Grow Book

The User Guide

Better plants in the palm of your hand


Grow your success

From New Zealand to the world. The products and the support needed for truly successful growing.

At Bluelab®, we're wholly dedicated to your growing success. Our tools, our technology, our innovation, our services and our support are right by your side.

With 30 years of experience behind us, our aim is straightforward: more efficient growth of stronger, healthier plants and more reliable, nutritious crops. We're worldwide leaders in easy-to-use tools and equipment for measuring and controlling key success factors such as pH, conductivity and temperature in controlled growing environments of water-based solutions, soil and other soil-less growing media.

Welcome to the 2nd edition of our Grow Book.

A new standard of growing success right here in your hands.

Let's get growing!

When you grow your understanding...

You can grow better plants

Whether you're growing plants for food, for business or as a hobby, you need to understand their growing environment. When you understand that environment, you can manage and control it.

It's about knowledge

You need to know the strength of your nutrient solution, as well as when and which nutritional elements are actually available to your plants. These are areas where accuracy and simplicity matter.

That's where Bluelab® comes in

We'll help you measure the things you absolutely need to know in order to grow strong, healthy and reliable plants.

Moreover, we'll make these essentials easy to understand so that you can have greater growing success.

Contents:

Let's get started

Maybe you're a seasoned grower. Or perhaps you're just starting your own business or an at-home system. At Bluelab®, we're totally committed to helping you grow reliable, healthy and nutrient-rich plants.

Every grower recognizes the need to achieve optimal productivity, whether in a greenhouse, field, garden or hydroponics system.

So how can we do better? How can we improve tried-and-tested growing practices?

We're in the business of answering these questions. Moreover, the answers concern understanding, working with, improving and managing the growing conditions of plants.

This is where the Grow Book comes in. It's a place to explain some of the crucial and practical concepts that support healthy plant growth. And it's a place that'll help you put these concepts to work.

First up, we'll focus on plant nutrition. This means ensuring your plants are getting all the nutrients they need, exactly when they need them. Much of this depends on a plant's environment, on what you feed them and how you feed them. It's the basis of an efficiently managed growing system.

It doesn't matter whether you're growing hydroponically with a soil-less substrate or traditionally. The principles are the same.

Let's start with the basics. Through its leaves, a plant takes in light and carbon dioxide (CO_2) from the atmosphere. Primarily through its roots, it takes in water and nutrients as ions from the soil or growing environment. It converts light and CO_2 into chemical energy (as sugars) and releases oxygen (O_2). The plant uses the sugars, water and nutrients for its growth.

Just like our own biological system, the growth and development system of a plant is complex. However, it's well understood. It's also highly efficient, having been refined by nature over countless growing generations.

We bring our own minds and our technologies to work with this marvelous natural system. We know the key factors to measure in our growing environment and we know how best to manage these factors to help a plant's growing system run even more smoothly.

Put simply, we add our knowledge and skills to nature. It's what we at Bluelab help growers do.

Fact File

Watch and respond to these key factors. They're essential for growing successful plants and better crops.

The key factors to manage:

- **Environment:**
  Humidity range, clean air, proper CO_2/oxygen (O_2) ratio, adequate air, circulation, light (sunlight or plant lamps), support.
- **Food:**
  Sufficient nutrients in the root zone in a form that's available to the plant.
- **Temperature:**
  Of the soil, media, environment and water.
- **Water:**
  Sufficient levels, good quality and drainage.
- **pH level:**
  Allows uptake of essential ions.

Shoot system

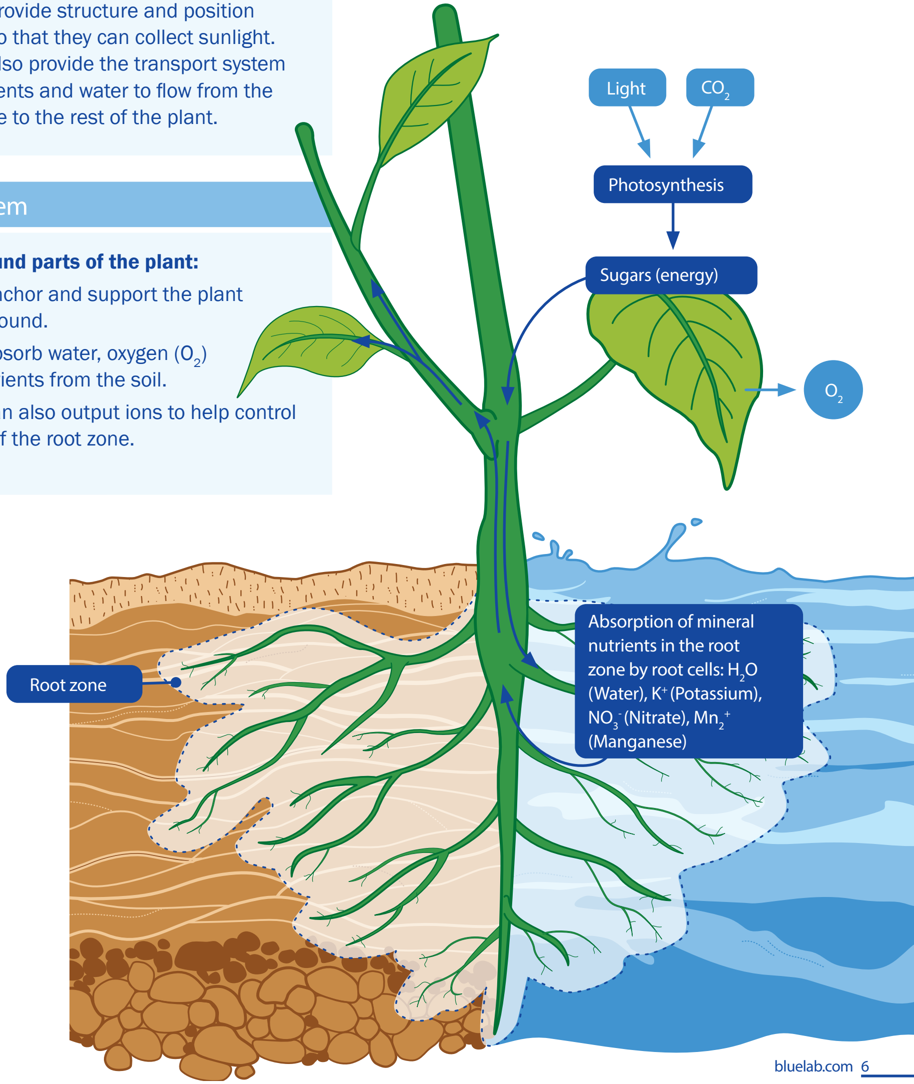
Above-ground parts of the plant:

- Leaves trap energy from light and carbon dioxide (CO_2) from the air to create sugars (chemical energy) through a process called photosynthesis.
- Leaves release oxygen (O_2) into the air (respiration).
- Stems provide structure and position leaves so that they can collect sunlight. Stems also provide the transport system for nutrients and water to flow from the root zone to the rest of the plant.

Root system

Below-ground parts of the plant:

- Roots anchor and support the plant in the ground.
- Roots absorb water, oxygen (O_2) and nutrients from the soil.
- Roots can also output ions to help control the pH of the root zone.



Plant nutrition

What foods they need and how they need them

Just like us, plants need to secure food sources. Through photosynthesis, they convert energy, but that isn't enough to adequately sustain them. They need specific nutrients.

However, it isn't as simple as feeding nutrients in any old form or amount.

Plants need appropriate, soluble nutrients in the correct quantities. This is key to everything else.

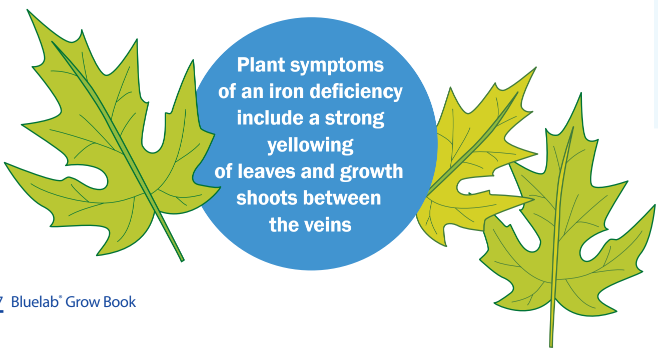
There are four main things to consider:

1. The nutrient quantities that each plant needs for each stage of its life cycle eg generative or vegetative.
2. Plant species have different nutrient requirements.
3. The ratio of nutrients, as the nutrients can interact with each-other and enhance or prevent the plant from absorbing them.
4. Whether the nutrients we add are actually available to the plant.

With complete nutrient mixes available, it's relatively easy to reach for this or that plant food product. However, just as with people, an unbalanced diet in plants leads to nutrient deficiencies and toxicities. You can see this in stunted growth and damaged or yellow leaves.

The primary means of nutrient uptake is through the roots. When dissolved, nutrients are carried up by water. In fact, plants can only absorb nutrients in their dissolved form as ions.

Managing pH is vital to ensure nutrients remain soluble and available to the plant. You need to control the pH of the root zone environment and the nutrient solution or fertilizer you're using. We'll expand on this in the following pages.



