the grow book

better plants,
better hydroponics,
in the palm of your hand

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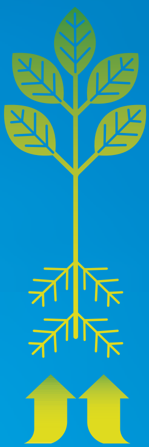

measuring the balance of health and life...

Bluelab has been dedicated to helping the hydroponic industry manage crop health and productivity easily and effectively for over 30 years.

The Grow Book provides information on the essentials for plant growth. This information, combined with our world leading water-based measuring systems, will ensure you obtain optimum plant growth and health.

bluelab®
success by simplicity

everything you need
...nothing you don't

the grow book

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Table of contents

Welcome. Meet Bluelab's customer support.

Our Grow Book will take you through some of the essentials for healthy plant growth.

In particular, we'll focus on adequate plant nutrition. We'll go over some of the key factors that affect food uptake. And we'll show you how to manage them.

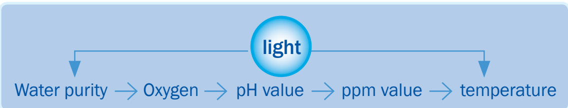
But first things first. We need to keep in mind that plants, like all living things, respond to their environments for good or for bad. A good environment breeds a healthy plant. A bad environment breeds an unhealthy plant, or can kill the plant.

You likely know the basic plant life system. But let's refresh. Through its leaves, a plant takes in light and carbon-dioxide (CO_2) from the atmosphere. Through its roots, it takes in water and nutrient from the soil or growing environment. It converts light and CO_2 into sugar, and releases oxygen (O_2). The plant then uses these sugars, the water and nutrients for its growth.

no ifs or buts

Hydroponic growing lets you give the best care possible to your plants.

The quality of care is in your control. And these are the most important factors you need to know:



It sounds simple. And it is. Like all natural processes, it's a very elegant system, refined by nature over millions of years.

Hydroponics is the first choice when you want the most control possible over plant growth. That control depends on knowing as much as possible about the growing environment. It's why we need accurate measuring systems. They tell us when things are going well, and when they're turning for the worse.

First, we measure what's happening in the growing environment. Then we can make sure we keep growing conditions superb.

We can, in other words, add our knowledge and skills to nature.

factfile

the key factors to manage

Environment
Temperature range; humidity range; clean air, proper CO_2/oxygen ratio, adequate air circulation; light – sunlight or plant lamps; support.

Food
Nutrients.

Temperature
Environment and nutrient solution.

Water
Quality and drainage.

pH level
Allows absorption of essential elements.

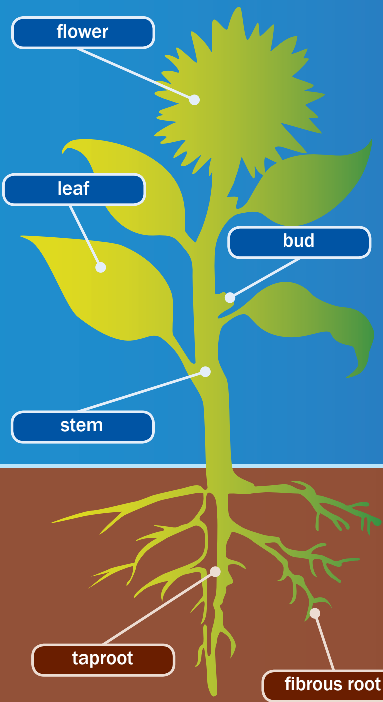
Adverse influences
Insect and disease control.

Keep your eye on the overall environment and your plants together. When you're managing the growing system as a whole, watching these key factors and responding as needed, you'll have a successful crop.

vascular system

Water and nutrient conducting tissue throughout the plant

ensure that all parts of the plant get the water and nutrition they need to grow



Shoot System

Above ground parts of the plant

› Leaves trap energy from sunlight and carbon dioxide from the air to create "food" (photosynthesis)
› leaves release oxygen into the air (respiration)
› stems provide structure and position leaves so they can collect sunlight.
› buds produce new plants or plant parts
› flowers or cones produce seeds from which new plants can grow.

Root System

Belowground parts of the plant

› anchors and supports the plant in the ground
› fibrous roots absorb water and nutrients from the soil
› taproots store "food" created during photosynthesis
› may produce new plants from root buds

It sounds obvious. And it is. Plants eat.

They get their nutrition from minerals. But they can only get all the minerals they need if certain conditions are right.

These two facts are at the heart of plant management.

Plants take in minerals as ions - through their roots, dissolved in water. Think dissolved pills.

What matters is creating the best nutrient environment. Just adding nutrients isn't enough. In fact, adding nutrients without understanding the consequences can be disastrous. You need to understand – and manage – a number of key factors.

Your growing environment could be awash with nutrients. But whether the plants can get the food they need isn't simple. The ions could be readily available. Or they could be tied up with other elements. Or tied up in the solution itself.

A key thing that affects food uptake is whether your solution is acid or alkaline. We measure this in pH.

no ifs or buts

First... **get the food mix right.**

Then... **make sure your plants can take the food in.**

Think!

- ✓ The right food
- ✓ In the right amount
- ✓ In the right growing environment

factfile

essential minerals

Plants need most, if not all, of at least 16 different elements for optimum growth and health.

Three essential elements from air and water.

