Giving strawberries real fight: Seaweed extracts prime plants for optimal yields and profits

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- Plants constantly need to defend themselves against stresses from the environment and pest and disease
- 'Plant priming' is a strategy that increases a plants defence capability
- Seaweed extracts can 'prime' strawberry plants to increase protection against stress
- Seaweed extract was shown to increase yield and profits in strawberry

Summary

We conducted a series of laboratory and field experiments to evaluate the effect of a combined drench (10 L/ha) and foliar spray (1:400 to the point of run-off) of a seaweed biostimulant (Seasol®) on strawberry production.

Application of the seaweed extract significantly increased strawberry fruit yields by 8-10% and revenue by AU$0.37-0.59 per plant.

Furthermore, the extract significantly reduced the incidence and severity of post-harvest rots in strawberry fruit by 52-87%, respectively.

A key to achieving these responses was the regular monthly application of the product. Evidence showed the extract worked by 'priming' strawberry plants for better stress tolerance and increased root growth.

Have you ever had to 'put up your dukes' and defend yourself?

We hope not! But strawberry plants must regularly defend themselves against a range of different stresses. Plant stress can come from the environment (called abiotic stress), like extreme temperatures over summer that cause strawberry plants to stop fruiting, poor water or nutrient availability, and saturated soils at the start and end of the season.

Plant stress can also come from other living things (called biotic stress), like *Botrytis* that causes strawberry rots (Figure 1), other diseases, and a range of insect and mite pests.

Figure 1. Strawberry badly affected by grey mould rot caused by the fungus *Botrytis*
Photo credit: VSICA Research

A recent paper published in the scientific journal Plants has explained one way that strawberries defend themselves against such a variety of different stresses (Garza-Alonso et al. 2022). The process is called 'plant priming' and is a bit like telling a strawberry plant to 'put up your dukes' and get ready to fight!

Scientifically, plant priming is an adaptive strategy that improves the defensive capacity of plants (Mauch-Mani et al. 2017). One of the important biochemical groups involved in telling (signalling) cells in strawberry plants to prime themselves for defence are reactive oxygen species. And one of the key reactive oxygen species is a familiar chemical – hydrogen peroxide (H_2O_2).

There are several ways that you can prime a strawberry plant to 'put up its dukes' and defend itself. One of them is by applying biostimulants, which are *'any substance or microorganism applied to plants with the aim of enhancing nutrition efficiency, abiotic stress tolerance and/or crop quality traits'* (du Jardin, 2015).

Plant stimulants differ from fertilisers because they typically have a very low nutrient content. Some of the common biostimulants include humic and fulvic substances, fish by-products and blood meals (called protein hydrolysates), and extracts from seaweeds.

If you want to read more about the scientific basis for plant priming and defence in strawberry, go to https://doi.org/10.3390/plants11243463.

Can we prime strawberry plants to 'put up their dukes' and defend themselves?

We conducted an experiment in the laboratory with our colleagues from Deakin University to see if a biostimulant could initiate plant priming in young strawberry plants.

The biostimulant product we used was an alkaline extract from the seaweeds bull kelp (*Durvillaea potatorum*) and knotted kelp (*Ascophyllum nodosum*), sold commercially as Seasol®.

We used strawberry plug plants of the variety *Albion* in the experiment, sourced from the Foundation stock (2nd generation of runners) in a screenhouse at Toolangi, Victoria. This meant that the strawberry plants were like babies and had not yet been exposed to much biotic or abiotic stress.

We grew the plug plants in solutions containing the seaweed extract (1:400) and a water control for four days. Following this, we sampled roots from the plants and stained them with a chemical called **3,3′-diaminobenzidine (DAB)**.

This chemical reacts with hydrogen peroxide to form a brown precipitate or stain. Results showed that root cells from strawberry plants in the seaweed extract stained brown with DAB indicating the presence of hydrogen peroxide, but not roots from plants in the control (Figure 2).

Separate analysis showed that, the seaweed extract doubled the concentration of hydrogen peroxide in the roots of strawberry as soon as 1-day after treatment.

These results showed that biostimulants like seaweed extracts can initiate the production of reactive oxygen species like hydrogen peroxide in strawberry, which is a strong indicator of plant priming. It suggests the strawberry transplants were 'putting up their dukes' and getting ready for a fight! If you want to read more about the science in this experiment, go to https://doi.org/10.1007/s10811-023-02979-0.

