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CASE STUDY | JULY 2026

Know to grow – Optimising inputs in hyrdroponic cucumbers

Carabooda, WA demonstration site

Background

Grown Smart Produce is a family-owned hydroponic protected cropping business, managed by Doug Chamberlain and Peter Ruddle, in the outer northern Perth region of Carabooda, Western Australia. Doug and Peter have trialled a range of crops, including eggplant, gourds, beans, capsicums, and heirloom tomatoes, and decided to focus primarily on cucumbers. Tomatoes have had the best financial return of the other crops, and they will continue to pursue this crop to diversify the business.

Late in 2023, the Soil Wealth and Integrated Crop Protection (Soil Wealth ICP) program, in conjunction with VegNET WA (vegetablesWA), commenced working with Doug and Peter on a hydroponic production demonstration site.

Purpose

The focus for the demonstration site was on **improving crop health, fine-tuning nutrition, and improving nutrient use efficiency** by monitoring plant nutrition levels and managing fertigation inputs accordingly. It also looked at temperature and relative humidity in the greenhouse production system.

Doug and Peter identified several opportunities to fine-tune their production system.

KEY MESSAGES

- A trial was undertaken in a hydroponic cucumber system to improve crop production through better nutrition management.
- The trial found hydroponic cucumbers may require greater nutrients during active growth to achieve maximum production than the lab ‘acceptable’ levels.
- Use multiple crop response observations, including strategic sap testing and observations, to inform nutrient inputs.
- Lab nutrient analysis in hydroponic systems tells if nutrition is sufficient, but not whether it is maximised for growth and yield under a specific system.
- Creating farm-specific nutrient targets is required, based on nutrient results and crop performance metrics.
- Adding hydrogen peroxide to the source water for the fertigation mix appeared to control low levels of Pythium spores, reducing infection.

Hort Innovation

This project has been funded by Hort Innovation using the vegetable and melon research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

RMCG

ahr applied horticultural research

Soil Wealth ICP role

The Soil Wealth ICP team worked with Doug and Peter to optimise plant health and crop quality, developed trial protocols and agreed on the basis to adjust the production system.

For Grown Smart Produce, these included sap, plant dry tissue and water testing (bore water and hydroponic tanks, as well as drainage from the substrate). The team assisted with test interpretation and possible adjustments based on the data.

The team supported building on Doug and Peter's existing relationships, for example, with WASP Agri Technical, who assisted with remote climate and substrate sensing in the greenhouses. The team worked with the WA VegNET Regional Development Officer (RDO) to conduct on-the-ground training on the best ways to collect and handle samples for sap and dry tissue testing (read more on sap and dry tissue testing: soilwealth.com.au/2020/02/plant-analysis-for-vegetable-crops-a-practical-guide-to-sampling-analysis-and-interpretation/).

Opportunities for fine-tuning identified by Grown Smart Produce

Electrical conductivity (EC)

- Explore monitoring and nutrient input options to address issues

Irrigation scheduling

- Ensure plants receive sufficient water
  - in greenhouses with varying temperatures while limiting runoff

Water recycling

- Consider ultraviolet (UV) options
  - to allow re-use/re-application to crop
  - reduce potential loss of nutrients

Nutrition management

- Monitor nutrient levels and balances, and input options to address shortfalls or oversupply

Coir substrate

- Consider alternative coir quality/grow bags
  - to decrease the likelihood of pythium root disease, and
  - to improve drainage but reduce potential loss of nutrients
- Explore quick and accurate testing of plant and coir samples

Air flow

- Improve to limit foliar disease pressure such as powdery mildew
- Improve calcium and boron uptake

Data monitoring equipment

- Explore options to get better, timely data from moisture probes used for hydroponics

What was investigated, and what insights were gained?

Not all of the opportunities for fine-tuning have been fully explored yet. The areas examined to optimise plant health and crop quality, and what was learned, are detailed below.

