Throw Away Your pH Meter: A Nutrient Breakthrough that Eliminates the Need for pH Monitoring and Adjusting

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CONTINUING A SERIES OF WHITE PAPERS BASED ON RESEARCH AND FACT

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Throw Away Your pH Meter: A Nutrient Breakthrough that Eliminates the Need for pH Monitoring and Adjusting

One of the main challenges you face in your hydroponic garden is maintaining the correct pH throughout the life cycle of your crop. You have to monitor the reservoir or the growing medium with a pH meter or pen and watch the leaves for any discoloration or other signs of nutrient deficiencies. If the pH changes, you have to add harsh chemicals such as pH up or pH down to the nutrient solution. The whole process is stressful—not only for you, but also for your plants. This white paper describes groundbreaking technology that allows you to effortlessly stabilize and maintain the pH for bigger yields and better harvests.

Tackle the challenge of pH

Just like every hydroponic grower, you face the same challenge: how to maintain the correct pH throughout the life cycle of your crop. The solutions used to include:

- Constantly monitoring the reservoir or the growing medium with pH meters and pens,
- Carefully watching the leaves for discoloration or other signs of nutrient deficiencies,
- Or just plain guesswork.

And whenever the pH became a problem, you had to add harsh chemicals, such as pH up or pH down additives, to your reservoir, causing sudden changes in pH that could be stressful for your plants.

All that has changed. This white paper answers the question, “What is pH?” It also explains how to use this new knowledge for bigger and better harvests.

What is pH and why is it so important?

pH is the measure of the level of acidity or alkalinity of the nutrient solution and growing medium. Figure 1 shows the pH values of various common materials from battery acid to lye.

To achieve optimal growing conditions, you want to maintain the pH of your hydroponic

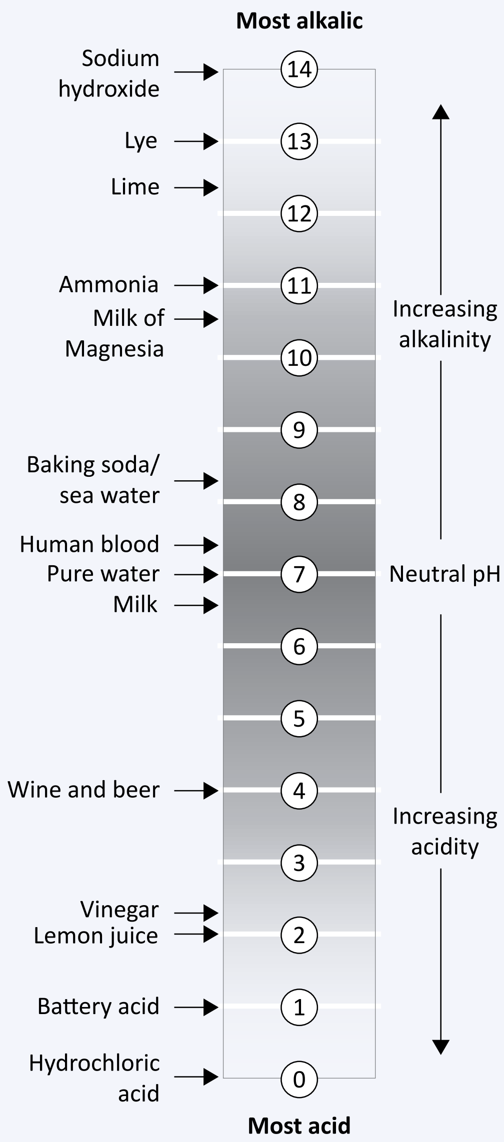

Figure 1. pH can vary widely, but living organisms thrive when it is close to neutral. The pH level inside plants and human beings is slightly above 7. However, plant roots prefer a more acidic pH.

