Can biostimulants add value to soilless productions systems?

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Jessica Bell was awarded First Class Honours for her study *"Influence of Biostimulants on the Microbial Associations and Plant Growth Characteristics of Sunflower (Helianthus annuus cv. 'Dwarf Sunsation') and Strawberry (Fragaria x ananassa cv. 'Toscana F1 Rose"*. She is currently undertaking her PhD studying soil health of apple orchards.

Key messages

Seaweed extract is an effective biostimulant, Natrakelp® increased strawberry yield.

- Microbial inoculants boosted microbial populations on strawberry leaf surfaces. This also occurred in coir, but only when the fertigation nutrient concentration was reduced. More work is needed to determine whether mixed microbial inoculants can reliably deliver improvements to plant production that justify their use in soilless systems.
- When applying biostimulants in combination there is the potential for additive benefit, but this does not automatically translate to the more the better.
- Stronger regulation of biostimulants is needed in Australia to drive improvements in product quality and reliability and ensure a return on investment for growers.

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Biostimulants are a widely accepted addition to horticultural crops, promoted by a global market valued at US$2.5 billion. However, the huge range of products with long lists of potential benefits is not always supported by rigorous science. In Australia, the absence of regulation makes this situation more unpredictable. Jessica Bell, a recent honours graduate from the Tasmanian Institute of Agriculture (TIA) at the University of Tasmania, adds some valuable science to this field in her study of selected plant biostimulants applied to strawberry in a soilless production system.

Plant Biostimulants – what are they?

Plant Biostimulants (PB's) are classified as: *'diverse compounds, substances and microorganisms that are applied to plants or soils to improve crop vigour, yield, quality, and tolerance to abiotic stress'* (European Biostimulant Industry Council). Biostimulants can influence the way plants function in a variety of ways, from the whole plant down to a cellular and molecular level. Unravelling how they work is a complex process and can vary with each plant species and its environment. Products commonly available on the Australian market include microbial inoculants, seaweed extracts, humates, botanical extracts and nitrogen containing compounds. These substances have potential to add value to soilless production systems which lack the biological and chemical complexity of traditional soil-based agriculture.

In this study Ms Bell investigated the potential of three of the most frequently applied categories of PB's: seaweed extracts, humic substances, and microbial inoculants.

Seaweeds have been used to improve agricultural fertility since ancient times, however our understanding of the biostimulatory role of seaweeds is a more recent development.

Seaweed extracts contain an incredible array of micronutrients, plant hormones and bioactive compounds which have a demonstrated ability to improve plant growth, resilience, and yield.

Humic substances – often sold as humic acid, fulvic acid, or their combination – are carbon rich compounds extracted from material including leonardite shale, vermicompost and manure. These substances can act as powerful chelating agents, improving nutrient availability and uptake. They have also been shown to stimulate soil biological activity and improve soil structure.

Microbial inoculants can be applied both for their capacity to enhance plant growth, and their ability to act as biocontrol agents – preventing or managing outbreaks of pest and disease.

Some inoculants, such as *Rhizobia* (for legumes) and *Bacillus thuringiensis* (Bt) (caterpillar management) will be familiar to many growers and have a proven track record in the field. Recently, an increasing number of multispecies inoculants have entered the market. These products look to stack the functions of a range of microbial agents, potentially delivering more consistent and significant benefits to production systems.

While this presents an exciting new direction for industry there are significant challenges around developing a shelf stable product that delivers measurable benefits to growers at economically viable application rates.

Combining plant biostimulants – The most recent generation of PB products have looked to combine different categories of biostimulants. Ms Bell explains the rationale for this.

"The idea is to create combination products that harness the strengths of each different biostimulant to enhance the benefit. While this is promising, there is only limited research to support this and some studies report negative interactions between PBs. I saw a real need to find out more," she said.

In this study Ms Bell evaluated whether the application of PB's, applied alone or in combination, could deliver significant benefits to strawberry plants grown in soilless culture.

Key questions:

- Can a mixed microbial inoculant establish in soilless substrate?
- Do PB's improve strawberry plant growth and productivity in soilless culture?
- Does the application of PB's in combination deliver any complementary or synergistic benefit?

A study of foliar and substrate applied plant biostimulants

Plant biostimulants are most often applied to plants as foliar sprays or in solution to the substrate. In this study Ms Bell tested both modes of application. The trial took place in a heated greenhouse from January to May 2020. Strawberry plants (cv. 'Toscana F1 Rose') were grown in coco coir and fertigated with Hoagland's solution.