In other studies, our colleagues from Deakin University applied the seaweed extract to a plant called *Arabidopsis* in the laboratory. Scientists like to use this plant in experiments because it has a short lifecycle, and its genetics are well known. Results showed that treatment with the seaweed extract 'switched-on' (upregulated) genes in *Arabidopsis* involved in plant defence against stress, production of plant hormones that promote growth, uptake and transport of nutrients, and cell wall formation.

Separate experiments showed that treatment with the extract increased *Arabidopsis*' production of metabolites involved in plant defence against stress (e.g., glucosinolates) and energy generation (tricarboxylic acid cycle derivatives). These experiments demonstrated that the seaweed extract works by priming plants for defence against stress and improved growth to get them ready to fight!

If you would like to read the scientific details of the experiments, go to https://doi.org/10.3389/fpls.2020.00852, https://doi.org/10.3390/plants10112476, and https://doi.org/10.3389/fpls.2023.1114172.

Figure 2. Root tips of strawberry (*Albion*) stained with the chemical DAB. A red/brown precipitate (see white arrows) formed in root cells of plants treated with a seaweed extract (Seasol®). This indicates they accumulated hydrogen peroxide, and were primed for defence against stress. Photo credit: VSICA Research

Can 'primed' strawberries really defend themselves in the field?

It is one thing to initiate plant priming in the laboratory and another thing to get plants to increase their defence against stress in the field.

So, we conducted a series of strawberry experiments on commercial fruit farms in the Yarra and Don Valleys in Victoria. We applied the seaweed extract to strawberry plants (*Albion*) as a drench (10 L/ha) and foliar spray (1:400) every month through the season.

We planted the experiment at the Don Valley in winter with bare-rooted runners (full season crop), and the trial at the Yarra Valley in summer with cold-stored runners (short season crop). We picked and measured fruit yields 2-3 times per week through the season.

In both experiments, strawberry plants treated with the seaweed extract produced significantly more fruit (8-10%) than plants in the untreated control (Figure 3).

A key to the yield increase was the regular application of the seaweed extract to plants throughout the season. It is understandable that growers sometimes cease treatments with biostimulants because they cannot see a visual growth difference in their crops.

It is important to note, however, that differences in fruit yield of 10% are impossible for growers to see at any individual pick. Growers can only see these differences if they record the yields through the season, like we did in our field trials.

The results from the experiments also showed that strawberry fruit treated with the seaweed extract developed 52-87% less rot from *Botrytis* (Figure 1) following harvest and commercial storage than the untreated control.

In our experiments, we applied the seaweed extract as a supplement and not a replacement to the standard fungicide program.

Therefore, these results indicate that the use of seaweed extract can help strawberry plants defend against *Botrytis* (a biotic stress) when applied with fungicides.

If you want to read more on the science from these experiments, the results are published in two articles in the Journal of Applied Phycology at https://doi.org/10.1007/s10811-017-1387-9 and https://doi.org/10.1007/s10811-023-02979-0.

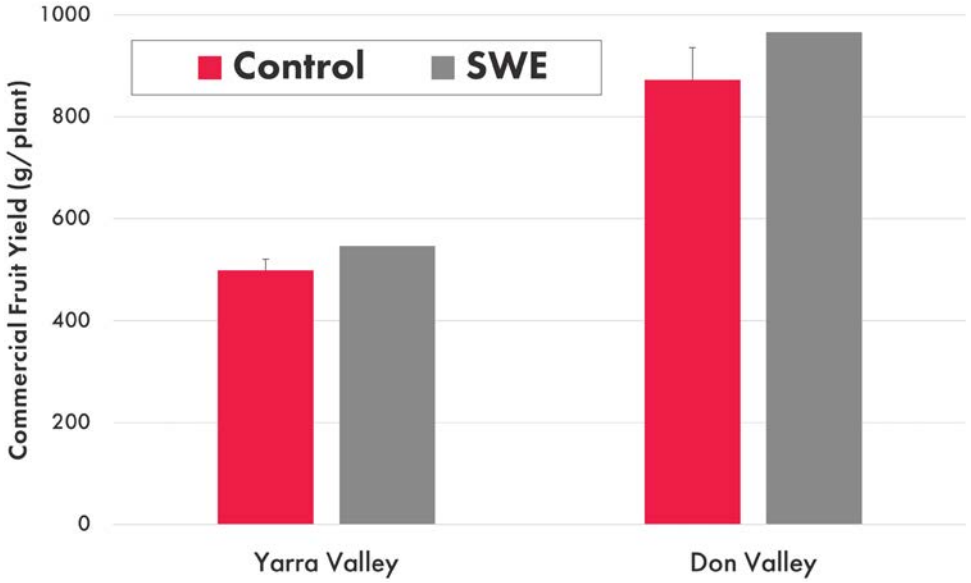

Figure 3. Commercial fruit yields from strawberry plants (*Albion*) treated with a seaweed extract (SWE, Seasol®) or a control treatment in field experiments at Yarra and Don Valleys, Victoria.

