIOSTIMULANTS: ARE THEY USEFUL AGAINST SOILBORNE PESTS AND PATHOGENS?

Synthetic pesticides dominate the global crop protection market but their intensive use in modern agriculture has resulted in many detrimental effects including a reduction in biodiversity; losses of the natural enemies of target pests; insurgence of secondary pests; the development of pathogen resistance; and the occurrence of pesticide residues in food, soil, rivers, and groundwater. Microbial pesticides and biostimulants are seen as a more sustainable alternative and this fact sheet considers whether they are likely to be useful against soilborne pests and pathogens.

Microbial pesticides

Microbial pesticides (sometimes termed biopesticides) consist of a microorganism (bacterium, fungus, virus, or protozoan) that targets a specific pest and closely related organisms. Most products contain bacteria such as *Bacillus*, *Pseudomonas* and *Streptomyces*, or fungi such as *Trichoderma*, and are sometimes marketed for use against soilborne pests and pathogens.

Biostimulants

Biostimulants have the capacity to modify plant physiological processes in ways that improve plant growth and development or enhance tolerance to abiotic stress. One group of biostimulants contain organic materials such as fish hydrolysate, humic substances, seaweed extracts, vermicasts, amino acids, and various organic fertilisers, while a second group contain a diverse range of microorganisms. Hundreds of such products are sold in Australia and they are usually promoted on the basis that they improve soil health, enhance nutrient uptake, or increase microbial activity in the root zone.

Microbial pesticides and organic products for soilborne disease control

Microbial or organic products used for crop protection in Australia must be registered by the Australian Pesticides and Veterinary Medicines Registration Authority (APVMA), but as of January 2023, only two products had been registered for use against a soilborne disease. The first registration was for Nogall™, a peat-based formulation containing *Agrobacterium radiobacter* var. *radiobacter* strain K1026, an antibiotic-producing bacterial strain that inhibits or kills a closely related strain that causes crown gall disease in stone-fruit, nut trees and some ornamentals. The only other biopesticide registered for soilborne disease control is Actinovate®, a product containing a strain of *Streptomyces lydicus*, a filamentous bacterium that controls Fusarium wilt, Rhizoctonia root rot and Pythium damping off.

Several other products currently sold in Australia contain fungi known to provide some control of soilborne pathogens. The most common fungal constituent is *Trichoderma*, which is often formulated for use against *Phytophthora*, *Pythium*, and *Rhizoctonia*, while one product contains *Pochonia chlamydosporia* and *Purpureocillium lilacinum*, two fungi that parasitise nematode eggs. However, the fact that these products have not been registered suggests that the companies marketing them are not confident they are effective, or cannot provide data showing that the target pathogen is controlled.

Hundreds of other microbial and organic products are also marketed in Australia and they are generally promoted on the basis that they improve crop health or stimulate beneficial activity in the root zone. Claims of soilborne disease control are never made, but phrases that a product will 'outcompete soilborne pathogens' or 'enhance disease resistance' are sometimes made. Regardless of the claim, supporting evidence is rarely provided.

Should microbial products and biostimulants be considered in a disease management program?

Although there has been a huge increase in the number of biological products marketed in the last 10-20 years, there is little evidence to indicate that they are effective in the field. Most of the products marketed in Australia are aimed at vegetable and horticultural markets, but other than the research which resulted in the registration of Nogall™, there are no scientific papers showing that these products are effective. The same applies to products aimed at the broadacre grain cropping market. CSIRO and the University of

Western Australia screened about 90 biostimulants and microbial inoculants in the laboratory and glass house and tested many of them in the field. Very few products produced significant yield responses and more in-depth analysis of soils from several treatments at each field site revealed sporadic and generally minor responses in microbial community structure and various soil health and fertility indicators (Cooke, 2018).

Although the number of products being marketed will continue to increase, and claims of efficacy will continue to be made, the above results suggest that most microbial inoculants and biostimulants are likely to be ineffective or will only produce occasional responses in a limited number of situations. The following points explain why.

- A gram of most agricultural soils will contain at least one billion bacterial cells, kilometres of fungal hyphae, and large numbers of protozoa, nematodes, microarthropods and other microscopic organisms. Thus, applying a few litres of a microbial product per hectare is somewhat akin to adding a drop of water to a swimming pool.
- All introduced organisms are subject to competitive forces, and when applied to soil they rarely survive at high population densities for more than a few weeks. Thus, microbial products are likely to only produce short-term effects such as better emergence or improved early growth. Also, they may only be effective in biologically impoverished soils.
- The microbes included in commercial biopesticides can be found in all healthy, well-managed soil and will already be adapted to the local environment. Thus, microbial strains introduced from elsewhere may not be as effective as the strains already present on a farm.
- Most biological products contain only one or a few microbial species. However, research has shown that soilborne disease suppression is rarely the result of a limited number of organisms. It usually occurs when many different organisms with different modes of action act collectively against a pest or pathogen.
- The activity of plant pathogens and the organisms that make up the soil biological community is influenced by many different factors, including soil type, temperature, rainfall, pH, tillage practices, cropping history, fertiliser inputs, soil organic matter content, and farm management practices. Thus, if a biological product has shown promise in another state or country, or even on a neighbouring farm, this does not mean it will have an impact at a nearby location.
- There is plenty of scientific evidence to show that adding composts, manures, biochars, chicken litter, crop residues and other organic materials to soil changes the soil biology and sometimes reduces losses caused by soilborne diseases. Thus, some of the organic products marketed as biostimulants may produce a similar response. However, these products are expensive and it may be possible to obtain similar benefits at a lower cost by applying locally available amendments at higher application rates.