Foliar study:

The three PBs tested in the foliar study are detailed in Table 1. Each was applied alone and in combination to give a total of 8 foliar treatments, including a water control. The foliar sprays were applied fortnightly for the duration of the trial.

Substrate application study:

The substrate application study compared the commercially formulated Multikraft Soil Program (MSP) to water application. The Multikraft Soil Program consisted of Microlife®, the same mixed microbial inoculant used in the foliar study (Table 1) plus Soil NRG® a combination of seaweed extract, humic acid, and molasses. This was applied fortnightly according to the manufacturer's recommendation.

Microbial colonisation and persistence

Ms Bell measured biofilm formation on leaves and changes in microbial density in the coir substrate to visualise how well Microlife® established and persisted. Foliar applications of Microlife® successfully produced a biofilm on the leaves of the strawberry plants. Interestingly, this was significantly enhanced by the addition of the seaweed extract Natrakelp®. Ms Bell suggested some potential reasons for this.

Figure 1. Strawberry Toscana F1 Rose in a randomised block greenhouse trial under drip fertigation.

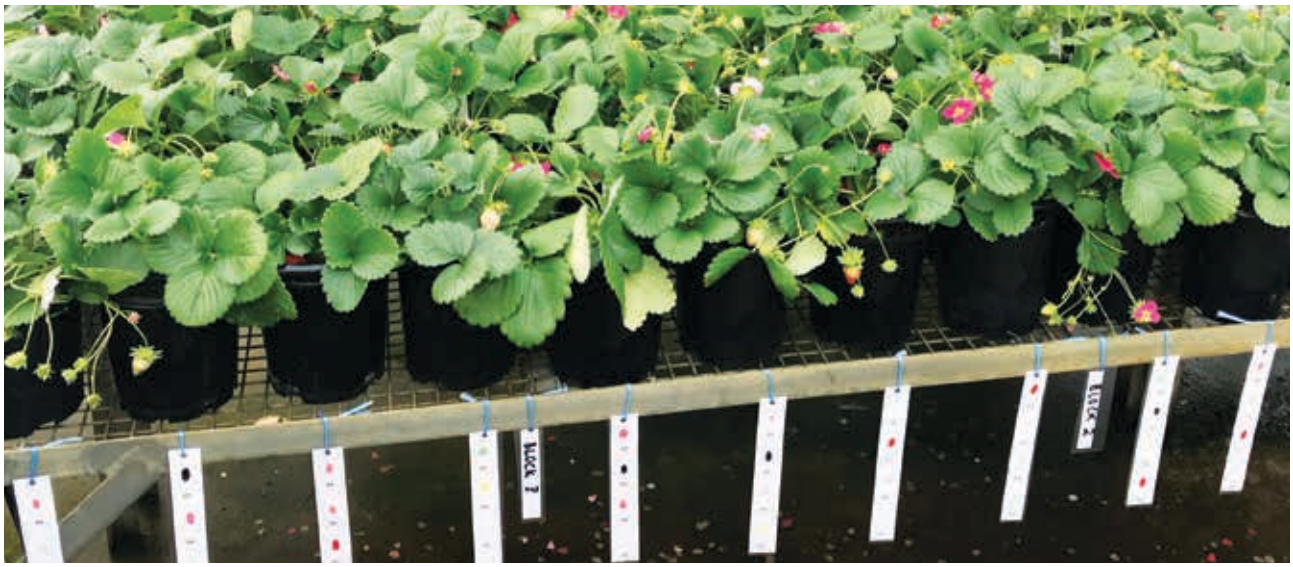

Table 1. Biostimulant products used in the study.

Seaweed extract (SE) Natrakelp®	Fulvic Acid (FA) Integrate®	Mixed Microbial inoculant (MM) Microlife®
***Ascophyllum nodosum* brown seaweed**	2% FA from leonardite shale	• Lactic acid bacteria: *Lactobacillus casei, L. plantarum;* • Photosynthetic bacteria: *Rhodopseudomonas palustris* • N-fixing bacteria: *Acetobacter tropicalis, A. lovaniensis, A. szyygii, Rhizobium spp.* • Bacillus spp.: *B. subtilis, B. amyloliquefaciens* • Yeasts: *Saccharomyces cerevisiae*

"It is possible that Natrakelp® was acting as a 'glue' sticking microbes to the leaf surface; a humectant protecting the microbes from drying out; or by providing nutrients to the microbes allowing them to establish," Ms Bell explained.