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

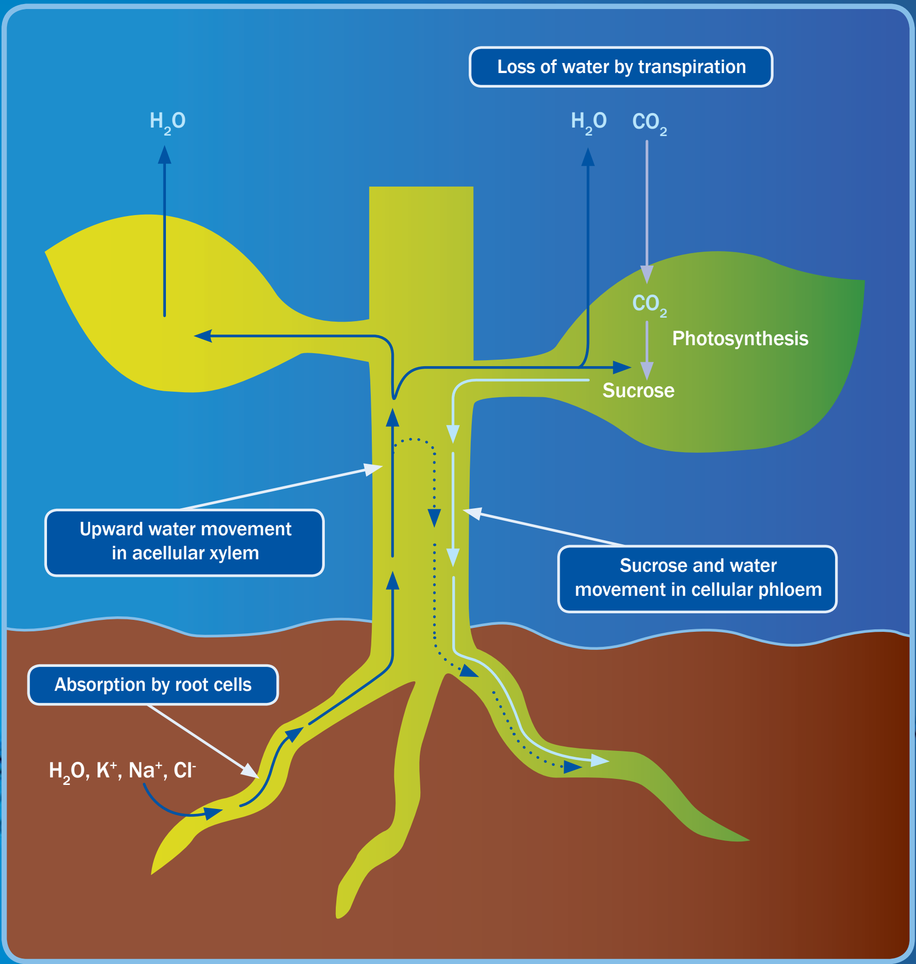
Six macronutrients

Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S). These are required in large amounts.

Other minerals, called micronutrients.

These are only required in trace amounts - boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), sodium (Na), zinc (Zn), molybdenum (Mo), nickel (Ni), silicon (Si), and cobalt (Co). The last two mentioned - silicon and cobalt - aren't needed by all plants, but they are essential to some.

transpiration



Hydroponic food

Wherever you are in the world, some soils lack certain elements. Or the elements may be present but not in forms that will allow the plant to absorb them. So, left to their own, plants will display deficiencies.

It's where hydroponics comes into its own. It's why plants grown hydroponically show rapid, strong, healthy growth. With hydroponics, you can make sure plant nutrients are always available in the right proportions. You manage and measure the nutrients you supply to your plants.

For a start, of course, you're using a soil-less growing medium. When you can add micro- and macro-nutrients as liquid as needed throughout crop life, you can increase your control over the crop. You can easily adjust nutrient levels, compensating for any environmental factors you meet.

no ifs or buts

You need to know the strength of your nutrient solution. And accurately.

It can be too strong in nutrients... or too weak in nutrients.

Too strong, and you're overfeeding. Elements can become unavailable, plant tissue can become damaged. Plants go into severe stress, become susceptible to pathogens, and they can die.

Too weak, you're underfeeding. The results are nutrient deficiencies, poor growth, poor bloom.

So how do you manage food strength? It doesn't have to be difficult.

Sure, there are all sorts of meters, monitors, feed charts, calibration fluids, etc. Don't let them scare you. Plants can stand a fair amount of stress and still produce well. But if you're prepared to learn what's necessary, you'll get consistently good results. Learn first. Don't try to fix afterwards.

While we're talking about plant care, let's mention insects and diseases. It's best to stop them getting a foothold. Be proactive. The number one thing is keep the grow area and all your equipment clean. And clean up between crops. They're the best ways to avoid common plant diseases. It's simple. Healthy plants are better at avoiding disease than stressed-out ones.

factfile

understanding mineral uptake

Several things affect the uptake of mineral ions. Uptake is dependent on weather conditions, the cation exchange capacity or CEC, the pH of the growing medium and water supply, as well as the total alkalinity of the irrigation water. pH is a big one. We'll deal with pH in detail in the following pages.

CEC (cation exchange capacity) means the ability of the growing medium to hold exchangeable mineral elements within its structure. These cations include ammonium (nitrogen), potassium, calcium, magnesium, iron, manganese, zinc, and copper.

Mineral uptake affects enzymes too. And these are important. These are proteins involved in increasing the rate and efficiency of biochemical reactions. Most require metal ions for activation and function. Without correct enzyme function, growth in an organism would stop.

Notes

Note down information about your nutrient solution or place your feed chart here.

It tells you whether plants can get at the food

There are two things to get a grip of here. And pH is the clue to both.

Your nutrient solution will either be more acid or more alkaline. Measuring the pH tells you exactly which.

pH is the measurement of acidity and its opposite, alkalinity, in a solution.

› Neutral pH is 7.0 pH.
› Acidity measures below seven pH (7.0 pH).
› Alkalinity measuring above seven pH (7.0 pH).

So if the nutrient solution is high in pH it's alkaline. Low in pH, it's acidic.

You need to maintain your hydroponic nutrient solution at a pH level where the elements in the nutrient solution are consistently available to the plant. If the solution is too acidic or too alkaline it can cause 'lock up', meaning certain elements essential for growth can't be absorbed by the root structure. It can also cause the following:

› Slow growth
› Leaf, flower and fruit drop
› Leaf discolouration
› Root burn
› Upsetting the chemical balance of the nutrient solution
› Pests and diseases entering your growing system
› Crop failure
› Death

There's not a lot to understand. But you need to get hold of it.

no ifs or buts

You need to master pH

Most nutrient elements are available to a plant when the pH is slightly acidic.

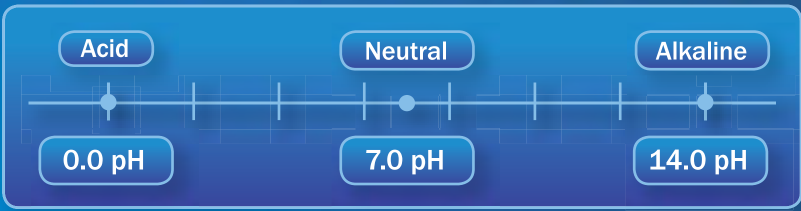
This is between 5.5 and 6.3 pH.