Plant symptoms of an iron deficiency include a strong yellowing of leaves and growth shoots between the veins

Fact File

Essential nutrients:

Plants need most of - if not all - 17 different elements for optimal growth and health.

- **Non-mineral nutrients:**

  Obtained from air and water.

  Carbon (C), hydrogen (H), and oxygen (O).

- **Primary macro-nutrients:**

  Required in the greatest quantities. Building blocks of critical cellular components.

  Nitrogen (N), phosphorus (P), potassium (K).

- **Secondary macro-nutrients:**

  Also required in large amounts and assist the transport and function of the primary macro-nutrients.

  Calcium (Ca), magnesium (Mg) and sulfur (S).

- **Micro-nutrients:**

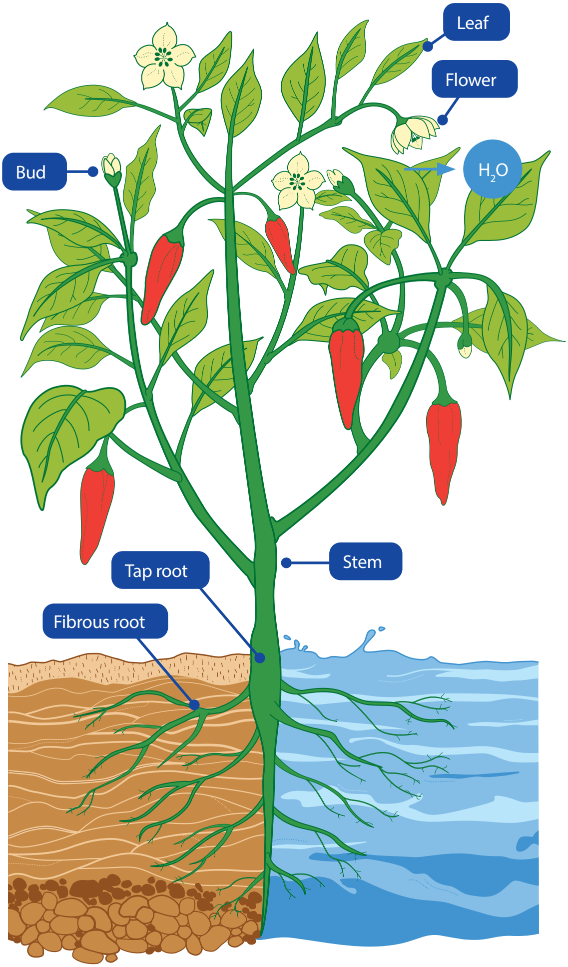
  These are only required in trace amounts but are still just as important.

  Boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn), molybdenum (Mo), nickel (Ni), silicon (Si) and cobalt (Co).

  Silicon and cobalt aren't technically essential nutrients but - when used - do improve growth and plant health.

What else do plants need?

- **Light:** Key reactant for converting energy, through photosynthesis, into a usable form.
- **Oxygen:** A by-product of photosynthesis, but also absorbed by the roots. Roots don't undergo photosynthesis but still require oxygen.
- **Water:** Carries the soluble nutrient ions from the root zone (the area close to the roots) into the root through transpiration. The plant roots need to be in a moist environment.
- **Transpiration:** The process by which the plant loses water through the leaves by evaporation, which pulls more water in through the roots.
- **Temperature:** The temperature of the environment impacts the plant's internal temperature and how much water exchange is required to cool it down. This goes hand in hand with the humidity of the environment. Temperature can also impact specific nutrient absorption.
- **Humidity:** The amount of water present in the atmosphere and how easy it is for the plant to lose water by evaporation. With high humidity, there is a lot of water in the atmosphere, so it is hard for the plant to lose water and vice versa.



Fact File

Keep nutrients soluble and available:

Nutrients are commonly separated into at least two parts, A and B, to keep specific ions, sulfates and calcium, apart. If these two ions are not kept apart, they will combine (precipitate out) into an insoluble form. If this happens, the ions are no longer available to the plants.

Some micro-nutrients also readily precipitate out. This is generally prevented by adding micro-nutrients as chelates.

Nutrient supply in soil-less growing:

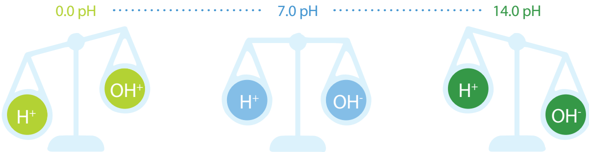
In hydroponics and soil-less growing, nutrients are primarily provided in the water supplied to the plant. That is, a nutrient-rich solution directly provides plant roots with the essential nutrients they need.

Want to know more about plant nutrition? Check out:

Mechanisms and Control of Nutrient Uptake in Plants. Robert Reid and Julie Hayes. Department of Environmental Biology, University of Adelaide. (Reid & Hayes, 2003)

Understand pH and nutrient availability

The pH determines whether the nutrients you add are actually available for the plant to absorb. Control the pH and you'll help ensure that the plant gets all the nutrients it needs.



Be aware: different plants have their own preferences for pH values.

Quick science: the nutrients that a plant takes up are present in their purest and simplest form as ions. To be available to the plant they need to be soluble (dissolved in water) and have a positive or negative electrical charge.

The pH value we measure is also based on ions, specifically hydrogen ions (H^+). The amount of H^+ present determines the acidity or alkalinity of whatever you're measuring. The pH is a ratio between H+ and hydroxyl groups (OH^-). If more hydrogen ions are present, the pH will be acidic (0-7) and if there are less H^+ relative to OH^-, the pH will be alkaline (7-14).

The hydrogen and hydroxyl ions that determine the pH play a particularly important role in nutrient availability. They can interact with and bind to nutrient ions and make them drop out of solution in an insoluble form, meaning that the plant is unable to recognize and absorb them.

If this happens, you get nutrient wastage and you may also experience equipment blockages.

Each nutrient ion has a pH range within which it will be soluble (available to the plant). Outside this range, the ions could interact or change their chemical form and become unavailable. Known as nutrient lockout, it's a leading cause of nutrient deficiency, especially with nutrients such as iron and molybdenum. Nutrient lockout isn't easy to reverse so you'll need to take care to prevent this from happening.

To summarize: having soluble nutrient ions in the root zone is essential and dependent on the pH.

Controlling the pH so that all your nutrient ions are soluble in your reservoir is vital for healthy plant growth.

Fact File

Trying to grow without managing pH can cause nutrient lockout. The nutrients become insoluble and unavailable to the plant. You may be faced with the following challenges:

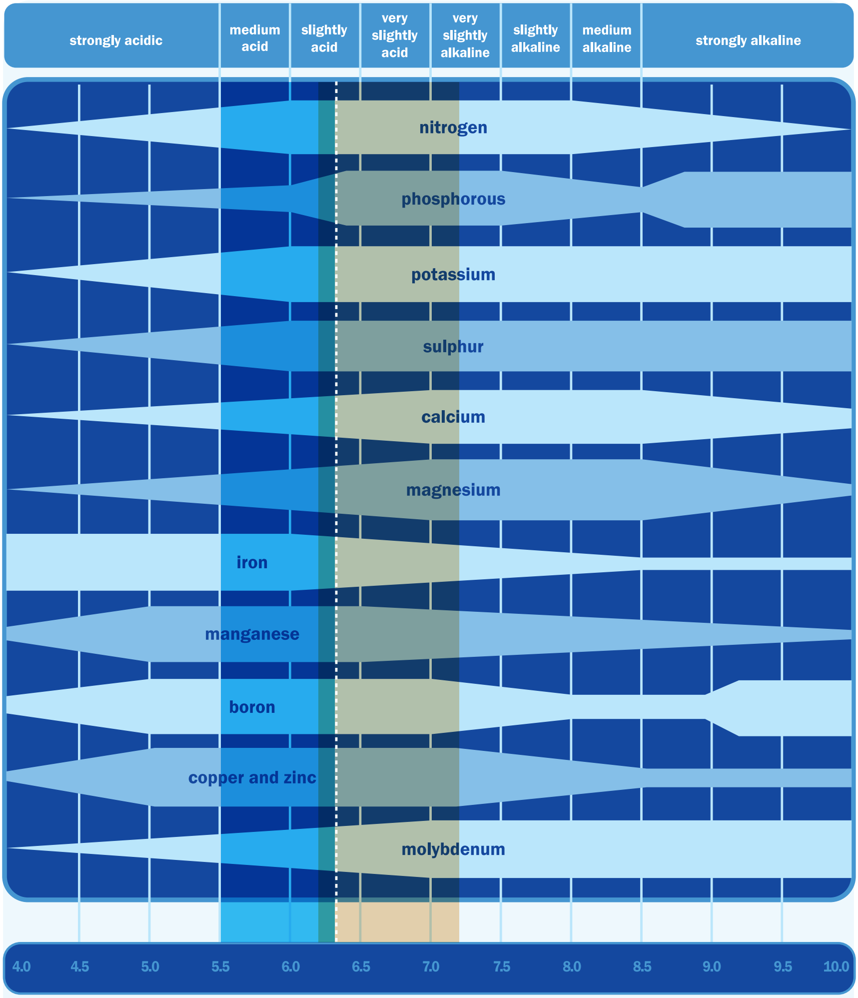
- Slow and stunted growth.
- Leaf, flower and fruit drop.
- Leaf discoloration.
- Root burn.
- Chemical imbalances/overuse of nutrient solutions.
- Pests and diseases.
- Crop failure.