The Multikraft Soil Program® also demonstrated an ability to boost microbial population densities in the coir substrate. However, it is not clear whether it is the microbes in the Multikraft® product or the other components, the seaweed, humates or molasses – driving this change.

"Whilst these measures are a good indication that the products are having an impact, they unfortunately don't tell us which microbes are responsible. DNA testing, although expensive, could be an option for future research to find out which microbes are flourishing," Ms Bell said.

More microbes with less nutrients

A serendipitous conversation with Dutch strawberry consultant Klaas Plas prompted Ms Bell to ask a further question 'Do high nutrient concentrations in the fertigation solution inhibit microbial establishment in hydroponic systems?'

To assess this, Ms Bell split the strawberry trial into two phases. In phase one, plants were fertigated with the standard Hoagland's nutrient concentration. In phase two, the Hoagland's solution was reduced to 30% concentration.

The results backed the theory that high nutrient levels can inhibit microbial populations. The microbial population density in the substrate only increased in phase two after the nutrient concentration had been reduced to 30% (Figure 2).

This raises serious questions about how this might translate to plant performance, and if the benefits of microbial inoculation could justify reducing nutrient concentrations in a commercial setting. In this study, despite increasing the microbial population density in the substrate, there were no measurable improvements in plant growth or yield. This could be resolved by comparing plants grown in microbe amended coir under a reduced nutrient regime with normal commercial practice.

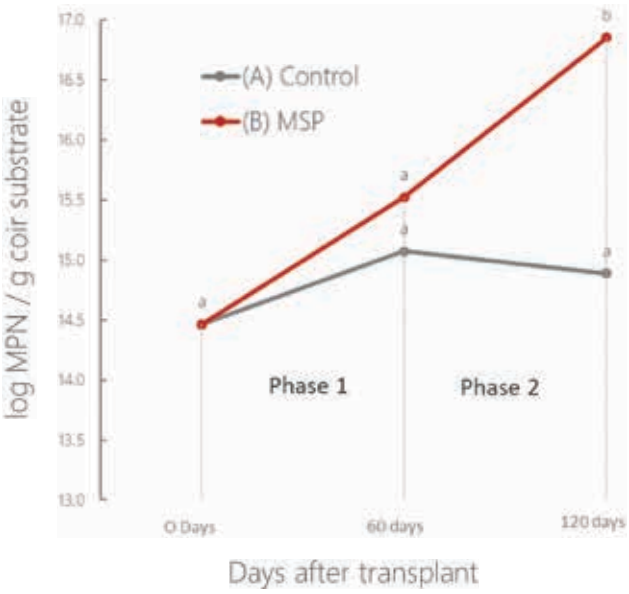

Figure 2. Effect of media treatment with biostimulant Multikraft Soil Program 'MSP' on the microbial population density in the growing media of Strawberry (Fragaria x ananassa cv. 'Toscana F1 Rose'). Bars marked with the same letter do not differ significantly according to Fishers LSD test (p = 0.05).

Seaweed improves plant performance

Despite the large amount of data collected, only a few treatments delivered significant improvements to plant performance. Foliar treatment with Natrakelp® and Natrakelp® plus Integrate® FA produced standout results whilst the Multikraft Soil Program® had no effect.

Strawberry plants treated with Natrakelp® applied alone or in combination with Integrate® FA produced up to double the yield of fruit for both total fruit weight (g/plant) (Figures 3 & 4) and total fruit number per plant. Fruit number was the main driver of the yield increase.

The effectiveness of Natrakelp® might be explained by seaweeds multiple mechanisms. Seaweeds contain phytohormones that stimulate processes such as cell division, root and shoot growth (Kurepin et al., 2014).

The seaweed product used in this trial was derived from A. *nodosum* which not only contains the plant hormone cytokinin, but also has the capacity to turn on genes that drive its synthesis within the plant – heightening phytostimulatory action. Seaweed extracts also contain minerals and trace elements that enable them to act as a biofertilizer, boosting the nutritional status of a target crop (Battacharyya et al., 2015).

Biostimulants in combination

It is often assumed that applying biostimulants in combination will enhance the benefit. However, this study found no significant improvements in plant productivity. In fact, a potential antagonistic effect was detected in the strawberry trial, with significantly fewer berries harvested from the combination biostimulant treatment (M + SE +FA) than for seaweed extract alone. This highlights that a cautious or well researched approach is needed when combining plant biostimulants, resisting the temptation of 'the more the better'.