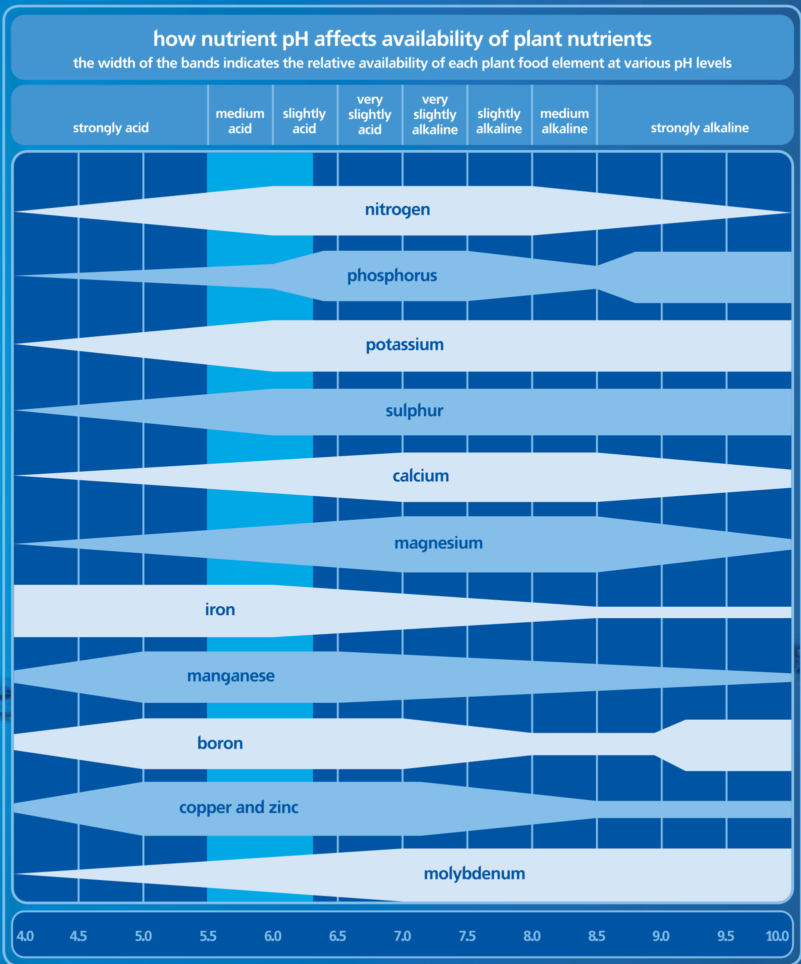
Individual crops have their own preference for pH values. That is, they do best at certain pH levels. You need to know what these are.

Whatever food solution you use, keep your pH in a fairly tight band. Consistent balance gives consistent growth.

It's not just the nutrient mix. It's the right pH that delivers the food.

Think of nutrients like a lock. pH is the key.


Acid
Neutral
Alkaline
0.0 pH
7.0 pH
14.0 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
strongly acid
medium acid
slightly acid
very slightly acid
very slightly alkaline
slightly alkaline
medium alkaline
strongly alkaline
nitrogen
phosphorus
potassium
sulphur
calcium
magnesium
iron
manganese
boron
copper and zinc
molybdenum
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0

Measuring pH matters

It tells you whether plants can get at the food

The pH measuring scale

We measure pH the same way worldwide. The scale runs from 0.0 – 14.0.

7.0 pH is the middle or neutral point. That's the middle between high acid and high alkaline.
Less that 7 = increasingly acidic, down towards 1.
More than 7 = increasingly alkaline up towards 14.

What changes pH levels?

Three main things:

1. Water. Most water. Except rainwater, tends to be slightly alkali. The carbonates in it work to neutralise the slightly acidic water in your reservoir. So as you add fresh top-up water to your tank, the pH value will rise.
2. The plants themselves. If you're growing in high light conditions, the pH value will rise. If you're growing in low light conditions, the pH value may fall.
3. Your nutrient. Nutrient stock solution is usually slightly acidic.

Using the pH scale

Measuring pH for soil crops can be tricky. It's much quicker in hydroponics, because your plant food is in liquid form.

A practical example. If your pH is too high, your plants won't be able to get the iron they need. Your food mix might have an ideal amount of iron – but the plants may not be able to absorb it. With iron deficiency, leaves will yellow and weaken.

no ifs or buts

Keep the pH balance healthy

Most plants like pH less than 7.0. An average pH for crops is 6.3. This means the solution is slightly acidic.

A measure from 5.5 to 6.3 is usual. This gives the greatest availability of all essential plant nutrients.

Remember, the measure is a compromise. The minerals are all different atomic compounds. So they're best available at their different, individual pH values.

factfile

when the pH goes higher or lower some of the compounds in the nutrient can be altered or 'de-natured'

(Minerals are compounds of atoms.) This means the acid or alkali can snap the atomic bonds. This lets the free ions re-combine with other atoms to create new compounds. These might be insoluble or unusable by the plant. Meaning, they can't get the food they need.

The pH measure won't stay the same over time. And slight variations are normal - say from 5.8 to 6.5 over a few days.

But watch for big swings. They may mean danger. Extreme variations can cause mineral deficiencies. Or they can mean toxicity - by binding or releasing large amounts of various elements. Big pH swings may also mean you have unwelcome microbes living in your solution. These are pesky little things. They can change the pH to suit themselves. Deal with them by adding beneficial microbes into your solution and root zone. These typically help plants grow bigger, stronger, with better roots.And they protect the roots from bad microbes and environmental stress.

no ifs or buts

Keep your pH probe alive

We go over this in detail later. But it's worth saying now. Loud and clear.

pH probes don't last forever. Their life depends on:

› The number of readings you take.
› Contamination from the type of solution you are measuring.
› Different temperatures of the solutions.
› Age of the probe.
› If it has ever dried out.

But you can extend their life with a couple of simple habits.

Keep your probe clean. Always rinse it after use, with fresh running water.

Keep your probe glassware wet. Always replace the storage cap after use.

Remember, if it dries, it dies!

Check page 26 for all you need to know to care for your pH probe.

Adjusting the pH in your reservoir

Take extra care here. Phosphoric acid (used to lower pH), and potassium hydroxide (used to raise pH), can burn. Unless you're very experienced, you should also avoid using nitric acid and sulphuric acid.

For safety, we recommend using adjuster solutions. They're readily available. Before adding them, always pre-dilute them to a concentration of below 1% or 2% at the most.

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the science of pH

Let's dig deeper. We know pH refers to the potential hydrogen-hydroxyl ion content (alkalinity or acidity) of a growing medium or water solution. This solution consists of mineral elements dissolved in ionic form in water. We know that salts in solution ionise into positive and negative ions.