What can change the pH of a solution:

- **Water:** Most water, except rainwater, tends to be slightly alkali. The carbonates in it work to neutralize the slightly acidic water in your reservoir. As the water in your tank is topped off, the pH value will rise.
- **The plants themselves:** The plant taking up nutrients or releasing ions into the root zone can affect the pH.
- **Your nutrient:** Nutrient stock solution is usually slightly acidic and may lower the pH.

How nutrient pH affects availability of plant nutrients

The width of the bands indicates the relative availability of each plant food element at various pH levels:



Recommended pH range for plants grown in:

Solution	Soil
5.5 - 6.3	6.2 - 7.2

can be plant specific

CASE STUDY

The impact of pH

In 2016, the Center for Applied Horticultural Research did a study on the impact of pH on plant growth.

They were analyzing the effect of pH on plant health and yield across three plant species grown in nutrient solution and mixed media with fertigation. They compared growing plants in conditions without any control of the pH to growing with a set pH. A wide range of set pH values was used, from 4.5 to 8.5, increasing in 1.0-value increments.

Firstly, they found that the different plant species had different optimal pH values where the best quality plants were produced. For example, tomatoes grew best at pH 6.5 and petunias had a 50% growth increase at pH 4.5 than when they were grown at any other pH value.

Secondly, they found that even if the pH value of the root zone wasn't the optimal one for that species, the plant would still grow better than if the pH was not controlled. In fact, there was a 44% loss in tomato yield when there was no control of the pH.

These findings clearly show the importance of taking regular pH measurements and controlling this in the growth environment to increase and optimize production levels.

The full research report can be found by visiting bluelab.com/knowledge-base

Measuring pH in different growing environments

Solution:

- **In the nutrient reservoir:** If you have full control of the pH levels here, you can prevent nutrient ions from becoming insoluble and unavailable to the plant.
- **Inline with your growing system:** Monitoring exactly what your plants are receiving.
- **From the run-off:** Ensuring that the plants aren't shifting the root zone pH to values that affect nutrient availability.

In solution, it's easy to use a pH meter. Alternatively, you can send samples to a laboratory or use test strips (although test strips can be difficult to interpret accurately).

Soil:

Soil can have a natural ability to prevent the pH from shifting dramatically. This is called buffering. Soil also contains microorganisms, decomposing matter and varying moisture levels, all of which can change the pH value. It's best to measure soil pH before planting as well as during growing, as different plants thrive in different pH soil values. Knowing the pH value of your soil could impact what you plant and determine soil treatment to optimize plant growth.

When you're growing, measure the pH at the plant's root zone. You'll prevent damage to the roots (eg acid burns) and nutrient ions becoming insoluble. The plant can release ions that can change the pH so careful monitoring is essential.

There are four methods to measure pH in soil: The first method is quick and simple. The other methods are more labor- and time-intensive. They require taking a pH measurement with a solution pH probe or being sent to a laboratory for analysis.

1. The easiest method is to use a multimedia pH probe directly in the soil by the root zone of the plant.
2. 2:1 Dilution Method: Mix two parts of distilled water with one part of your soil mix. Then wait for the solids to settle and measure the pH of the liquid.
3. Saturated Media Extract (SME): Add distilled water to a sample of your soil until it's saturated (you'll see a thin film of water on the surface). Stir and wait at least an hour, drain through a filter to separate liquid and solids and then measure the pH of the liquid.
4. Leachate PourThru Method: Fill your soil container to saturation (so that a few drops of water come out of the bottom of the container) with your normal irrigation water. After the container has drained for one hour, place a saucer underneath. Then pour enough distilled water on the surface of the container to get 50 ml (1.5 fluid ounces) of leachate to come out of the bottom of the container. This leachate can then be measured.

In soil-less media:

These are mostly used in container growing. Materials include coco coir, perlite, vermiculite, soil-less mix and peat. Accurate measurement of the pH of any media is essential. Note that pH levels are not standardized and the medium may require treatment before use for growing. The natural pH of stone wool, for example, is quite high.

Be aware that these media also do not have buffering ability to control pH. Therefore, pH control during growing will be required.

Ways to measure the pH vary depending on the medium. However, they are very similar to measuring the pH of soil. A soil-specific pH probe is fastest.

The takeaway message here is that the pH can change very quickly and have a massive impact on your production levels. Rapid and accurate methods of measuring pH are essential.

What can change the pH of soil:

- **The plant itself:** Plants can change the pH of soil or media. By how much depends on their stage of growth. Recording pH levels through the growing cycles are helpful. It'll give you a useful history, so you know whether the values you see are expected.
- **Applications of and types of fertilizers:** These can alter the pH significantly. Some fertilizers can make your pH level head in a direction you don't want.
- **Applications of sprays:** These can soak into the soil or growing media and change your pH.
- **Soil/media temperature:** Soils with high temperatures can have a high concentration of carbon dioxide (CO_2). This leads to the production of more carbonic acid, which lowers pH.

Practical pH measurement

Recommended range of pH values for commonly grown crops

	Optimal pH range
General range for most crops	5.5 - 6.8
Leafy greens	
Lettuce	6.0 – 7.0
Basil	5.5 – 6.5
Fruiting crops	
Tomatoes	5.5 – 6.5
Chillies	6.0 – 6.5
Strawberries	5.0 – 7.5
Flowering plants	
Roses	5.5 – 6.0
Fungi	
Mushrooms	6.5 – 7.5

Bluelab® pH Pen

Handheld device that measures solution for:

- pH
- Temperature

Bluelab® Soil pH Pen

Handheld device that measures solution or root zone for:

- pH
- Temperature

Bluelab® Multimedia pH Meter

Handheld meter that easily measures:

- Root zone pH in soil and substrates
- pH in solution

Bluelab® Combo Meter

Three-in-one handheld device that measures solution for:

- pH
- Nutrient (conductivity)
- Temperature

Bluelab® Combo Meter Plus

Handheld device with all the features and benefits of the Bluelab® Combo Meter:

- Plus root zone pH measurement using the included Bluelab® Leap pH Probe

Making sense of Electrical Conductivity (EC)

Measuring electrical conductivity is one of the most important things to do during growing. Let's explain.

Why EC? Simple. The electrical conductivity of a nutrient solution is a vital measure of the total available nutrients in the sample.

When nutrients (or other salts) dissolve in water, they split into ions. For example, potassium nitrate dissolves into a potassium ion and a nitrate ion. Each ion carries an electrical charge (potassium carries a positive charge and nitrate a negative charge).

The ions enable water to conduct electricity. Without these ions, water is not a good conductor. The more ions present, the better the water conducts electricity.

The key fact is this: only nutrients that are in an ionic form are available to be absorbed by plants.

So measuring the electrical conductivity of the water is a really good way of measuring the strength of your nutrient solution. While it doesn't give information about individual nutrients, it's a highly useful guide to its overall strength.

Just as with pH, different plants have different ranges of EC value for optimal growth. In general, if your EC is very low, your plant probably doesn't have enough food. If your EC is very high, you may run the risk of burning the roots or toxic buildups. However, bear in mind that EC is just a general measure of the ions present. It can't distinguish or quantify the different types of nutrient ions, such as K^+ and NH^+, present in a sample.

There's one worldwide scale for measuring acidity - it is pH. For conductivity, it is not that simple. The scientific scale most commonly used is millisiemens per centimeter (mS/cm^2). However, there are at least four other conductivity scales or conversion factors in use. These are EC, CF, PPM 500 (TDS) and PPM 700. Be sure to know which scale your meter is set on and which scale is used by your nutrient manufacturer.

Getting to grips with the different measuring scales

What are all the different terms?

- EC (Electrical Conductivity [1 mS/cm^2 = 1 EC]
- PPM (Parts per Million) [EC x 700]
- TDS (Total Dissolved Solids) or DS (Dissolved Salts) or MS (Measured Salts). Otherwise known as PPM 500 [EC x 500]
- CF (Conductivity Factor) [EC x 10]

They're all related and concerned with measuring the same thing. Using this table shows how to convert from one scale to another.

Conductivity conversion chart

mS/cm² (Millisiemen per cm²)	EC	CF	PPM 500 (TDS)	PPM 700
0.1	0.1	1	50	70
0.2	0.2	2	100	140
0.3	0.3	3	150	210
0.4	0.4	4	200	280
0.5	0.5	5	250	350
0.6	0.6	6	300	420
0.7	0.7	7	350	490
0.8	0.8	8	400	560
0.9	0.9	9	450	630
1.0	1.0	10	500	700
1.1	1.1	11	550	770
1.2	1.2	12	600	840
1.3	1.3	13	650	910
1.4	1.4	14	700	980
1.5	1.5	15	750	1050
1.6	1.6	16	800	1120
1.7	1.7	17	850	1190
1.8	1.8	18	900	1260

mS/cm² (Millisiemen per cm²)	EC	CF	PPM 500 (TDS)	PPM 700
1.9	1.9	19	950	1330
2.0	2.0	20	1000	1400
2.1	2.1	21	1050	1470
2.2	2.2	22	1100	1540
2.3	2.3	23	1150	1610
2.4	2.4	24	1200	1680
2.5	2.5	25	1250	1750
2.6	2.6	26	1300	1820
2.7	2.7	27	1350	1890
2.8	2.8	28	1400	1960
2.9	2.9	29	1450	2030
3.0	3.0	30	1500	2100
3.1	3.1	31	1550	2170
3.2	3.2	32	1600	2240
3.3	3.3	33	1650	2310
3.4	3.4	34	1700	2380
3.5	3.5	35	1750	2450
3.6	3.6	36	1800	2520

Where is it useful to measure EC?