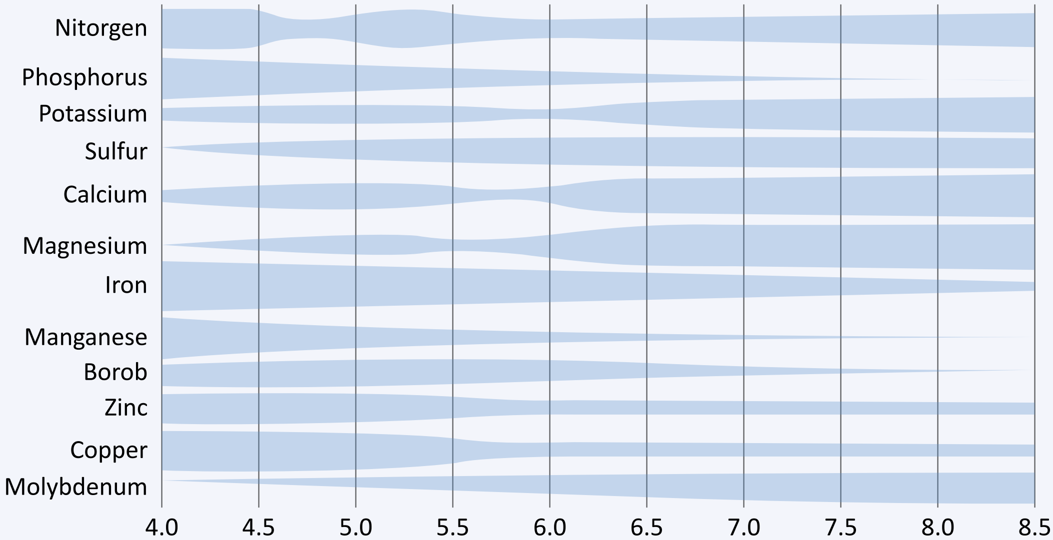

Figure 2 shows how pH affects the absorption of different nutrients: magnesium prefers slightly (but not too) alkaline pH; iron is better absorbed when the pH is more acidic. The optimal pH range for your plants is a compromise between the preferred pH absorption ranges of different nutrients.

system in the range best suited to your plant species. Here is why this is so important.

Living, growing organisms such as your high-value plants are essentially chemical machines. One of your most important jobs as a grower is to keep those chemicals in balance. This means avoiding a shift in the pH toward either pH extreme: excessive acidity or excessive alkalinity.

The pH level makes the difference between having a growroom full of nutrient-healthy, thriving plants and seeing your time, effort, and money end up on a compost pile.

Here's what happens when the pH gets out of balance

When the pH of your hydroponic system gets out of balance—which can happen quickly if some kind of stabilizing agent or mechanism is not put in place—the ability of your plants to absorb macro-, secondary, and micronutrients, as well as vitamins, carbohydrates, and other beneficial sources, is limited. Figure 2 shows how the ability of your plants to absorb various nutrients is affected by a fluctuation in the pH of the nutrient solution or growing medium.

The pH scale was introduced in 1909 by Danish biochemist Søren Peder Lauritz Sørensen of the world-renowned Carlsberg Laboratory in Copenhagen. In practical terms, pH is a measure of the concentration of hydrogen ions: in other words, the level of acidity (low pH) or alkalinity (high pH) of a solution. A pH of 7 is considered neutral.

For example, when the nutrient solution has a high (alkaline) pH, iron and manganese are locked out. That's because they form poorly soluble chemical compounds. Adding chelators to compounds helps to keep them in bio-available form. However, chelation itself is a pH-dependent process. (Read our white paper on chelation and how it provides your crops with a secondary layer of protection against poor water conditions and extreme pH ranges.)

Another reason why pH is so important for the absorption of nutrients is biochemistry. Nutrients cannot enter the plant roots on their own because plant cells are protected by membranes that are difficult for water-soluble ions to penetrate. To overcome this barrier, nutrients are carried inside the plant by special transporters. These transporters are big protein molecules flowing in the cell membranes. They recognize nutrient ions and let them enter the plant cells. Since proteins are rich in ionizable chemical compounds, their function is dependent on pH. Thus, every transporter protein has an optimal pH range where it works best.

In addition, the beneficial bacteria and fungi included in sophisticated hydroponic supplements need a consistent pH. These microorganisms thrive at pH 5.5–7.0 (Perry, 2003). A more acidic pH can foster an environment that allows the growth of pathogenic microorganisms, which may pose a risk to plant health.

In fact, pH affects every function of the root zone.

For example, carbohydrate transporters in the roots require the right pH in order to perform their job of absorbing carbohydrates. These carbs are assimilated from decaying organic matter or carbohydrate supplements, which the plant uses as food. (Read our white paper on carbohydrates, the role they play in flowering, and how best to apply carbs to your hydroponic garden.)

Maintaining the normal pH of the nutrient solution and growing medium as close as possible to your plant species' unique pH "sweet spot" is critical to obtaining a rich harvest. The sweet spot is the optimal pH range where all the plant-essential nutrients are readily available for absorption. For the plants you grow, the sweet spot is pH 5.5–6.3.

This pH range is always a bit of a compromise because different nutrients are better absorbed by plants at slightly different pH levels. For example, phosphate is best absorbed at pH 6–7 while non-chelated iron prefers a more acidic pH 5–6 (Olsen, 1958). However, every plant species—indeed, every variety of every species—has a favorite pH range where it flourishes.

Consider the typical plant grown hydroponically

Plants grown in hydroponic greenhouses are an excellent example of why and how pH is so important. These plants come in many varieties from all over the world. Because in nature they have evolved in so many locations, they have had to adapt to a wide variety of climates, ecosystems, and soils with various pH levels.

For example, popular Geranium varieties are descendants of wild plants from South Africa. Tomato plants, *Solanum lycopersicum*, originated in Central America. The soils of these regions are poor with a pH between 4 and 5.