And that's the clue to pH. The pH scale tells us how strongly the electrical charges hold the atoms and molecules of substances together. When there are more hydrogen (H+) (positive) ions the solution will be acidic (pH less than 7.0). If there are more hydroxyl (-OH) (negative) ions, the solution will be alkaline (pH greater than 7.0). An exact balance of hydrogen and hydroxyl ions results in a pH neutral soil (pH=7.0) or pure (pH neutral) water.

In practical terms, as we emphasise, what matters is whether your solution is acid, neutral or alkaline. This is what affects the availability of mineral elements to plant roots.

Measuring the pH of soil and soil solutions

pH is equally important if you're growing in soils or other growing media. Just as in hydroponics, pH strongly influences the availability of nutrients and the presence of micro-organisms and other plants in the soil.

Certain plants require a particular pH range for the required nutrients to be consistently available. Low soil pH causes aluminium and manganese toxicity in plants and reduces the availability of soil phosphorus. High soil pH also reduces soil phosphorus availability and reduces micronutrients such as zinc and boron to plants.

In the past, you either presumed the pH of the soil or substrate was OK, or you sent a sample to a laboratory for testing. Fortunately, you can now get pH meters with probes made for direct use in soils.

no ifs or buts

Measuring pH in soils is not an exact science

The recommended pH range for soil crops is 6.2 - 7.2, but this is crop specific. Refer to page 15 for more information.

It's always going to be indicative rather than absolute. The key factors are:

Soil type

Growth stage of the plant. It's useful if you've recorded pH levels through the growing cycle, and have some history to go on.

Applications 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). High concentrations of CO_2 lead to more carbonic acid, which lowers pH.

factfile

what influences pH levels and pH readings in soils?

Moisture level / raw water. If the sample you want to measure is dry, moisten it with distilled water. Don't use tap water. This can influence the pH reading based on the tap water pH value.

Calibration of the pH meter and cleanliness of the probe tip. For accurate readings, calibrate the meter at least once a month or every 30 readings. Keep the probe clean and, after use, always rinse with water.

Sample selection. For field testing, take your samples some 20cm or 8 inches down in the substrate and from various areas. Then take an average of your readings. For container-grown plants, you're best to check the pH level of the substrate before planting.

recommended pH for plants

Vegetables		House plants	
Artichoke	6.5 - 7.5	Abutilon	5.5 - 6.5
Asparagus	6.0 - 8.0	African Violet	6.0 - 7.0
Barley	6.0 - 7.0	Anthurium	5.0 - 6.0
Bean	6.0 - 7.5	Araucaria	5.0 - 6.0
Broccoli	6.0 - 7.0	Azalea	4.5 - 6.0
Brussels sprouts	6.0 - 7.5	Begonia	5.5 - 7.5
Cabbage	6.0 - 7.5	Camellia	4.5 - 5.5
Carrot	5.5 - 7.0	Croton	5.0 - 6.0
Cauliflower	5.5 - 7.5	Cyclamen	6.0 - 7.0
Celery	6.0 - 7.0	Dieffenbachia	5.0 - 6.0
Chicory	5.0 - 6.5	Dracaena	5.0 - 6.0
Chinese cabbage	6.0 - 7.5	Gardenia	5.0 - 6.0
Corn	5.5 - 7.0	Geranium	5.0 - 6.0
Cress	6.0 - 7.0	Hibiscus	6.0 - 8.0
Cucumber	5.5 - 7.5	Jasmine	5.5 - 7.0
Egg plant	5.5 - 7.0	Kalanchoe	6.0 - 7.5
Lettuce	6.0 - 7.0	Mimosa	5.0 - 7.0
Maize	6.0 - 7.5	Orchid	4.5 - 5.5
Melon	5.5 - 6.5	Palms	6.0 - 7.5
Mushroom	6.5 - 7.5	Peperomia	5.0 - 6.0
Oat	6.0 - 7.0	Philodendron	5.0 - 6.0
Onion	6.0 - 7.0	Yucca	6.0 - 7.5
Pea	6.0 - 7.5	**Lawn**	
Pepper	6.0 - 7.0	Lawn	6.0 - 7.5
Potato	4.5 - 6.0	**Fruit**	
Sweet Potato	5.5 - 6.0	Apple	5.0 - 6.5
Pumpkin	5.5 - 7.5	Apricot	6.0 - 7.0
Rice	5.0 - 6.5	Cherry	6.0 - 7.5
Shallot	5.5 - 7.0	Grapefruit	6.0 - 7.5
Soybean	5.5 - 6.5	Grapes	6.0 - 7.0
Spinach	6.0 - 7.5	Lemon	6.0 - 7.0
Strawberry	5.0 - 7.5	Nectarine	6.0 - 7.5
Sugar bett	6.0 - 7.0	Orange	5.0 - 7.0
Sunflower	6.0 - 7.5	Peach	6.0 - 7.5
Tomato	5.5 - 6.5	Pear	6.0 - 7.5
Watercress	5.8 - 8.0	Plum	6.0 - 7.5
Watermelon	5.5 - 6.5	Pomegranate	5.5 - 6.5
		Walnut	6.0 - 8.0

Conductivity

Tells you how much food is in your solution

To feed plants well, we have to know what we're feeding them. And, as we saw in pH, we have to know if they can get at the food.

But we also have to know how much food they have available. That's where conductivity comes in.

Measuring conductivity gives an accurate measure of the nutrients in a solution. So understanding conductivity takes the guesswork out of feeding plants. It'll also save you money.

Why conductivity? Easy. Pure or distilled water does not contain salt, so has no electrical conductivity. It has no food in it for plants. They need minerals. And when you add minerals, you create electrical conductivity. The dissolved salts in water allow it to conduct electricity.

The more mineral salts you add, the more you increase conductivity. So measuring conductivity tells you how much nutrient there is in the water base.

As we saw, there's one worldwide scale for measuring pH. But there are several scales for measuring conductivity.

What affects nutrient levels?

A number of things. As water evaporates, a nutrient solution becomes more concentrated. On a hot day, plants will take up more water than nutrients - so the nutrient level, or conductivity, will rise. Fast-growing plants need anywhere from 500-2,000 ppm of nutrient in the water. If salt levels get too high, the internal osmotic system will reverse and the plants will dehydrate.

A diluted nutrient solution is common in hydroponics. The reason's obvious. Plants growing in moderate temperatures can fairly quickly use up the food in their nutrient solution.

To keep the nutrients at optimal levels for growth or flowering, test every day.