- **In the reservoir:** This is the solution that will be used to feed the plants. It must have sufficient nutrient concentration to do this.
- **At the root zone:** The root zone is the region where the plant absorbs nutrients from its growing media. Measuring the EC here will give you the best picture of nutrient quantities available to the plant. If you measure away from the root zone, you may obtain the optimal EC value, but the plant can't absorb nutrients from there.
- **In the run-off:** While not in the root zone, it can give a useful approximation, so long as the percentage of run-off is around 20%.
- **In the water supply:** Unless you are using treated water (deionized or reverse osmosis), there is a risk of contaminate ions giving an EC value. This may affect your actual EC value and may prevent optimal nutrient availability for the plant.

Get EC measurement right

Bluelab® Truncheon Nutrient Meter

Handheld meter that measures in solution for:

- Nutrient (Conductivity)
- Temperature

How to measure EC:

The simplest way is to use a digital EC meter. Various types measure EC in solution and other growing media. Be aware, though, that soil is a non-homogenous media type, so an EC measurement could vary significantly within a couple of centimeters.

Other commonly used measurement methods for soil or soil-less media include the Slurry Method. Take a soil sample and add deionized/RO water until it becomes a thick slurry. Run sufficient slurry through a filter to cover the tip of any EC probe and take the measurement (follow the manufacturer's directions).

Note: The EC of a slurry tends to be considerably lower than the EC of the solution you put into your media. A factor of 10 difference is not uncommon.

Bluelab® Guardian

Fixed wall-mounted monitor that measures and monitors your reservoir 24/7 for:

- pH
- Nutrient (Conductivity)
- Temperature

Bluelab® Conductivity Pen

Handheld device that measures solution for:

- Nutrient (Conductivity)
- Temperature

Bluelab® Pulse Meter

Handheld three-in-one root zone measurements for:

- Moisture content
- Nutrient (Conductivity)
- Temperature

Bluelab® inline Guardian

Fixed wall-mounted monitor that measures and monitors your fertigation or irrigation solution 24/7 for:

- pH
- Nutrient (Conductivity)
- Temperature

Bluelab® Pro Controller

Fixed wall-mounted controller that measures, monitors and controls your nutrient solution 24/7 (when used with a Bluelab® PeriPod) for:

- pH
- Nutrient (Conductivity)
- Temperature

EC in soil and soil-less media

Keep in mind that the following factors can affect EC (nutrient) levels:

- **Uptake of nutrients by the plant:** This will generally decrease the nutrient ions present in the solution and lower the EC. However, the plant may release other ions into the solution that would increase the EC.
- **The growth medium:** Some media can release ions, generally by breaking down, which raises the EC measurement. Conversely, they can sequester nutrients and prevent them from conducting electricity and being measured.
- **Reactions between ions:** Some ions can easily react with each other and form an insoluble complex that is no longer able to conduct electricity. A common example of this is the precipitation of calcium sulfate complexes.
- **Change in water concentrations:** High environmental temperatures causing evaporation or high transpiration rates can result in a more concentrated nutrient solution.

As a practical example: on a hot day, plants take up more water than nutrients, so the nutrient level, or conductivity, will rise. If salt levels get too high, the internal osmotic system will reverse and the plants will dehydrate.

Some soils can retain nutrient ions and stop them from moving freely in solution and conducting electricity. If you have soil components that behave like this, like clay, your EC value may not represent all the ions present and be lower than it should be.

These changes can happen quite rapidly so take regular measurements. It's easier to prevent a nutrient imbalance issue than correct one.

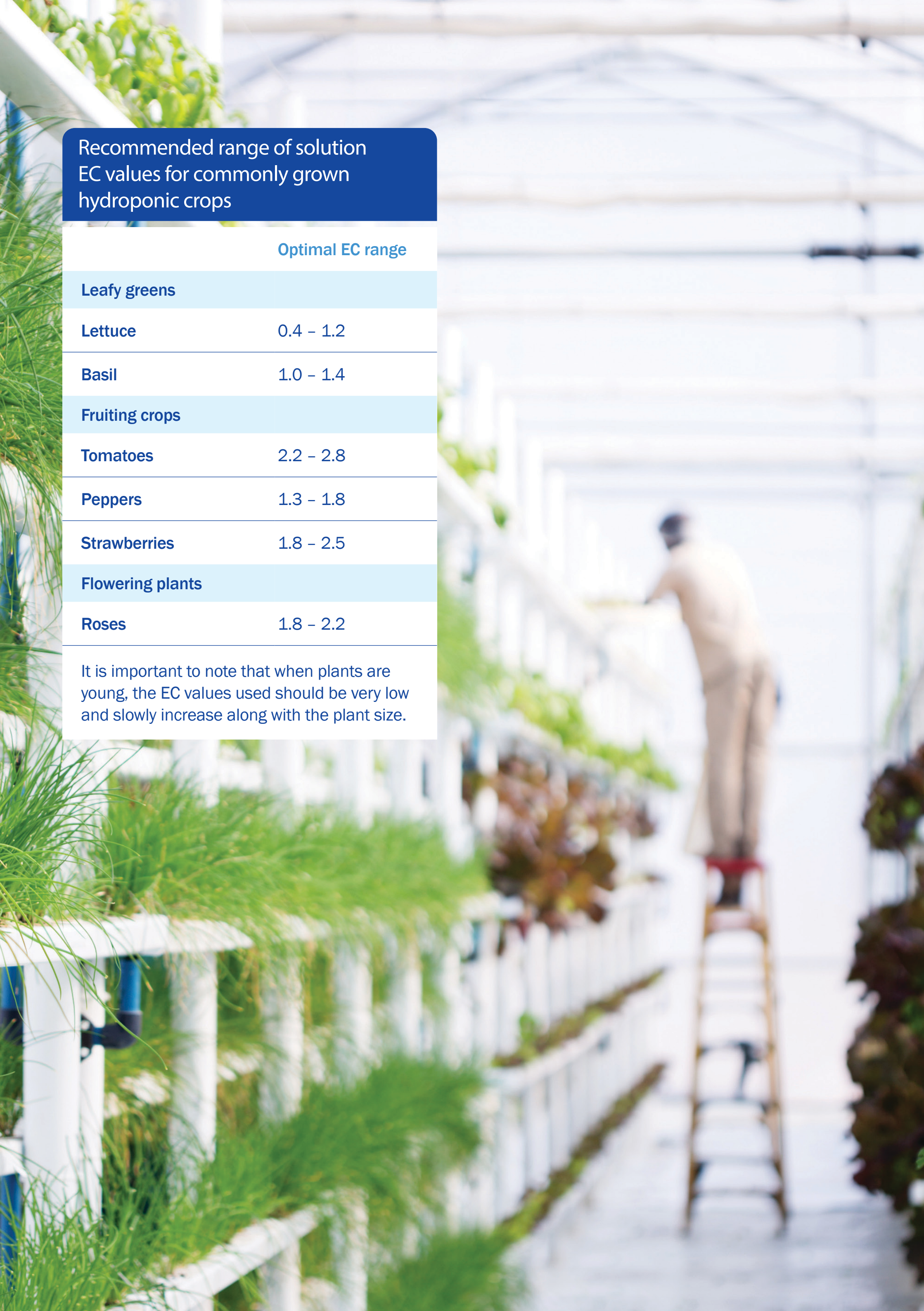
Remember, EC measurement in or from media will generally be considerably lower than the EC used in solutions.

Fact File

Measuring organic nutrients:

If you're using organic nutrients, you may think you can't quantify the available nutrient or nutrient levels using solution conductivity – because you may often get a low reading. However, a low reading does mean a low level of nutrients available to the plants. It may be that the organic nutrients haven't yet been broken down into an available form or that they have already been taken up by the plants. Either way, your reading indicates the current level of available nutrients.

Remember: EC is a general measure. It can't tell you whether you have a balanced nutrient composition.



Recommended range of solution EC values for commonly grown hydroponic crops

	Optimal EC range
Leafy greens	
Lettuce	0.4 – 1.2
Basil	1.0 – 1.4
Fruiting crops	
Tomatoes	2.2 – 2.8
Peppers	1.3 – 1.8
Strawberries	1.8 – 2.5
Flowering plants	
Roses	1.8 – 2.2

It is important to note that when plants are young, the EC values used should be very low and slowly increase along with the plant size.

Be sure of your water quality

The quality and content of water is key to any growing system. Water can contain contaminants that limit irrigation flow, affect plant nutrients and inhibit the control of pathogens.

Not all water is equal. Don't assume any water you use will benefit crop health. You might be surprised at the levels of physical, chemical and microbial contaminants discovered in a survey of commercial horticultural operations.