What are the characteristics of a 'primed' strawberry?

One of the major differences we saw in strawberry plants treated with the seaweed extract was their improved root growth.

We measured root growth (root length density) by taking soil cores around the plant, washing the roots from the soil, imaging the roots, and then analysing their length. Plants treated with the extract had up to 38% more functional roots than the control.

There was a strong scientific relationship (correlation of 94%) between improved root growth of strawberries treated with the seaweed extract and increased commercial fruit yields.

You can read the details of this field experiment at https://doi.org/10.1007/s10811-017-1387-9

In the laboratory we conducted separate experiments where we took the tips of strawberry plants (*Albion*) from the Foundation screenhouse at Toolangi and grew them in solutions containing the seaweed extract and a control.

We used timelapse photography to visualise root growth of the strawberry plants. The effect of the seaweed extract in stimulating root growth was dramatic (Figure 4), and you can see it for yourself on YouTube at https://www.youtube.com/watch?v=zvw5l28FJ8g, or in the scientific literature at https://doi.org/10.1007/s10811-015-0574-9

Can 'primed' strawberries increase my profits from strawberry?

It's good to have a strawberry plant that is primed and ready to fight against plant stress, but we wanted to know if this meant they also produced more profits for growers.

So, in addition to measuring commercial fruit yield in our field experiments, we calculated the revenue at each pick based on wholesale prices for strawberry fruit at the Melbourne, Victoria market (FreshLogic, Hawthorn, Victoria).

Results showed that the economics of using the seaweed extract to prime strawberry plants can be very favourable for growers. We showed the use of the seaweed extract increased revenue from fruit by AU$ 0.37 and AU$ 0.59 per plant while the cost of the treatment was AU$ 0.01 and AU$ 0.03 per plant in the Yarra and Don Valley experiments, respectively (Figure 5).

Most strawberry growers in Victoria have the equipment to apply the seaweed extract through their fertigation system and as additives to their spray programs, and therefore there would be negligible additional infrastructure and labour costs from the treatment.

The intangible benefits of using extract for strawberry growers are reduced post-harvest fungal decay, increased shelf-life of fruit, and associated retailer and consumer confidence in the quality of the product.