Remember too, it's important to change the nutrient solution regularly. Plants discard wastes into the nutrient solution. You don't want these wastes to build up.

factfile

different conductivity measures

You've probably met with all or some of these terms:

EC
Electrical Conductivity

mS/cm²
millisiemens per cm²

ppm
parts per million

TDS
Total Dissolved Solids (or DS – Dissolved Salts, or MS – Measured Salts)

CF
Conductivity Factor

They're all related. They're concerned with measuring the same thing. EC, mS/cm², PPM and TDS can all be converted from one to the other.

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	250
0.5	0.5	5	250	350
0.6	0.6	6	300	420
0.7	0.7	7	350	450
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	960
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
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

Getting a grip on the different measuring scales

All these scales measure the concentration of dissolved solids in a solution. They just use different processes and scales to do so.

EC is the only absolute measure of conductivity for nutrient solutions. EC is measured in millisiemens mS/cm^2. It's the standard everywhere outside North America. It also gives the most accurate conductivity measure. This is because different tester manufacturers use different standards to convert from EC to ppm - often resulting in inaccurate and confusing ppm readings. (Use our conversion chart on page 17).

CF is closely related to EC. It just doesn't have the decimal point.

ppm verses TDS. The ppm 500 scale is the same as TDS. TDS, Total Dissolved Solids, is represented as ppm by some meters. A TDS reading of 50 means that there are 50 milligrams of dissolved solids in each liter of water. 50 ppm.

The ppm 700 scale has no relation to TDS so 70 milligrams of dissolved solids in a litre of water is 70 ppm. However, the actual ppm of a solution can only be measured accurately by chemical analysis.

Understanding these scales

We saw that EC measures are the most accurate. Most ppm meters measure in EC. They then convert this to a ppm value.

The conversion factor from EC to ppm can vary, but those most widely used for measuring nutrient solutions are the 'EC x 500' scale and the 'EC x 700' scale. These two scales are also called the KCl (ppm 500) and NaCl (ppm 700). (Worth remembering, the ppm 500 scale is also sometimes called TDS.)

ppm is a measure of the total ions in a solution. Different ppm scales measure different ions. The ppm 500 scale measures potassium chloride (KCl) concentration. The ppm 700 scale measures sodium chloride (NaCl) concentration. Both scales are used in hydroponics to measure nutrient solutions. There's a third scale too. Some meters use a '640' scale. Yes, there are more, but let's keep it simple.

This said, ppm sometimes causes confusion. Different ppm meters may give different readings for the same solution. EC meters should - depending on their cleanliness, accuracy and resolution - all give the same reading. If you're told about a target ppm, you need to know what scale is relevant.

no ifs or buts

Measure the conductivity every day

If you don't know which ppm scale to use, ask your nutrient manufacturer or use EC.

Avoid over-diluting or over-concentrating your nutrient solution.

Start with a quality nutrient.

Completely change the reservoir solution every 7 days.

Top up the nutrient level between changes - so your plants always have the right amount of food.

If you measure	TDS (EC x 500)	ppm (EC x 700)	EC	CF
Use...	1385ppm	1940ppm	2.77	27.7

EC x 500 = ppm 500

EC x 500 = TDS

EC x 700 = ppm 700

ppm 500 + 500 = EC

ppm 700 + 700 = EC

ppm = parts per million

TDS = Total Dissolved Solids

EC = Electrical Conductivity

CF = Conductivity Factor

mS/cm^2 = millisiemens

Let's emphasise a useful warning. If you don't change the entire solution at least every 10 days, and if you only top up when necessary, you risk toxic levels of certain elemental salts or metals. The amount of nutrient in the solution may be correct, but you won't know the amount of each elemental salt or metal. The result? Your plants may not have all the elements they need.

If you're growing plants in pots - in soil or soil-less mixes - there's an easy way to maintain the proper EC level. Water the plant so that a third of the solution drains out the bottom. This will wash away any salts or metals left behind from past waterings. Even with premium nutrients, use pH-balanced water every third watering.

Be aware that an EC or ppm meter can't distinguish individual minerals. It can't tell you exactly which elemental salts or metals are low, or which are too high. Some ingredients, such as urea and the chelates, won't register at all as they don't conduct electricity. You need very expensive equipment or a lab to give you these answers. It comes back to proactive management of your nutrient mix.

Think oxygen too. Fish need it in water. So do plants. The roots absorb oxygen and use it to fight anaerobic bacteria such as phytophthoroa root rot, and fungi such as rhizoctonia root rot. Keep your water moving. Let it travel against the air. It'll pick up oxygen as it flows.

Think there's been a spike in your nutrient levels? Empty the reservoir and fill it with a clearing solution. Clearing solutions also latch onto salts in the plants, and draw the salts out. They can save a crop from toxicity.

no ifs or buts

Manage your water quality

Test your water with an EC/ppm meter before you add anything to it.

Use RO water (reverse osmosis). This has four major benefits:

1. Lower overall ppm. Meaning more room for nutrients and additives.
2. Is pH neutral.
3. Reverse osmosis removes chlorine and chloramines. It removes the potential for tap water to damage beneficial microbes.
4. You avoid other pollutants and contaminants. You don't want these getting in from the water supply.

Remember, keep the water moving to keep its oxygen content up.
And manage your water temperature (detailed in the next section).

NOTE: If you don't have RO water and need to use raw water, measure the conductivity prior to mixing in your nutrient stock solution and include the conductivity reading of the raw water in the overall required conductivity.

ppm 500 crop values

Crop	ppm 500 value (TDS)	Crop	ppm 500 value (TDS)
African Violet	500 - 600	Lavender	500 - 700
Asparagus	700 - 900	Leek	800 - 1000
Avocado Pear	900 - 1300	Lettuce - Fancy	150 - 400
Balm	500 - 700	Lettuce - Iceburg	300 - 700
Banana	900 - 1100	Melons	500 - 1100
Basil	500 - 700	Mint	500 - 700
Beans	900 - 1250	Mustard/Cress	400 - 1200
Beetroot	700 - 1100	Onion	900 - 1100
Blueberry	900 - 1000	Parsley	400 - 900
Borage	500 - 700	Passion fruit	800 - 1200
Broccoli	700 - 1200	Pea	700 - 900
Brussels Sprouts	900 - 1200	Pumpkin	700 - 1200
Cabbage	700 - 1200	Radish	600 - 1100
Capsicum	100 - 1350	Rhubarb	800 - 1000
Carrot	700 - 1200	Roses	900 - 1300
Cauliflower	700 - 1200	Sage	500 - 800
Celery	750 - 1200	Spinach	900 - 1750
Chives	600 - 1100	Silver beet	900 - 1200
Cucumber	800 - 1200	Squash	900 - 1200
Dwarf Roses	800 - 1300	Strawberry	900 - 1250
Eggplant	900 - 1100	Thyme	600 - 800
Endive	400 - 750	Tomato	1100 - 1400
Fennel	500 - 700	Turnip, Parsnip	900 - 1200
Kohlrabi	900 - 1100	Watercress	200 - 900

Extremes of temperature affect us. They affect plants too.