Pure water (H_2O) is composed of equal parts the hydrogen ion (H^+) and hydroxyl ion (OH^-) and nothing else. A balance of H^+ and OH^- produces a neutral pH of 7.0. Pure water contains no other minerals, microbes, pathogens or other contaminants. Monitoring water quality can help determine how pure your water is, meaning how close it measures to pH 7.0 and an EC value of zero or very close to zero. In our world today there are few sources of pure water. Therefore, growers should establish a water monitoring and treatment programme that enhances the ability of water to hydrate and transport essential minerals and plant-available nutrients to the plant. Irrigation management can be improved with an awareness of its contents to determine the level of treatment needed and help you prevent problems further on.

Pure water is used as a reference point in growing systems because there are no contaminants interfering with water treatment and there's nothing present that could be detrimental to the plant growth or to the performance of any added nutrients.

Why is using pure source water preferable?

- No 'waste ions' present that could disrupt the optimal nutrient ratios once a nutrient mix is added. Having waste ions like sodium present in the source water will limit plant uptake of essential nutrients like potassium. If additional fertilizer is added without removing the sodium in the water, it could result in toxic EC levels due to an excess of salts and nutrients, which results in health issues within the plant.
- No physical, chemical or biological contaminants that could react with added nutrients and result in an insoluble precipitate that is not only unavailable to the plant but can also block or damage equipment.
- No elements that could harm biological treatments, such as beneficial microbes present in growth media or other biological control organisms that may be part of an integrated pest management programme (IPM).
- No pathogens present or insoluble matter that could interfere with water disinfection treatments.
- No unwanted salts that could cause problems for plants eg sodium chloride.

Source water is the water we have available to use for irrigation. The quality of the source water can affect the delivery and solubility of fertilizers and availability of added nutrients to provide crop fertilization.

Issues caused by excess ion levels in source water:

- **Iron:** Can quickly oxidize to rust and cause damage to system equipment. Once oxidized, it is no use as a nutrient. Iron is commonly found in bore or ground water and, if present in high quantities, will turn brown after several hours once exposed to air.
- **Nitrogen:** Causes excessive growth, but delays maturity of the crop and so can delay harvesting.

The best system to optimize growth is one we can fully control. Control of the water you use is essential. That depends on knowing everything in it.

Common characteristics of untreated water:

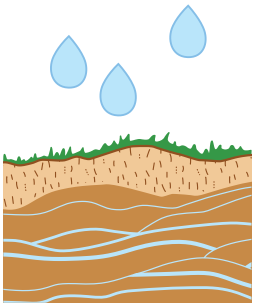
- **Water hardness:** This is water with a high mineral content, commonly from excessive quantities of calcium and magnesium that has dissociated from bicarbonate (HCO -) complexes. This causes nutrient ratio imbalances when adding set nutrient mixes as crop foods. The presence of calcium increases the risk of the white precipitate of calcium sulfate forming (CaSO), which can then cause equipment blockages. You can get nutrient mixes for hard water, but unless you know the exact concentration of excess elements present, this isn't a fail-proof solution.
- **Salinity: This is** the number of salts, such as sodium chloride (NaCl), carbonate (CO_2-) and bicarbonate (HCO -) complexes, in the soil or water, which can have a detrimental impact on the availability of water to the crop and result in them becoming dehydrated. While some of these are essential plant nutrients, the excess will disrupt the nutrient ratios and result in toxicity. However, measuring the EC of your source water will give you an idea about the total salt concentration already present. So, if the EC of your source water seems quite high, you may have an issue with salinity. If the salinity of your water (or even soil) is an issue, your crop can have a drought-like appearance.
- **Alkalinity:** A measure of the number of bicarbonates (HCO_3) present in source water. Bicarbonates are an alkaline compound and cause the pH value to rise. You can fix this by adding acid, but if you have a very high alkalinity, this is a very effective chemical buffer. It can make it very difficult to shift the pH to the optimal level for nutrient availability. If you notice that your pH value requires a large quantity of a pH down adjuster agent and then rapidly decreases, you may have an issue with alkalinity. Bicarbonates also often cause blockages in system equipment. All in all, adding water with high alkalinity can bring you many unwanted challenges.

What types of source water are available?

You may have a choice of water or you may not. All water sources have advantages and disadvantages. It's best to be aware of them.

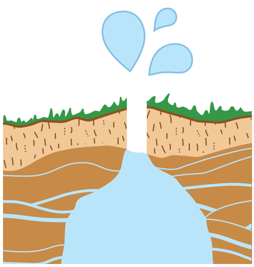
There are three main naturally occurring water sources: rainwater, surface water and groundwater. Domestic or tap water is also a common option.

Plants are significantly more sensitive to water quality than we are and they have different water requirements. Just because water is suitable for us doesn't mean it will be for crops.



Rainwater:

Often the best water for crop irrigation. The natural water cycle (evaporation, condensation, rainfall) results in quite pure water with only traces of minerals due to reactions with atmospheric gases. Collection from roof structures may add contaminants such as lead (from paints) and asbestos. Be cautious in this case.



Groundwater (springs, wells and bores):

Can be extremely good for crop irrigation and horticulture. It may be high in dissolved minerals such as calcium carbonate, especially if limestone is present. The pH may be higher as a result. Lab analysis is advisable to quantify the levels of minerals in the water and to ensure that levels of salt (sodium chloride) are adequately low. Groundwater can be contaminated from material leaching into it from surface activities such as waste disposal, farming or industry. Be careful if you suspect this risk in surrounding areas.

Domestic water supplies (tap water):

Water from the tap can be very variable, depending on its origin and how it has been treated. Normally, it will have been purified through filtration or desalination and had elements such as chlorine or chloramine added to neutralize pathogens. These elements can slow growth and negatively impact microbes present in the growing environment.

Fact File

If your source water quality isn't up to standard, these are the usual treatment options:

- **Deionizing:** The removal of all charged ions through the use of ion exchange membranes. This method won't remove pathogens or microbes from your water.
- **Reverse osmosis:** This method uses a semi-permeable membrane to remove ions, molecules and larger particles to purify water. It can't remove pathogens or microbes, but is an effective way of removing excess or unwanted nutrients and elements.
- **Ultraviolet (UV) light treatment:** UV light acts as a chemical-free disinfecting agent to effectively remove microorganisms (such as bacteria, viruses and pathogens) from water supplies. These can, of course, have a negative effect on the health of crops, as well as people and animals. It doesn't remove ions or other contaminating particles.

There are other methods of water purification, but these are widely preferred and most commonly used.

Recirculated or recycled water:

The purer your source water, the less treatment is required for optimal plant health. The purer the water, the fewer contaminants or unwanted minerals and reduced nutrient lockout.

If you're growing in soil, the microbial community is vitally important, and contaminated water could harm this and affect the utilization of organic matter. Contaminated water often results in a chain effect, decreasing the nutrient amounts present in soil that are available for beneficial microorganisms and plant growth.

No matter which source water you use, monitoring is key to knowing the level of contaminants and effective treatment to remedy poor growing conditions. Regularly monitor the EC and pH of your source water to determine the starting point for your plant nutrition and water treatment systems.

The closer the EC value of your source water is to zero and the pH value to 7.0, the better. It means that the water is likely able to carry nutrients and other enhancements designed to improve plant health.

When to test the water?

- **Before adding any nutrients:** They're expensive, so you don't want to add what's already there. Nor do you want to risk nutrients precipitating out of the solution or having toxic effects on the plants. The aim is to maintain optimal nutrient ratios. Knowing if the water has high alkalinity can make things much easier when you try to adjust the pH further on.
- If you're growing hydroponically, you'll be able to examine your nutrient solution once it has run through your system, but do note that you won't be assessing water quality alone.

Testing:

Test your source water regularly. You can send samples for laboratory analysis, but you should use these fundamental measurements to monitor its quality:

- **pH:** Ideally, your source water should have a pH of 7.0. As previously mentioned, the presence of contaminants such as bicarbonates will cause the pH to rise and be alkaline. Measuring the pH can indicate the presence of contaminants.
- **Electrical Conductivity:** Pure water doesn't have any components able to conduct electricity, so ideal source water will have an EC value of zero. By measuring your EC, you'll get an idea of the presence of ionic nutrients, elements or heavy metals that may disrupt a carefully calibrated growing system. However, even with an EC reading of zero, non-ionic contaminants could be present and cause issues.
- **What does the water look like?** Clear or cloudy? Clear water can be deceptive, appearing to be free of contaminants. However, these may well be invisible so it should still be tested. Cloudy water contains insoluble particles that can block your equipment and may also contain unwanted contaminants.

24/7 growing, made easy

Growing doesn't need to be complicated. The more that things are well managed, the fewer surprises. And there are management systems to take care of much of the day-to-day work.

Think automation:

You have tools and systems readily available that'll add to the success of your growing system.

Automating nutrient preparation and maintenance provides more consistent nutrient composition over time and facilitates better plant growth. Constant monitoring and correction mean that nutrient solution values are stable 24/7.

Automation also saves money. When you efficiently control how many nutrients and water are provided to the plants and you eliminate mistakes that slip in when you're preparing nutrients manually, your valuable nutrients are not wasted and water use is reduced.

You will have peace of mind. When you know the system is monitoring and controlling growing conditions 24/7 and you can monitor it when off-site, you can be free of the growing operation, knowing that all is well.

You'll save time too, which means more time to check plants for disease, pests and overall health – or to even get away from it all for a while.