Table 1: Areas for fine tuning at Grown Smart Produce

Change	Why do it?	Desired outcome	Insights
Hydroponic water probes – nutrients (nitrogen, phosphorus, potassium), pH, EC	Rapid feedback on plant nutrient availability/ requirement/status	Optimised nutrient availability for uptake	Nutrient inputs may be adjusted as required to match crop stage requirements
Hydroponic water tests	Feedback on water quality status and plant nutrient availability	Optimised growing conditions	pH and EC stabilised during the growth cycle with changes made to nutrient inputs
Weekly plant sap/dry tissue tests	Allow adjustment of nutrients (via fertigation) to meet plant needs at different growth stages	Optimised nutrient uptake, reduced nutrient inputs, cleaner tanks, reduced nutrient losses	Ammonia was initially high and calcium low in plants – potassium nitrate and calcium nitrate application boosted nitrate and calcium uptake
Remote sensing – humidity and temperature	Provides indication of plant nutrient uptake efficiency and plant stress/disease risk	Reduced plant stress, optimised nutrient uptake, reduced water usage, reduced disease pressure	Real time understanding of transpiration rate allowed changes to be made to ventilation to reduce plant stress

Why test for nutrients in hydroponic systems?

Once a crop shows nutrient deficiency symptoms, it has already been negatively impacted. Further, potassium, iron and manganese deficiencies, and salinity stress, all produce very similar symptoms in the plant, and a lack of nitrogen or sulphur can be confused based on symptoms alone. So, to prevent yield losses from nutrient deficiencies or accurately determine the cause of visual symptoms, regular plant testing (2-4 weeks) is required.

Findings

By measuring both the nutrients in the fertigation solution and the plants (sap and tissue testing), it was possible to see how efficiently plants were converting nutrients to growth. Sap testing showed how efficiently plants were taking up nutrients, while tissue testing showed how those nutrients were being converted to biomass. Regular testing was used to develop a fertigation plan that matched nutrient inputs to crop growth and development needs, and to allow rapid adjustments if needed, to maximise nutrient use efficiency.

Testing regime and results

Sap, plant dry tissue and hydroponic water tests were conducted at various stages during the demonstration site's season, including at planting, harvest and post-harvest. Below are some of the results.

The desirable pH range for the fertigation emitters is 5 to 6.2[1]. Over the plant growth cycle, pH fluctuated and plateaued at an average pH of 6.5 in the weeks leading up to harvest in November 2024.

The desirable EC range is 1.5-2.5 dS/m for the emitter nutrient solution. The first hydroponic solution water test showed a slightly higher than optimal EC of 2.92 dS/m. This is likely due to the salt concentration of the bore water used. For the Gnangara Mound, the aquifer system underlying Carabooda, the EC level in bore water typically fluctuates between 0.5 and 1.5 dS/m (often reported as 500 to 1500 µS/cm) and may be higher at times of high usage.

Over the plant growth cycle, EC fluctuated from planting in September 2024 until mid-October 2024 when it started to stabilise at the desirable range for the remainder of the growth cycle.

REASONS FOR INITIAL EC FLUCTUATIONS (ABOUT WEEKS 1–3):

- **Immature root systems:** Young plants are developing roots, so their ability to absorb nutrients is inconsistent. This often leads to either under-absorption (EC rises) or uneven uptake (EC drops again).
- **Low water demand vs. nutrient demand:** Early on, plants drink less water but still require a baseline concentration of nutrients. If they drink water faster than they consume nutrients, the remaining water becomes concentrated, driving up the EC. If the plant demands more nutrients, the EC will drop.
- **Media interaction:** New growing media can hold onto or release salts initially, causing unpredictable shifts in the nutrient solution EC.
- **Environmental sensitivity:** Small plants are highly sensitive to temperature changes. High temperatures can cause rapid water consumption, increasing the EC, while cooler, humid conditions can inhibit water uptake, causing EC to fall.

STABILISATION OF EC IS DUE TO:

- **Established root zone:** By week 3 or 4, plants have a more robust, active root system that consumes nutrients and water in a predictable, balanced manner.
- **Consistent growth rate:** The plant enters a stable vegetative stage, where its metabolism and 'thirst' are consistent day-to-day, leading to a steady, predictable decrease in reservoir volume rather than a chaotic one.
- **System equilibrium:** The nutrient solution concentration (feed) and the residual salts in the growing medium (media EC) reach a balanced, stable state.

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1 NSW DPIRD (2019). Greenhouse cucumber production guide. Hort Innovation. nsw.gov.au/sites/default/files/noindex/2025-09/cucumber-book-2019_low_res.pdf

Sap NU-tests® petiole tests taken in September 2024 (during fruit set) showed that ammonium levels were too high at 660 ppm, indicating that the ammonium concentration in the nutrient solution was too high. Cucumber plants are sensitive to high ammonium concentrations. It was suggested to use different forms of nitrogen-based fertilisers, such as potassium nitrate and calcium nitrate, to reduce ammonium and boost nitrate, potassium and calcium levels.