Temperature affects plant growth, flowering, seed production and pollination. And more than these.

If it's too cold, seeds won't germinate, cuttings won't root, flowers won't produce pollen. Your plants will grow slowly or stop growing altogether. Too hot, your seeds won't germinate and cuttings won't root. Plants can die from oxygen deficiency, or succumb to pathogens that like higher temperatures.

no ifs or buts

Root health is vital

Control your nutrient solution temperature

Temperature affects the growth rate and structure of plants.

Most plants prefer a root zone temperature of 18-22ºC (65-72ºF).

(Cooler for winter crops, warmer for tropical crops.)

Keep your solution at around 20ºC (68ºF) for the best oxygen content and uptake by the roots.

High water temperature (above 22ºC or 72ºF) quickly reduces dissolved oxygen and increases the risk of root disease.

Cold water temperature can shock roots and cause other problems.

Adding water to your reservoir? Get it to the same temperature as the root zone water before you start the pumps. Rapid changes to the temperature of the solution will stress plants.

Prevent big temperature swings

In winter: Put a heat mat under your reservoir and/or use aquarium heaters for your nutrient.

In summer: Use chillers.

Protect your solution from direct sunlight: Insulate it or sink your reservoir in the ground.

If you can't prevent temperatures from rising too high: Lower plant stress levels by lowering the strength of your nutrient solution.

A warm, dry environment evaporates water quickly: Evaporation can cause big problems by increasing the concentration/conductivity of the nutrient solution.

Can't easily lower the temperature of your growing environment? Try covering your reservoir with black-and-white plastic (white side up, black side down). This will reflect light away and help prevent evaporation.

Reducing direct light on the solution will also slow or prevent the growth of algae and bacteria: If you're growing indoors, be aware of the heat from plant lamps. A slight change in a light's position can make a big difference to growth. Outdoors, or in a greenhouse, the amount of sunlight will affect the temperature of your growing environment.

Notes

Note down your temperatures to see if there are any trends.

Using a conductivity standard solution to check your conductivity meter? Not all conductivity standards note the conversion factor used. And not all ppm meters show it either. Only ever buy good brands of conductivity standards and throw them away three months after opening.

Here are the conversions required for conductivity standards and the ppm you wish to measure or test.

CF	EC	TDS/ppm 500 (ECx500)	ppm 700
27.7	2.77	1385ppm	1940ppm

Some brands of meters have to be calibrated for conductivity. Bluelab's instruments do not need calibrating for conductivity. We like to keep it simple.

pH meters require calibration solutions not conductivity standards. All Bluelab pH meters should be calibrated in two calibration solutions, pH 7.0 and pH 4.0. Meters that say they only need calibrating to 1 point (which is normally 7) can be inaccurate, especially if they say they measure the full scale from 0.0–14.0. If the reading you expect is normally higher than 7.0, calibrate with the solutions pH 7.0 and pH 10.0.

no ifs or buts

pH probes are fragile. Don't waste your investment.

Glass bulb pH probes can break. Treat them with care, and you'll get long service.

Don't touch the probe glass with your fingers – this will contaminate the probe, affecting performance.

Don't put sideways force on the electrode – this can break the glass stem.

Don't knock the probe against anything – it will damage the glassware.

A sudden temperature change can break the glassware – don't plunge a cold probe into a hot liquid.

Don't immerse in - oils, proteins, or suspended solids.

Don't kink the lead or bend sharply – the lead can't be lengthened.

You can submerge the probe in liquid - but don't submerge the BNC fitting.

Glassware is designed to stay wet.

Clean glassware regularly and carefully - it's critical to product life.

Care instructions come with the product - please follow them.

factfile

how your EC or ppm meter/ monitor works

The principle is simple. The meter has two electrodes. A small current is sent from one electrode to another. It's how we measure the ability of the solution to conduct electricity.

The temperature of the nutrient solution can affect the accuracy of the reading. Bluelab's testers are factory calibrated and compensate for temperature variables. But sometimes you'll be taking the probe from a warmish storage solution to measure a cold nutrient solution. Leave the probe in the nutrient solution for five minutes or so before using it. That way the probe will reach the same temperature as the nutrient solution. You'll need to do this most often in winter.

factfile

how your pH meter/monitor works

It is an extremely sensitive volt meter which measures the pressure of electricity. Pure water has no voltage at all but in acid or alkaline solutions there is a minute amount of electricity produced. It is too small to be measured by an ordinary volt meter. It works by taking a very small signal, multiplying it, adjusting it and then converting it to a pH level. This is the reason why pH probes must be cared for as per the manufacturer's instructions and high quality calibration solutions are used

Glass bulb pH probes are fragile. They won't last forever. They'll age through normal use, and eventually fail. But a little attention to care can extend their lives.

We listed a few 'don'ts' in the previous section. Now let's see what you can 'do' in service and care.

no ifs or buts

pH probes need it wet. That's wet. Wet.

Keep your pH probe wet.

pH probe glassware is designed to stay wet. You must keep it wet for optimal performance.

If it dries, it dies! Period.

Conductivity probes need cleaning and testing at least once a month.

Cleaning probes: keep them alive and accurate

When you buy a pH probe, you're buying a scientific instrument. You need to clean and calibrate it regularly. Do this, and you'll extend its life.

If your probe gets contaminated or dirty, it will lose accuracy. Helpfully, the Bluelab Truncheon Meter and Bluelab conductivity probes will read 'low' when the probe is contaminated.

So, again (something we repeat often), it's worth getting into the habit of cleaning.

Caring for pH probes

How to clean a pH probe

Step 1. Rinse the tip under fresh running water.

Step 2. Fill a small container with clean water. Add a small amount of mild detergent - such as dishwashing liquid.

Step 3. Put the probe in the container. Slowly stir it through the liquid. Make sure you don't knock the probe on the side of the container. This may damage the probe.