Easy nutrient management:

The critical nutrient parameters that can be automatically controlled are EC, pH and temperature. Controlling EC means that sufficient nutrients are provided at all times. Maintaining the correct pH ensures that the nutrients are available to the plants.

Having an automated system dosing nutrients as required instead of manually dosing larger quantities means that nutrients are fresher. Moreover, there's less chance of the nutrient elements precipitating out of solution over time.

If the temperature is maintained within the ideal range for the crop, growth rates are stable during cold periods and the problems caused by warmer nutrient temperatures, such as reduced dissolved oxygen levels and root diseases, can be avoided.

Controlling the growing environment:

You can also readily control environmental conditions like air temperature, humidity, light levels and carbon dioxide (CO_2) levels.

- **Humidity:** Humidity in the growing environment plays a huge role in the rate of water and nutrient uptake by the plant and, therefore, the rate of growth.
- **Temperature:** It plays a big role in water and nutrient uptake rates and affects growth rates directly. Too cold, and growth rates slow. Too warm, and plants can become stressed. Keeping environmental temperatures within an optimal range maximizes growth rates.
- **Carbon dioxide:** Carbon dioxide (CO_2) is an essential component of photosynthesis and the main source of carbon for the plant. It is taken in through the plant's stomata. Augmenting the atmospheric CO_2 level can increase growth rates in some plants.
- **Irrigation:** Control of irrigation can also be automated, based on time (especially in artificial light situations) or light intensity (in natural light conditions).

Automation equipment:

Nutrient automation equipment usually consists of a controller, which monitors the nutrient EC and pH values (sometimes temperature as well), and a doser, which, triggered by the controller, doses nutrient stock solutions and the pH adjuster to bring the nutrient solution to required levels. A typical doser has three pumps (part A and part B plus pH), as most commercial nutrients are two-part nutrients. Some controllers and dosers can dose multiple nutrients and additives at different ratios, changing the nutrient mix over the growing cycle of the crop.

Solution heaters and chillers can be used to keep the solution temperature within required limits.

Independent monitors are also often used to watch EC, temperature and pH levels as a backup to the controller.

In some situations, the control of all environmental factors is automated. This, of course, may be highly complex and thus expensive. Controlling the values of EC, pH and temperature is your best first step.

Fact File

How can we easily automate our system?

Monitoring equipment:

- **Bluelab Guardian Monitor:** Continuously measures the conductivity, temperature and pH of your reservoir using pH and EC probes. An inline model is also available to measure the same variables just before the solution is given to your crops.

Controlling equipment:

- **Bluelab pH Controller:** Continuously measures and automatically adjusts the pH of a given solution to a predetermined value using an inbuilt peristaltic dosing pump.
- **Bluelab Pro Controller:** Continuously measures and automatically adjusts the pH and EC of the reservoir. Also measures the temperature and has the capability to control this if connected to a heating or cooling unit.

Dosing equipment:

- **Bluelab PeriPods:** Currently come in a medium or large size with three (M3 & L3) or four pumps (M4). With the Bluelab Pro Controller, they automatically and accurately adjust nutrient and pH levels in growing reservoirs. Three PeriPod units (maximum 12 pumps) can be connected to allow experienced or experimental growers the ability to dose nutrient components and add other supplements individually.

Find these products and many more at bluelab.com

"If you want an accurate and reliable system to take care of your hydroponics setup, I highly recommend the Bluelab Pro Controller Connect. It has given me peace of mind knowing that my crop is controlled with this automated system. The backup support from the Bluelab team has been second to none."

SCOTT PILCHER - PASSIONFRUIT GROWER
Pilcher Farms Produce Ltd, New Zealand

How is the pH controlled?

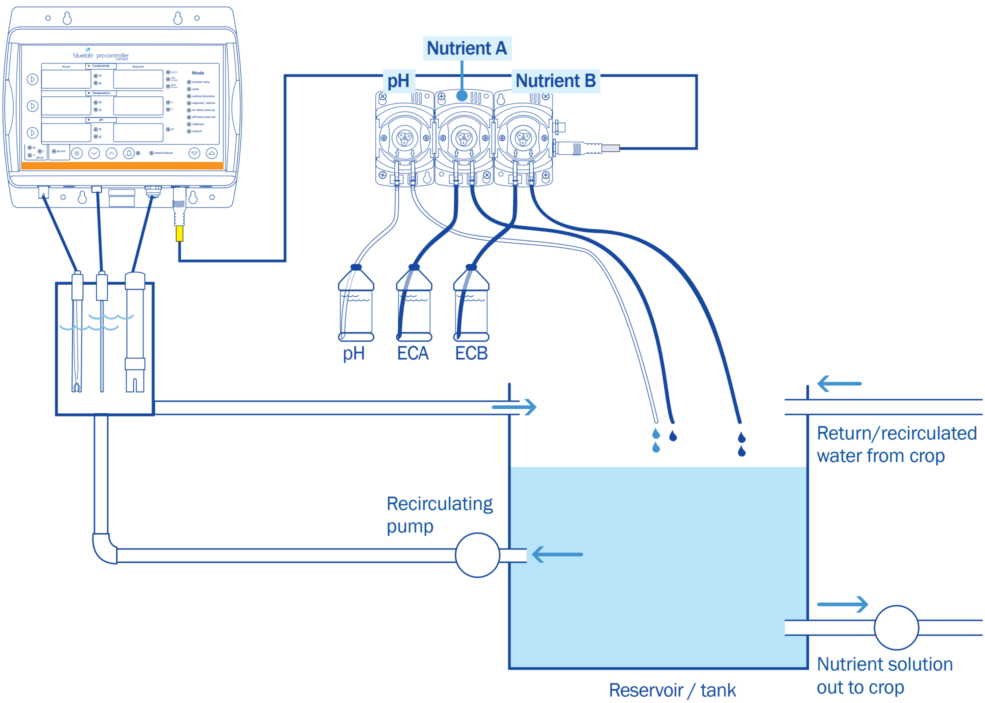
We already know the importance of pH and why it is controlled. Now, how can we control it?

In most growing systems, the pH will rise during the growing cycle and when nutrients are added. This requires the addition of acid to increase the level of hydrogen ions (H^+) to bring this level down to the optimal value. These control agents are commonly known as pH down adjusters.

Commonly used acids include nitric acid (HNO_3) and phosphoric acid (H_3PO_4), both of which separate into hydrogen ions and either nitrate or phosphates respectively, thus providing extra nutrients to the reservoir. As this addition will increase the concentration of that essential nutrient ion, be aware of this and adjust your nutrient mix if needed to compensate for the additional nutrients. The acid should be used at a 5-10% strength to have the most control over the changes of pH and to avoid nutrients dropping out of the solution on contact. Acid at a higher concentration poses a significant safety hazard. It is highly corrosive and will severely damage skin and equipment (especially the pump hoses).

To increase the pH value, use pH up. Potassium hydroxide can also be used, as it will split into potassium ions (K^+) and hydroxyl ions (OH^-). This provides a source of potassium ions, so as with the use of a pH down agent, do consider the additional amount when making up a nutrient mix.

Note: Even when diluted, these acids should still be treated with extreme care and contact with skin and eyes avoided.



Get to grips with growth media

Successful growth depends on the plant and its root system being supported. That's the role of a growth medium, chosen according to different methods of crop cultivation and various crops. Media vary from the traditional - soil - to mixes of soil-less media and substrates such as stone wool and solution-based hydroponic methods.

There are two categories: soil and then soil-less and solution-based growing. In the latter (defined as hydroponics), the plants are fed directly as opposed to feeding the soil, which then holds the nutrients that the plant can use.

All growing media types must provide:

- Constant oxygen supply.
- Supply of water to the roots to keep them hydrated.
- Sufficient drainage to prevent the roots from becoming waterlogged and rotting.
- Sufficient supply of nutrients to be transported by water through the media and to the plants' root zones.

The coarseness and porosity of the medium are what determines the ratio of pores and voids that are occupied by oxygen and water/nutrient ions.

Fact File

Moisture content:

The moisture content of the soil is the amount of water present in the soil and thus available to the plant. Measuring this ensures that the plant roots are sufficiently hydrated and not becoming waterlogged. This is particularly important as the physical properties of different growth media retain water differently and can cause issues if not monitored.

Measuring the moisture content of your growing medium will help you to decide how frequently your crop requires irrigation.

Thinking hydroponics:

The term hydroponics originates from the Greek words ‘hydro’, meaning water, and ‘ponos’, meaning labor or toil, translating to ‘working water’. It is used to define growing systems that operate without the use of soil. This bypasses the use and cultivation of the soil ecosystem, as the nutrients are made directly available for absorption by the plant by passing a nutrient-rich solution through the root zone. This method is proven to significantly improve crop yields compared to traditional in-soil growing. The plants don’t have to exert as much energy growing complex root systems to seek out and extract nutrients. Instead, they can use the energy for foliage and crop growth.

By its nature, hydroponics can be a highly controlled growing system. You can establish and maintain the plant’s optimal growing conditions so that it always has exactly what it needs to grow. Furthermore, as hydroponic systems aren’t reliant on arable land, they can be used close to distribution centres. This reduces food miles and means riper and more nutrient-rich crops when harvested.