Additional potassium and calcium were required to support fruit set, and fruit quality and shelf life, respectively. At the time of the second sap test in November 2024, ammonium levels had dropped to 6.6 ppm, and nitrate levels had increased from 2080 ppm to 4374 ppm, which was around the desirable level for fruit set (4300 ppm). Table 2 provides an overview of sap nitrogen data for the first two measurements.

Table 2: Test results for ammonium and nitrate levels

Nitrogen type	First test	Second test	Desired range
Ammonium (NH4+) levels	660 ppm	6.6 ppm	Keep low, never higher than 1:5 ammonium/nitrate
Nitrate (NO3-) levels	2080 ppm	4374 ppm	1700 ppm to 4300 ppm depending on the crop growth stage

A dry tissue test was conducted at the start of harvest to assess nutrient accumulation in leaves. This tissue test indicated that calcium, boron and magnesium levels were in the desirable range. Brix levels were good, but potassium levels were low despite increasing potassium in the nutrient solution after the first sap testing date in September 2024.

Potassium, which supports fruit growth and the regulation of transpiration, is required by most plants in similar volume to nitrogen. Potassium levels will be monitored more closely in the subsequent crops.

Doug and Peter were able to significantly reduce nutrient inputs by testing and adjusting them accordingly. Within three days of making a change in the fertigation tanks, the response was noticeable in plant sap tests.

Observations and conclusions from Doug and Peter

Substrate quality

> “Substrate quality is very important; not all coir (coco peat) is the same!”

Poor quality or old, dehydrated cocopeat will affect crop production. The coir has to have a grade/ structure that suits the crop (i.e. neither be too fine or too coarse).

Doug commented: “If the right quality, well-washed (to lower EC) coir is used, the fertigation solution gives better results.”

Usually, it is recommended to use 'buffered' and washed coir for hydroponics.

Buffered coir has been pre-soaked in a calcium-magnesium solution. This process removes excess sodium, stabilises the pH, and prevents the substrate from 'locking up' vital nutrients.

WHY 'BUFFERING' IS RECOMMENDED

Fresh coconut husks are soaked in saltwater during processing, which causes sodium and potassium to 'bind' to the coir. Like soil, coconut fibres have negative charges that tightly bind to sodium and potassium. Calcium and magnesium can break those bonds, force the sodium out, and take its place. When unbuffered coir is used, magnesium and calcium from the fertigation solution displace the bound sodium and potassium, causing magnesium and calcium deficiencies and potential toxicity issues with sodium and potassium.

WHY WASHING IS RECOMMENDED

Washing (rinsing) coir removes soluble salts (free sodium and potassium) not adsorbed to the coir fibres. It lowers the EC of the medium, but still leaves sodium attached to the fibres. It should be done after buffering for the best effect. Removing sodium is recommended because it is not a plant nutrient and reduces potassium uptake.

Nutrient testing

> "The continuous testing program used has shown us that the plants will only take up what is required (to sustain balance) from the hydroponic fertigation solution."

Adjustments to the fertigation solution during the demonstration trial were based on the testing regime, particularly sap and solution EC levels. However, Doug and Peter found that their standard mixture, not matched to crop growth stage, used in another greenhouse at the same time produced more vigorous, stronger plants with larger leaf area and darker leaf colour, despite the trial cucumbers returning nutrients within the ideal range.

Peter and Doug said that the testing did not provide them with the information they needed to optimise the crop in the demonstartion site house. The challenges included a lab turnaround for results of four days. In their experience, changes made to the hydroponic solution would show changes in the crop within three days. They also commented that different labs provide different desirable ranges, which is confusing.

> "It is still to be determined if an alteration of fertigation solution at the seedling stage and prior to flowering or fruit development will be beneficial to push the plant [into higher productivity]; any stress during early plant development (2 leaf to 6 leaf) will affect the plants' ability to significantly provide optimum production later in growth."

Based on the findings, Grown Smart Produce have now decided not to proceed with the construction of individual fertigation systems for each greenhouse and will maintain the current process of an average fertigation program across all greenhouses' stages of crop growth. This is $500,000 investment saved, based on trial results.