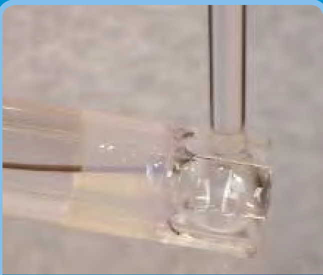
Step 4. If there's heavy contamination on the probe tip (nutrient salt build-up or algae), gently brush around the glassware with a few drops of mild detergent (dishwashing liquid) and a soft toothbrush. Give special attention to the area where the conductive wick comes out by the glassware. **But don't pull out or touch the wick.**

Step 5. Rinse it well under fresh running water. Remove all traces of detergent.

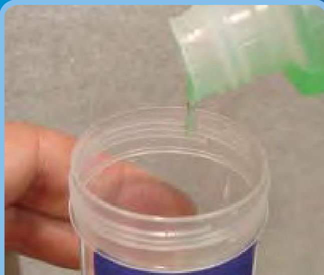
Step 6. Re-calibrate the instrument. Use freshly decantered Bluelab pH calibration solutions.

If you're not using it again immediately, put the storage cap on the probe tip to keep it moist.

cleaning your pH probe



Step 1

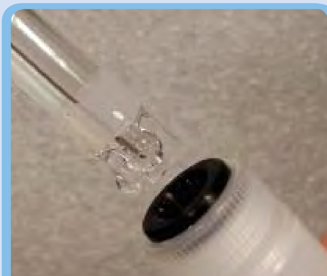


Step 2

Step 3

Step 4

Step 5



Step 6

Calibrating pH probes and meters: the 'why's

- To extend their life.
- To ensure accuracy. (Accuracy also depends on the solution quality, and on the age, use and cleanliness of the probe.)
- When you get a reading you weren't expecting.
- When the probe is new.
- If it's been a month since the last calibration.
- When you've done more than 30 readings.
- When the meter is re-set after an error message.

Calibrating pH probes and meters: the 'how's

It's not hard. It's very easy.

- First clean the probe.
- Pour a small amount of pH 7.0 and 4.0 into two small containers.
- Place the pH probe into pH 7.0 solution.
- Press the calibrate button (some meters differ – see instructions, the back of Bluelab meters or see the instruction manual).
- Rinse the probe in fresh water.
- Place the probe in pH 4.0 solution.
- Press the calibrate button.
- Rinse the probe in fresh water.
- Replace the storage cap with a little of the pH 4.0 solution.

Storing pH probes

- Glassware is designed to stay moist. Keep it wet for optimal performance.
- Long-term storage? Put a small amount of clean water (not distilled) or pH 4.0 solution in the storage cap and place over the probe tip. Never store the probe in de-ionised or distilled water. This will permanently damage it.
- If your pH probe has been allowed to dry out, soak it in water for 24 hours before use to re-hydrate it. BE WARNED; It may already be too late as the probe could have already suffered permanent damage.
- Always rinse probes off after use.

NOTE: The reading is only as accurate as the probe is clean!

Caring for conductivity probes

How to clean a conductivity probe:

- Remove the shroud from the probe.
- Put a few drops of Bluelab probe cleaner onto the probe face and rub vigorously with a finger or Bluelab chamois.
- Rinse under running water to remove all traces of cleaner.
- SHAKE DRY ONLY.
- Place shroud back on and test in a conductivity standard.
- If the reading is still low, clean again and test until the unit reads 2.7, 2.8 or 2.9 EC.

Calibrating conductivity probes

- Not required with Bluelab products. They are factory calibrated, so only require cleaning and testing.

Storing solutions

› Use Bluelab calibration solutions and conductivity standards. They're manufactured specifically for the purpose and they're referenced to high laboratory standards.
› Store the solutions with the cap on firmly to prevent evaporation.
› Store them in a cool place out of direct heat and sunlight.
› Replace the solutions three months after opening.
› **DO NOT take a reading directly from the bottle. You'll get contamination and have to discard the whole bottle.**

Storing meters

› Keep meters out of direct sunlight. It can cause irreparable damage to the LCD display.
› Store in a cool, dry, clean place when not in use.
› If the meter you use isn't waterproof and it's splashed with water, wipe it dry ASAP.
› Put a small amount of pH 4.0 solution or fresh water in the probe storage cap (as under 'storing probes' above).
› If you're storing for longer than 2-3 weeks, remove the pH probe from the meter's BNC fitting and place it in the solution described above. Then put it in a secure place.
› Take out the batteries to avoid any leakage if storing for a long period.

Batteries

Some don'ts to remember

› Don't mix brands or types and don't mix old with new.
› Check for corrosion at least every six months. Batteries that have been in the unit for a long time may corrode. If you find signs of corrosion, clean the contacts immediately.
› If you have a meter with a twist on the battery cap, make sure it's on tight to keep it waterproof.
› Remove batteries if you are storing your meter for long periods of time.

We hope you have found our ‘Grow Book’ to be a valuable tool for your pursuit of the perfect crop and that we have dispelled any myths or misconceptions you may have heard or had.

We are open to any questions or feedback you may have.

We want to ensure that the ‘Grow Book’ remains relevant and provides all the information that will support a new or experienced grower.

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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 acid are used to lower the pH value of a nutrient solution.

Actual value Refers to the present CF (Conductivity Factor) of pH within the hydroponic system.

Additive Specialist materials added to the nutrient solution in order to enhance some aspect of plant growth or system operation, eg OGP, potassium silicate.

Aeration Introducing air to the growing media and/or nutrient solution to provide adequate oxygen for plant root zones. (See 'Oxygenation'.)

Agitation Mixing or aerating nutrients – generally in the holding tank by means of a pressurised jet of nutrient or via a stream of air introduced by a venturi.

Air movement Essential to all growing. Air movement supplies carbon dioxide (CO_2) to the plants for the function of photosynthesis.

Alarms Automatic protection systems to alert the grower of an undesirable growing situation.

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 used in hydroponics for raising the pH value of nutrient.

Alkalinity The alkaline concentration of a nutrient solution.

Ambient Refers to the current surrounding area, such as 'ambient temperature'.

Anion A negatively charged ion – one of the basic building blocks of nutrient solutions. (See also 'Cation'.)

Aqueous concentrate Nutrients or other chemicals dissolved in water to form stock solutions.

Artificial lighting Electric light-bulbs and tubes used to replace or supplement the energy normally provided by the sun for photosynthesis.

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

Automatic Any device or process operating independently of the grower.