Mixed microbial inoculants

The underwhelming plant response to the microbial inoculants applied in this trial, Microlife® and the Multikraft Soil Program®, highlight some of the persistent challenges with mixed microbial products. While there is the potential for microbes to enhance production systems, further research and product refinement is needed to ensure that growers get a good return on their investment in biostimulants. This study took place over a relatively short time frame of 120 days in a controlled environment greenhouse. In a commercial situation, strawberries can be grown over an extended season of up to 200 days and under higher stress environments of temperature, humidity and pest and disease pressure. In these situations, the beneficial effects of microbial inoculants may become more apparent.

You can view Ms Bells presentation at: youtu.be/0DqSULvIZ_Y

Ms Bell supervisors at TIA were Dr Sally Bound and Michele Buntain.

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Figure 3. Effect of foliar treatment with biostimulants on the total fruit yield/plant (g) harvested from strawberry (Fragaria x ananassa cv. 'Toscana F1 Rose'). Bars marked with the same letter do not differ significantly according to Fishers LSD test (p = 0.05).

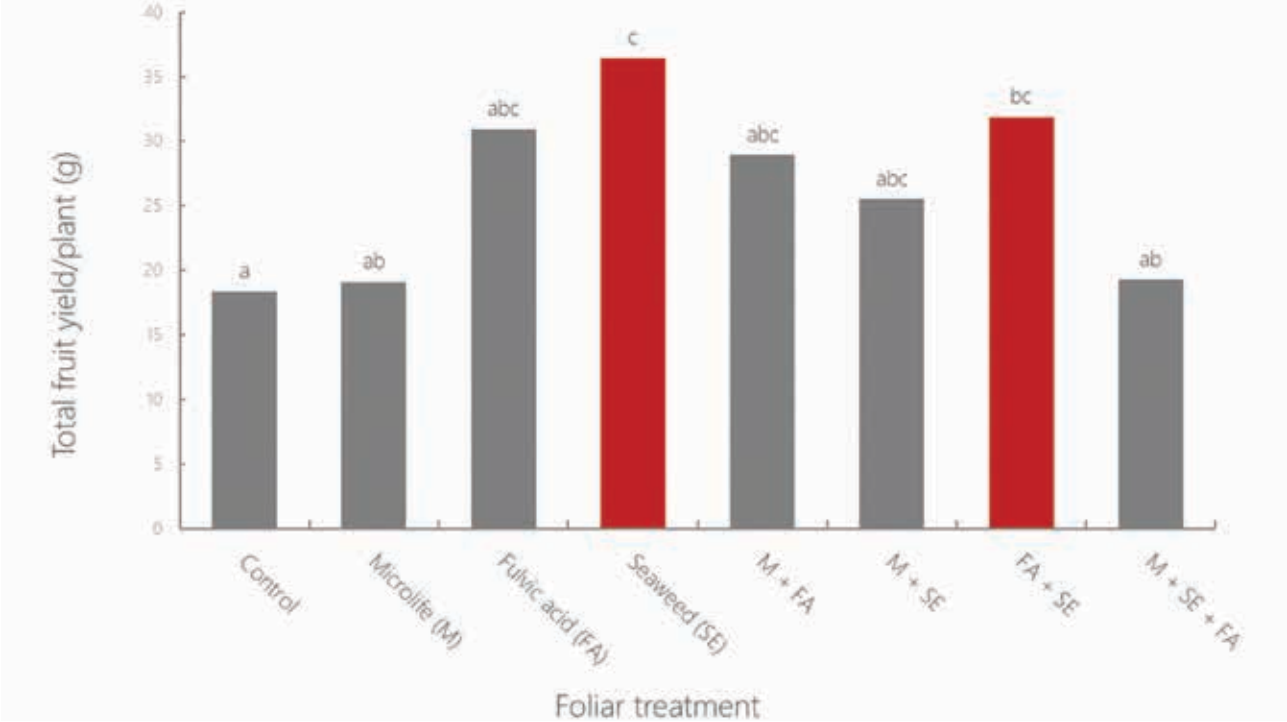

Figure 4. Effect of foliar treatment with biostimulants on the number of fruit/plant harvested from strawberry (Fragaria x ananassa cv. 'Toscana F1 Rose'). Bars marked with the same letter do not differ significantly according to Fishers LSD test (p = 0.05).