Disease management

Doug mentioned that, on a positive note, the identification of a low-level Pythium infection in the crop and the subsequent introduction of hydrogen peroxide to sterilise the water used on the crop has assisted with the reduction of disease. A hydrogen peroxide concentration of 30 ppm at the dripper output seems to be the target, as a higher concentration would especially stress young plants. Doug found the drainage output from coir bags always showed a zero hydrogen peroxide concentration.

What the project team learned from trial data and working with Grown Smart Produce

The testing showed that plants were not deficient, but the original standard fertiliser program was likely pushing the crop somewhat above adequate requirements to drive stronger growth. When the nutrient levels were reduced, it lowered the total supply the plants received each day because the water input stayed the same. Even though the sap levels remained within the 'desirable' range, the plants didn't have sufficient nutrient availability to support rapid leaf expansion and canopy development, which is why Doug and Peter observed less vigour and lighter leaf colour.

While sap testing showed the plants had sufficient nutrients, that did not mean they were being fed at a level to drive peak growth or yield. Testing in hydroponic systems is a good tool for avoiding deficiency and waste, but we learned that it does not automatically define the nutrient levels needed for maximum productivity in a high-performing hydroponic system.

In high-performance hydroponics, maximum growth appears to occur at the upper end or even above 'desirable' ranges. This may be especially true for cucumbers, which are very responsive to nutrient supply. Therefore, what looks like 'excess' in a lab results can actually be 'ideal' in a production sense.

When the EC of the fertigation solution was reduced, each irrigation event delivered less nitrogen, potassium, calcium and trace elements. As irrigation volume was not increased proportionally, the plant received less total nitrogen for leaf expansion, less potassium for stomatal function and growth, and less calcium for developing tissues. So, sap tests stayed in range, but growth drivers were actually reduced.

Even if all individual nutrients sit in ideal ranges, the ratios between key nutrients (N:K:Ca:Mg, etc.) can shift subtly. Some elements drive vigour particularly strongly, and there may be benefits to adjusting them for key growth stages:

- Nitrogen (N) drives canopy expansion and leaf size
- Potassium (K) drives osmotic regulation, stomata function and fruit expansion
- Calcium (Ca) drives cell expansion and growing point strength of shoots and roots.

We learnt that small reductions across all nutrients may disproportionately limit growth without triggering deficiency flags.

We cannot say whether the low-level Pythium infections in the trial area influenced plant vigour.

KEY LESSON

Plant analysis in hydroponic systems tells if nutrition is sufficient, but not whether it is maximised for growth and yield under a specific system. Growers should develop their own baseline for ideal nutrient levels based on crop performance and nutrient test results.

Sharing findings

Doug hosted two field days. The first was in December 2023, organised by VegNET WA, to talk about challenges and opportunities for Grown Smart Produce and other hydroponic producers. A second field day focused on a demonstration site update in October 2025.

Both Doug and Peter are very happy to share their knowledge with others in the industry, and the Soil Wealth ICP team is grateful for the opportunity to work with them.

Images: Doug with cucumber crop and harvest

Next steps

Soil Wealth ICP will continue to discuss with Doug and Peter how to work towards achieving optimum production outcomes. The team is committed to putting what we learnt into practice. This is what we can do:

- Re-establish the current performance baseline (standard solution) as suggested by Doug.
- Use sap testing differently and strategically at key growth stages but instead of targeting mid-range levels, allow nutrients to sit at or above the upper acceptable range during active growth.
- Track crop response by focusing on:
  - leaf size and colour
  - crop growth rate
  - marketable yield.

The aim is to find a 'productive optimum' – the maximum crop performance per unit of input, not the lowest nutrient input and 'perfect' sap numbers.

Further information

- Soil Wealth ICP resource for information on plant sampling and analysis: soilwealth.com.au/2020/02/plant-analysis-for-vegetable-crops-a-practical-guide-to-sampling-analysis-and-interpretation/
- A brief update on the Carabooda demonstration site: soilwealth.com.au/2025/06/reaching-new-heights-in-a-hydro-system-wa-demo-site-update/
- A video of Doug talking about the trial at one of the farm walks: soilwealth.com.au/2025/11/wa-demo-site-farm-walk-showcases-nutrition-in-a-cucumber-hydro-system/
- A guide to hydroponic cucumber production: nsw.gov.au/sites/default/files/noindex/2025-09/cucumber-book-2019_low_res.pdf