Water use also matters. Water is becoming one of the most valuable planetary resources, with agriculture and horticulture being primary users. Hydroponics systems typically use around 80-90% less water than soil-based agriculture. This is especially important when you consider that 70% of the world’s fresh water is used in agriculture, mainly for irrigation.

Hydroponics systems provide the plant with optimal levels of nutrients in the water supplied to them. It is thus preferable that the growth medium used is inert, meaning that it will not decompose and release nutrients that could disrupt calculated nutrient ratios and damage plant health. Some media require treatment before use to ensure their natural properties (pH or contaminants present) will not affect the pH or electrical conductivity of the growing environment.

Coconut coir:

Is the fibrous casing of the coconut.

Pros:

- Renewable and sustainable source.
- Inexpensive.
- Excellent porosity.

Cons:

- May contain a high level of salt, so may need to be thoroughly treated and buffered before use.
- Known to sequester and release different nutrients so may require special coir nutrient mixes.
- Decomposes at a very slow rate. This is not seen to be a significant issue.

Perlite:

Is a naturally occurring medium made from volcanic rock.

Pros:

- Highly porous.
- Requires minimal treatment before use.
- Neutral pH.
- Reusable (if treated before the next use).
- Inert medium.

Cons:

- Due to its light weight, perlite isn't often used as the sole medium.
- Poor water retention (also seen as a positive characteristic in good drainage).

Clay pebbles:

Made by expanding clay with heat.

Pros:

- Excellent drainage.
- The structure can be modified through crushing to improve water retention.
- Chemically inert medium.
- Reusable and durable.

Cons:

- Requires more irrigation.
- Floats without sufficient water.
- Requires soaking and rinsing before use to remove dust particles that may clog equipment.
- With relatively large gaps between pebbles, it isn't ideal for starting seeds as these can fall through the gaps.

Stone wool:

Inorganic growth media made from steam-treated molten rock or slag.

Pros:

- Inert medium.
- Good water retention.
- Good aeration of the roots.
- Comes in different shapes and sizes.

Cons:

- High (initial) natural pH, due to containing basalt, so requires prior treatment.
- Risks becoming saturated and damaging roots.
- Are a skin and lung irritant.

Growth media can be used on their own or in combination with other soil-less media. A combination can make an ideal medium for a certain crop, as this will have the properties of the different media.

The oldest of all media: soil

For millennia, soil has been the conventional growth medium for crop cultivation. The composition of soil can vary, but the basic components are air, minerals, water and a small amount of organic matter, all of which can foster a diverse microorganism community. The mineral components of soil are the sand, clay and silt particles contained within it.

The different chemical compositions of these components can impact the retention of nutrients in the soil and thus their availability to a plant. This is often referred to as the cation exchange capacity (CEC) of the soil and is a way to quantify the fertility of the soil. Clay and organic matter (sometimes called humus) are two common components that have a net negative charge and so can attract and hold positively charged ions, which includes most nutrient ions. This increases their availability to the plant within the soil, as they won't be leached out and will assist the soil's natural pH buffering ability.

Soil's ability to minimize shifts in its pH stabilizes the solubility of nutrient ions - if the pH is within the solubility range of those ions. However, different soils have different pH values due to their composition and this can impact the solubility of some nutrient ions. Plants have adapted to differing conditions, but species unaccustomed to certain conditions struggle and have nutrient deficiencies. Blueberries and pine trees, for instance, grow best at a low pH and have no nutrient deficiencies. Each species has a preferred pH range. It is thus advisable to measure the pH of your soil before planting to determine which plants will grow optimally. Conversely, if your crops aren't growing well, measuring your soil pH may uncover an underlying factor that you can treat.

TOP TIP

Don't measure soil pH at the surface of the soil. Most plant roots are lower. The pH at the soil surface may also be affected by accumulated salts, which may affect measurements.

Measure close to the root zone and at the same depth. You'll gain a more accurate picture of the growing environment.

Just as in hydroponics, it is the soil water that carries the dissolved nutrients to the plant root zone. However, instead of readily available nutrients being directly provided in the irrigation water, the nutrients are released from decomposing matter such as compost or converted from unavailable chemical forms through microorganism activity.

These microorganisms play an essential role in maintaining and improving soil fertility as well as assisting plant growth. An example is the process of nitrification, where atmospheric N_2 is converted into ammonium ions (NH_4+) by bacteria, making this essential nutrient available to the plant.

Microorganisms are always present in the environment and so will also be present in the growing environment. Microorganism communities will become established in any growth media nutrient solutions and the root zone and roots of cultivated plants. These organisms are very sensitive and any change to their environments, such as pH, the addition of fertilizers and water levels, can impair their performance.

Take good care of your soil and the organisms within it and you'll create a symbiotic ecosystem that can be relatively self-sufficient and requires minimal added nutrients. However, industrial malpractice and careless use of fertilizers have damaged much arable land, exhausting its essential nutrients and depleting the microorganism community. Where the natural soil ecosystem has been severely damaged, it must be built up again and healed before crops can obtain their essential nutrients.

It's also worth noting that many decomposable fertilizers derived from organisms at the top of the food chain - such as animal manure, guano and fish emulsion - and even minerals like rock phosphates can contain accumulations of heavy metals.

Repeated applications will cause these to build up over time. Heavy metals are usually toxic and, when present, can be absorbed by plants and found in their produce. Be careful when sourcing these types of fertilizers.

Fact File

Measuring the pH of your soil:

- **Bluelab Soil pH Pen:** Handheld device to measure the pH and temperature of your soil.
- **Bluelab Multimedia pH Meter:** Handheld device that comes with a multimedia pH probe to measure the pH of solution, soil or any growing media.

For other methods of measurement, refer to the pH chapter of the Grow Book.

Find these products and many more at bluelab.com

Microorganisms commonly present:

Microbes can colonize every part of the growing environment, from the substrate to the nutrient solution. They play important roles in breaking down organic matter to release nutrients, fertilizing the soil, recycling nutrients, assisting nutrient uptake and disease prevention. Some microbes can be pathogenic, but completely sterilizing your growth environment can do more harm than good. Aim to maintain a balanced microbial environment.

- **Bacteria:** Decompose organic matter and release nutrients by processing them from unavailable to available forms. Many different varieties of bacteria use the carbon content of the soil as an anchor and food source.
- **Nematodes:** Some nematodes (small worm-like animals) are parasitic and feed on algae, plant roots, fungi, bacteria and other nematodes. They assist and accelerate the decomposition of organic matter and the release of nutrients by digesting their food source.
- **Fungi:** There are many different species of fungi. Some form a mutualistic relationship with plants and attach to their roots to protect them and assist in nutrient uptake. Here they receive carbon (their food source) from the plant and in return transport nutrients to the plant. Some fungi decompose organic matter into acids, carbon dioxide and fungal biomass.
- **Algae:** Increase soil fertility by becoming organic matter when they die. Help increase water retention in the soil. Carry out photosynthesis and release oxygen underground, thus aerating the soil.

Some species of microbes can produce a variety of substances that promote and protect plant growth, including hormones, auxins, gibberellins and antibiotics. Hydroponic systems using soil-less media have also been found to contain the same microbes as soil and assist plant growth and control disease.

Still curious? Here's some further reading:

Comparison of Land, Water, and Energy Requirements of Lettuce Grown Using Hydroponic vs Conventional Agricultural Methods.
The microbiology of soil and of nutrient cycling.

Get to the bottom of organics

Growing methods and technologies continually diversify. New techniques and terminologies emerge. Sometimes terminologies are driven by certification in produce markets. Let's have a close look at organics.

Organic. This word is used by growers, scientists, retailers, consumers, everybody. However, definitions and explanations aren't the same.

You'll hear many people say they use organic nutrients. Fewer examine the chemical composition of nutrient types to see what really benefits plants.

Explaining organic nutrients:

Organic nutrients are a degradable matter that can be broken down and come from a source that was once living. So fish meal, guano, compost, worm teas and other matter are added to the soil - or in some cases to a hydroponic system - to provide slow-release nutrients. Decomposition is essential as the primary particles are too large for the plant to absorb. They need to be broken down by microorganisms into a readily available ionic form that plants can recognize and take up. The microorganisms consume the carbon present in the organic matter and then release the essential nutrients for the plant.

Using organic nutrients - in the form of decomposable matter - is an indirect method of providing plants with the nutrients they need by fostering a healthy ecosystem with microorganisms. However, as nutrients are released gradually, there is no way of controlling whether the plant has an optimal level of each nutrient at all times. Care is required to check the plant for signs of nutrient deficiency or toxicity.

The essential nutrients that the plant requires for healthy growth are always in the same form. For example, nitrogen can be available to the plant to absorb as ammonium (NH^-) and nitrate (NO^-) and potassium is always present as K^+. This is because plants have evolved highly selective and sophisticated transport mechanisms to recognize nutrients in these forms and only absorb these. The plant will not selectively absorb nutrients based on their origin, organic or not. It only responds to a particular nutrient form. This response doesn't change, whether it's an organic or direct application. Plant growth and health depend on having sufficient nutrients available in their appropriate form.

Fact File

When to calibrate your Bluelab device:

- If it's been 30 days since the last calibration. The product will notify you when the month is up. The successful calibration indicator will disappear from the screen.
- When you get a reading you weren't expecting.
- When the probe or meter is new.
- When you've done more than 30 readings.
- When the meter is reset after an error message.
- When batteries have been replaced.