Backup systems Emergency control, power or water supplies in case of failure of normal mains supplies.

Bacteria Micro-organisms, usually single-celled, occurring in a wide variety of forms. Usually found as free-living saprophytes, bringing about natural decomposition, or parasites, many of which cause disease.

Ballast An electrical device that starts and regulates fluorescent and discharge lamps.

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

Batching Mixing a volume of ready-to-use nutrient solution – generally done for 'to waste' systems.

Bleach Common household bleaches can be used to disinfect growing systems.

Bloom The flowers or blossoms of a plant.

Blue-print temperature The most desirable temperature for promoting growth and good health for a particular crop type.

Bolt Rapid stretching or going-to-seed prematurely of a plant, exacerbated by low light and/or undesirable temperature conditions.

Bottom heat Providing heat beneath a growing container to promote root growth over top growth.

Bottom watering Providing nutrient to the base of a container to allow capillary action for the plant's requirements.

Bud The protuberance on a plant stem which contains the undeveloped shoot, leaf or flower.

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

Buffer solution A stable solution of known pH value used to calibrate pH meters.

Burn Often called 'tip burn', usually caused by too high a conductivity level, resulting in cell death occurring at the leaf tips and margins.

Calibration Adjusting meters and controls to known standards.

Canopy The top growth of a plant, receiving most of the available light.

Carbonic Acid A weak acid, H_2CO_3 formed in solution when carbon dioxide is dissolved in water. $CO_2 + H_2O > H_2CO_3$.

Catchment Describes the drainage installation in a hydroponic system.

Cation A positively charged ion – the opposite to anion (see 'Anion'). Basic to nutrients and the way in which plants can absorb them.

Centigrade A measurement of temperature. Freezing point at sea level equals zero degrees and boiling point at sea level equals 100 degrees.

CF (conductivity factor) A scale of conductivity often used in Australia and New Zealand.

Channel See 'NFT gully'.

Chlorine An oxidising chemical used to sanitise water supplies and systems.

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.

Condensation The process of water vapor turning into water droplets.

Conductivity An electrical measurement of the total soluble salts contained within a solution. See page 16.

Conductivity meter Measures the electrical conductivity of a solution.

Contaminate (contamination) To make impure or to corrupt by exposing to some other unwanted chemical or agent.

Deficiencies Poor plant health or low productivity caused through too low a concentration, or the unavailability, of an essential mineral element.

De-ionisation Removal of all foreign ions in water - ie removal of impurities by distillation.

Desired value The nutrient CF, pH and/or temperature values required by a grower, set on an automatic dosing controller.

Dose (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.

Dosing bin A device to meter out a nutrient concentrate to a growing system.

Dosing systems Automatically monitor the status of nutrient in a growing system, and add new supplies of nutrient concentrates or pH correctors as required, to maintain the desired nutrient values.

EC (electrical conductivity) Pure or distilled water has no electrical conductivity. Added minerals (dissolved salts) create electrical conductivity. Measured by several different systems. See page 16.

Fahrenheit A measurement of temperature. Freezing point at sea level equals 32 degrees and boiling point at sea level equals 212 degrees. Largely used in the US and, to a lesser extent, in the UK.

Fertiliser – nutrient In conventional growing the materials used for feeding plants are generally referred to as fertilisers. These may not be readily soluble. In hydroponics we refer to them as nutrients, and all constituent parts of the formula must be 100% soluble in water.

Float switch Measures liquid level. When operated sends a signal to other equipment, ie a fresh-water make-up valve.

Float valve See 'Ball cock'.

Flushing Periodically washing out growing beds and systems with fresh water.

Formula Recipe for a mixture of several nutrient elements.

Humidity Measures water vapor in the air.

Hybrid A new variety of plant produced by combining plants of different genetic make-up.

Hydroponics The art of soil-less cultivation.

Irradiation level The intensity of artificial light required by a plant for effective photosynthesis.

Jif Trade name of a domestic liquid scouring preparation used for cleaning porcelain and enamel products, similar to 'soft scrub' in the US. Used for cleaning the surface of measuring probes.

Light The essential energy that provides for plant growth.

Lock-up If your nutrient solution is too acidic or too alkaline it can cause 'lock-up', restricting certain elements essential for growth from being absorbed by the root structure.

Major elements (macro-elements) The major elements for plant growth, including nitrogen, calcium, potassium, phosphorus, magnesium, iron and sulphur. See page 6.

NFT – nutrient film technique (also 'gully') Hydroponic growing system, with plants bare-rooted into a gully through which a thin film of nutrient solution flows.

Nitric acid A dangerous acid to use. Take extreme care and use only when additional nitrogen is required in the formula without the addition of any other element.

Nutrient tank Usually the main holding and nutrient status adjustment tank within a hydroponic system.

Oxygen (oxygenation) Essential for all living things. Oxygen is produced by plants as a by-product of photosynthesis. An essential gas for the root zone of all plants.

Parts per million (ppm) Scientific measurement of chemicals within a solution. (See 'ppm'.)

pH value The measurement of acidity (below 7.0 pH) or alkalinity (above 7.0 pH) of a solution. See page 10.

Peristaltic pump Moves liquid by mechanically squeezing a flexible tube and pushing liquid along the inside of the tube.

Phosphoric acid The preferred acid for use in pH correction of nutrient solutions.

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 (KCl) scales for those reluctant to change to EC. Calculate ppm by multiplying EC by the scale required, eg 2.5 EC x 500 = 1250 ppm. See page 16.

Probe conductivity and pH probe Purpose-designed probes for immersion into the nutrient to take measurements.

Reservoir A nutrient or water-holding tank.

Shroud The protective (and essential) vented cover fitted to the tip of a DIP-type CF probe.

Slope pH Term used when calibrating a pH meter to values either side of 7.0 pH.

Stock solution The A and B liquid nutrient concentrates used for addition by a dosing system to maintain a growing system's desired nutrient values.

Suspended solids Solid particles of matter contained within water or nutrient – can be removed by filtration.

TDS (total dissolved solids) The total content of inorganic materials dissolved into water – often incorrectly used as a measure of the strength of nutrient solution. Nutrient strength should always be measured with a conductivity meter. TDS also stands for the 500 ppm scale.

Temperature differential The difference between temperatures – generally referring to temperatures between the inside and outside of a heat exchange tube, or the inside and outside of the walls of a greenhouse, etc.

Total dissolved solids See TDS.

Venturi A passive device that is used in hydroponics to inject air (oxygen) into the nutrient solution.

guarantee.

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lets talk.

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