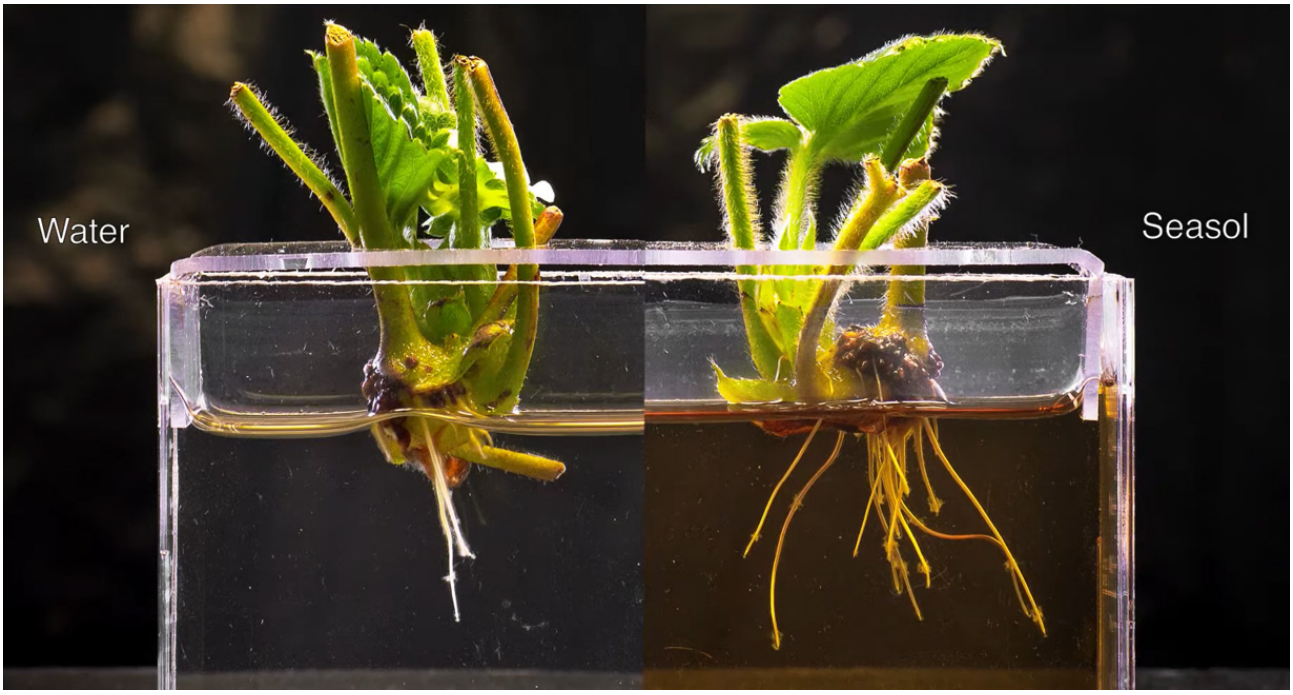

Figure 4. Image from a timelapse video showing the ability of a seaweed extract (Seasol®) to stimulate root growth of strawberry tips (*Albion*). Photo credit: VSICA Research

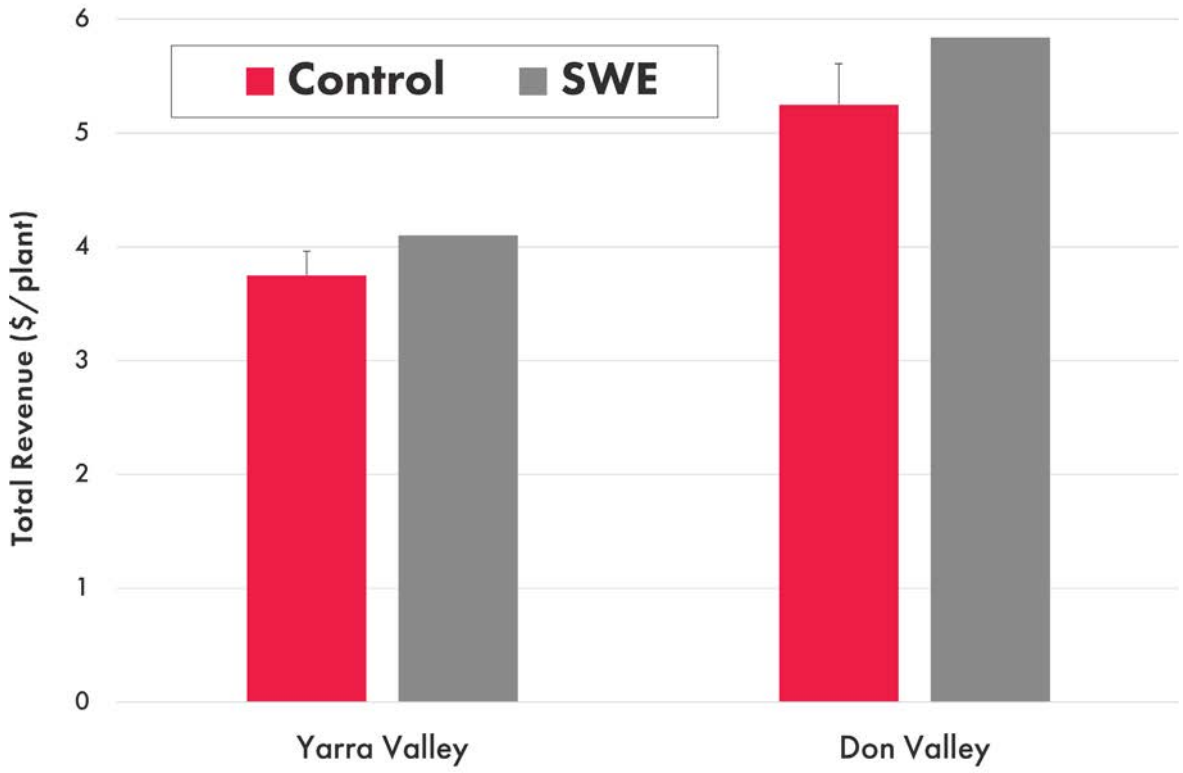

Figure 5. Revenue from fruit of strawberry plants (Albion) treated with a seaweed extract (SWE, Seasol®) or a control treatment in field experiments at Yarra and Don Valleys, Victoria.

Future research and conclusion

We would like to continue our research to see if the use of the seaweed biostimulant can increase a strawberry plant's tolerance of charcoal rot (caused by the soil-borne fungus, *Macrophomina phaseolina*) or reduce its fertiliser and/or irrigation requirements.

But for now, our evidence indicates that the use of a seaweed biostimulant (Seasol®) has the capacity to prime plants and put the fight in strawberries against stress.

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