Make your equipment last

Here are the basics you need to care for and calibrate your equipment. We explain this in greater detail for every Bluelab product at bluelab.com.

Calibrate to ensure accuracy:

All Bluelab pH meters/monitors are calibrated to two points, most often in pH 7.0 and pH 4.0 calibration solutions.

Meters that say they only need calibrating to one point (which is normally 7.0) can be inaccurate and will not hold their calibration, especially if they say they measure the full scale from 0.0–14.0. If the reading you expect is normally lower than pH 7.0 (as in most plants), calibrate with pH 7.0 and pH 4.0 solutions.

Looking after your pH probe:

Your pH measuring device is an investment in the success of your crop. It is a fragile piece of scientific equipment. By keeping a few simple habits, you can extend the lifetime of your probe.

Probe life is determined and affected by:

- The number of pH measurements you take.
- The age of the probe. Due to the nature of the glass bulb, the probes will eventually fail through normal use.
- Contamination from the type of solution you measure. Contamination can come from touching the probe glass with your fingers or the presence of oils, proteins or suspended solids that could coat the probe. More cleaning and calibration may be required if you're using organic nutrients that coat the probe.
- Contamination of the internal solution, which occurs when the solutions being measured or the solution that the probe is stored in enters the probe itself. Avoid leaving probes in calibration solutions other than when calibrating and always store in KCl storage solutions.
- The different temperatures of the solutions. A significant temperature change, such as putting a cold probe into a hot liquid, can break the glassware.
- The glassware is designed to stay wet and must be kept this way for optimal performance. Store in KCl storage solution for the best results.

Extend the life of your pH probe by:

- Keeping your probe clean. Rinse it after use, with fresh running water and (depending on the amount of use) cleaning the glass bulb with Bluelab pH Probe Cleaner and a soft toothbrush. More detailed instructions are available at bluelab.com.
- Calibrating regularly to ensure accuracy.
- Keeping the probe glassware wet and hydrated. Always replace the storage cap that is filled with sufficient KCl solution after use so that the probe tip is submerged.
- Not using RO, deionized or distilled water as this will damage the chemistry of the glass bulb.

Other things to bear in mind:

- The glass bulb of the pH probe is fragile and can break. Don't knock it against anything or apply sideways force on the probe as this will damage the glassware.
- The lead in the probe can't be lengthened so don't kink or bend it sharply.
- Don't submerge the BNC fitting in any liquid.
- When calibrating or taking a reading, wait for the reading to stabilize fully or you risk compromising the accuracy of the reading.

Looking after your conductivity probe:

Your conductivity meter/pen must be cared for and regularly cleaned to extend its life and ensure maximum accuracy.

Looking after your conductivity meter:

The meter has two electrodes. A small current is sent from one electrode to another and measures the ability of the solution to conduct electricity.

This gives us a general measurement of the available nutrients present.

Tips for use:

- The temperature of the nutrient solution can affect the accuracy of the reading. Your probe or meter should have been factory calibrated (as all Bluelab conductivity products are) and should automatically compensate for temperature. Check this with the manufacturer if you're not using a Bluelab product.
- Sometimes you'll be taking a cold probe and putting it into a warmer nutrient solution or conductivity standard solution. If this is the case, leave the probe in the solution for five minutes before taking the reading. This allows the probe to reach the same temperature as the nutrient solution and will ensure accuracy as the probe's reading is temperature dependent. You may need to do this regularly in winter.

Cleaning:

- Conductivity (EC/CF) probes require cleaning at least once a month. This removes the buildup from nutrient salts, ensuring better accuracy with your readings.
- Always test the probe in a known solution after cleaning – such as Bluelab 2.77 EC Conductivity Standard Solution. Only use sachets once and throw away bottles three months after opening.
- Conductivity probes that consistently give low readings need cleaning.
- The shroud (white tip) on the conductivity probe must always stay on the probe tip (only remove for cleaning) or the readings will be incorrect.
- Avoid touching the probe face with your fingers; the oil from your skin will contaminate the probe.
- Rinse the probe head in fresh tap water after each use to reduce contaminant buildup.
- You'll find more information in the care instructions that come with your product.

FAQs

Q If I'm using organic nutrients, why is my EC so low? Is my probe broken?

A Organic nutrients often must be broken down by microbes into ionic forms that the plant can absorb. Until they are broken down into ionic forms, they don't conduct electricity and therefore don't contribute to the conductivity reading.

Q Why can't we just use one bottle of nutrients?

A If all the nutrients are present together in a concentrated form, some will react together, becoming insoluble and are therefore unavailable to the plant. Using two-part (or more) mixes reduces the risk of wasting expensive nutrients.

The meaning behind the words

Acid: A chemical substance that unites with an alkali base to form a salt. An acidic solution has a low pH – below 7.0 pH. Phosphoric and nitric acids are commonly used to lower the pH value of nutrient solutions.

Aeration: Introducing air to the growing media and/or nutrient solution to provide adequate oxygen for plant root zones.

Agitation: Mixing or aerating nutrients - generally in the holding tank - by means of a pressurized jet of nutrient or via a stream of air introduced by an air pump.

Alkali: A soluble chemical substance which, when mixed with an acid, produces a salt. An alkali has a high pH, being above 7.0 pH. Potassium hydroxide (caustic potash) is the alkali commonly used in hydroponics for raising the pH value of nutrients.

Alkalinity: The alkaline concentration of a nutrient solution.

Anion: A negatively charged ion (eg sulfate, SO_4^{2-}).

Atmosphere: The quality of the air or climate in a growing area.

Ball cock: A float-operated valve allowing automatic replenishment of water levels in holding tanks (also used in toilet cisterns).

Batching: Mixing a volume of ready-to-use nutrient solution.

Buffer: A solution that maintains the relative concentrations of hydrogen and hydroxyl ions by neutralizing, within limits, added acids or alkalis, thereby producing a pH-stable solution.

Calibration: Adjusting meters and controls to known standards.

Cation: A positively charged ion (eg potassium, K^+). The opposite of anion (see above).

CF (Conductivity Factor): A scale of conductivity often used in Australia and New Zealand. Calculated by EC times 10.

Chemical: A substance with constant composition and defined properties.

Colorimetric: A method of measuring chemical values. A chemical will turn a certain colour when brought into contact with the chemical of interest. Colorimetric tape can be used to measure the general pH value of a nutrient solution.

Conductivity: A measure of a material's ability to conduct an electrical current. Pure or distilled water has no electrical conductivity. Added minerals (dissolved salts) create electrical conductivity. Measured by several different systems. See page 16.

Contaminant: An impurity or unwanted chemical or substance.

Deficiencies: Poor plant health or low productivity caused through the unavailability of an essential mineral element.

Deionization: Removal of all ions in water. Resulting in pH-neutral (pH 7.0) water.

Dosing: Adding concentrated nutrient mixes, or pH correctors, to return the nutrient contents of the growing system to the desired values.

Dose 'on' time: The length of time dosing is allowed by the controller.

Dose 'off' time: The length of 'standby' (dosing stopped) time, allowing materials to mix in the tank before dosing recommences.

Humidity: A measure of water vapor in the air.

Hydroponics: A growing system that uses soil-less growth mediums and supplies nutrients via a nutrient solution.

Inert: Chemically inactive. A substance that does not react or change form is inert.

Ion: An atom or molecule that has a positive (cation) or negative (anion) charge due to having lost or gained electrons.

Lockout: If your nutrient solution is too acidic or too alkaline, it can cause nutrient lockout, restricting certain nutrient elements essential for growth from being absorbed by the root structure.

Macro-elements: The major elements for plant growth, including nitrogen, calcium, potassium, phosphorus, magnesium, iron and sulfur. See page 6.

Microorganisms: Living organisms (such as bacteria, fungi and viruses) that are only visible under a microscope. Also called microbes.

Peristaltic pump: A common component of a dosing system. Moves liquid by mechanically squeezing along a flexible tube, pushing liquid through it.

pH (potential Hydrogen): The measurement of acidity (below 7.0 pH) or alkalinity (above 7.0 pH) of a solution. Determined by the quantity of H^+ cations (protons) present. See page 10.

PPM (Parts per Million): Not a true measure when measuring the conductivity of a nutrient solution. PPM has many different scales. Bluelab products use 500 (TDS) and 700 scales. Calculate PPM by multiplying EC by the scale required. See page 16.

Precipitation: When a chemical reaction occurs and forms a solid material that subsequently falls, as a precipitate, to the bottom of the container or reservoir, becoming unavailable to the plant.

Reservoir: A nutrient or water-holding tank.

Soluble: Is able to be dissolved in water. The opposite of this, insoluble, is a substance that cannot be dissolved in water.

Stock solution: The liquid nutrient concentrates added to water to create and maintain a nutrient solution.

Suspended solids: Solid particles of matter contained within water or nutrient solution. Can be removed by filtration.

TDS (Total Dissolved Solids): The total content of inorganic materials dissolved into water. TDS also stands for the PPM 500 scale as a measure of nutrient concentration.

Tip burn: Usually caused by too high a conductivity level, resulting in cell death occurring at the leaf tips and margins.

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**Note that the Grow Book is not fully referenced.*

Notes

Notes

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