Given the above, growers should be sceptical about microbial inoculants and biostimulants and be willing to consider alternative approaches to improving the health of their soils and reducing losses from soilborne diseases. The ultimate objective of a farm manager must always be to develop a farming system that builds an active and diverse biological community capable of maintaining pest populations at levels that do not cause economic damage. The practices that can be used to achieve this are discussed in other fact sheets (PSN 012 and PSN 041).

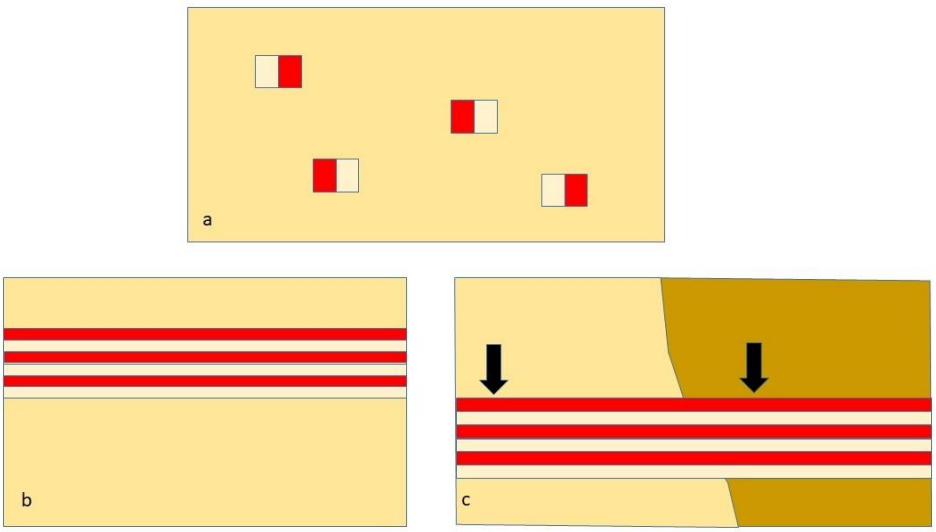
Confirming the efficacy of organic and biological products

There will always be growers who are interested in applying a particular organic or biological product. The first things they should before purchasing such a product is 1) check whether agencies independent of the company selling the product have conducted field trials at a nearby location, and 2) assess the results from those trials and determine whether the product increased yield, reduced losses from soilborne disease, or provided other benefits.

In most cases, appropriate trial work will not have been done, and so a new biopesticide, a novel organic blend, or untried biological products should be tested on-farm before being used on a large scale. The best way of doing this is to treat a few small, randomly selected areas of a paddock and leave the adjacent areas untreated. Measurements of the yield response or ratings of disease symptoms will indicate

whether the treatment is effective and economically worthwhile. Several trial designs can be used (see the figure below) but the key points to keep in mind are:

- Choose a plot size that is large enough to provide meaningful data.
- Establish plots that are convenient to manage with the farm machinery available, and can be easily assessed using yield monitoring equipment.
- Always include a 'control', 'nil' or 'standard' treatment against which other treatments can be compared.
- Ensure that application of the product being tested is the only factor altered within the trial area. If another factor such fertiliser rate is also changed, it will be unclear whether the measured response is due to the treatment or the change in the amount of fertiliser applied.
- Replicate all treatments (i.e. repeat each treatment at least three times), as this will improve the reliability of results.
- Mark the plots in some way and prepare a field plan that clearly depicts the location of plots.
- Record the management practices used at the site and keep accurate records of all procedures.
- Measure crop yield and other relevant parameters such as disease incidence. If the aim is to improve the soil's biological status, assess total organic carbon and use analytical tests to determine the occurrence of key pathogens and beneficial organisms.
- Analyse the data to check that a response is real and is not the result of natural variability.



Three simple field trial designs for assessing the effects of any new biopesticide or biostimulant. In figures a, b and c, the new product or practice is applied to the plots in red, while the light-coloured plots are not treated, or remain as standard practice. a. Small plot design with 4 replicate plots. b. Strip trial with 3 replicate plots running across the paddock. c. Strip trial in a paddock where soil type, slope or some other factor varies along the length of the paddock. In this case, it is important to take measurements at both ends of the paddock (arrows), as the variable factor may affect the response.

Literature cited and further reading

Cooke A (2018) In-depth look at biological amendments. GRDC Groundcover, Issue 137, Nov-Dec 2018, page 13.

Stirling GR, Hayden HL, Pattison AB, Stirling AM (2016) *Soil Health, Soil Biology, Soilborne Diseases and Sustainable Agriculture. A guide.* CSIRO Publishing, Melbourne, 275 pp.

Author: Graham R Stirling, Plant and Soil Nematodes. **Contact details:** graham.stirling@biolcrop.com.au