These are just two examples of how so many of the plants we commonly grow originally grew in hostile or suboptimal conditions—to which they successfully adapted. Does this mean they should be grown in these same conditions (for example, within an acidic or alkaline pH range) in your growroom?

Not necessarily.

So why subject these or other commonly hydroponically cultivated plants to a standard pH range?

To answer this question, consider the heavy demands that hydroponics puts on plants. For example, in their wild state, the ancestors of modern varieties are poorly suited to indoor growing because they are much less productive or too tall for most growrooms. To solve this, wild varieties have been crossbred with existing indoor varieties. The new hybrids have the same aroma and taste as their wild cousins, but they are more productive and more suitable for cultivating indoors. They also require a less acidic pH than their tropical ancestors. The reason for this change in pH preference is the modern hydroponic fertilizers used by breeders.

For almost a century, such fertilizers had a typical starting pH of greater than 5—and most still do. Thus, adaptation of most wild food and flowering plants to hydroponic growing conditions has resulted in hybrids that prefer a consistent range, generally pH 5.5–6.3. Maintaining that range is a critical factor to your growing success, as we will see later in this white paper.

Why is maintaining a stable, consistent pH so difficult?

Three major factors tend to disrupt the stability of the pH in any hydroponic system. Learning to control these influences is essential for a successful harvest.

pH imperfection #1: the pH of the water used to dilute nutrients

Freshly distilled or deionized water has a pH of 7. However, the pH of the water may fall to as low as 5.5 within hours of preparation. This is because water absorbs carbon dioxide (CO_2) from the air.

The behavior of tap water is even more complex. It contains dissolved and slightly alkaline calcium and/or magnesium salts. In this case, absorption of CO_2 from the air makes predicting the pH even more challenging.

Because the calcium and magnesium salts in most tap waters, not to mention even

How to measure pH with a meter

1. *Calibrate your pH meter before each measurement:*
    - *Why? Because the electrode does not give reliable readings over long periods of time.*
    - *How? Calibration should be performed with at least two standard buffer solutions that represent the low (the most acidic—usually pH 4) and the high (the most alkaline—usually pH 10) extremes of the pH range to be measured*
        - *1.1. Bring all your solutions to room temperature.*
        - *1.2. Wash the meter probe with distilled or deionized water, then blot dry it.*
        - *1.3. Put the probe in the pH 4 buffer, stir slowly, and adjust the meter to pH 4.*
        - *1.4. Rinse the probe in distilled or deionized water, then blot dry it.*
        - *1.5. Repeat the process with the pH 10 buffer solution.*
        - *1.6. Repeat steps 1.2 to 1.5 until the readings at both ends of the pH range are stable.*
2. *Rinse the probe, blot dry it, and measure the pH of your nutrient solution and/or growing medium.*

more chemically complex well and spring waters, create such serious problems, many hydroponic growers, from hobbyists to huge commercial greenhouses, prefer using treated water. Although a number of water treatment systems exist, reverse-osmosis (RO) is considered the most economical. Water obtained from an RO system is almost as good as expensive distilled water.

During your crop's life the growing media undergo subtle changes that affect the pH of the nutrient solution.

Another option is to adjust the pH of tap water before using it. This can be done with so-called pH up or pH down additives. However, this task is demanding and often done incorrectly—and what's worse, the acidic and alkaline chemicals used in these products, and the resulting sudden fluctuations in pH when they are added to the reservoir, can be hard on your plants.

pH imperfection #2: biochemical processes in the nutrient solution

Many pH changes are caused by the nutrients themselves.

The more compounds in the water—measured in parts per million (ppm) or by the nutrient solution's electroconductivity (EC)—the greater their influence on pH.

For example, the urea used in many fertilizers is broken down by enzymes into one molecule of CO_2 (a slightly acidic compound) and two molecules of ammonia (a slightly alkaline compound). This can cause erratic changes in pH.

In addition to urea, any compound containing an amide chemical bond (e.g., the proteinates used in many fertilizers) can, when broken down, affect the pH in unpredictable ways.

Nutrient absorption also leads to changes in pH. When a plant absorbs a lot of potassium ions, it gives out hydrogen ions in return. The result is a net decrease in pH. The situation reverses when the plant absorbs a lot of nitrate ions and gives out hydroxyl ions to compensate, thus increasing the pH (Bar-Yosef, Ganmore-Neumann, Imas, and Kafkafi, 1997; Ryan, P.R. and Delhaize, E., 2001). The higher the rate of nutrient absorption, the more dramatic the change in pH.

pH imperfection #3: the substrate through which the nutrient solution flows

The growing medium (also called the substrate) affects pH as well. For example, coco-based growing media undergo subtle changes during your crop's life cycle that affect the pH of the nutrient solution. Even baked clay pellets, which are far more stable than coco coir in terms of pH, are less than rock solid in this regard.

In fact, every chemical or biochemical process that goes on in the growing vessel changes the pH of the nutrient solution. Each additional factor drives it further from the sweet spot.

In nature, the volume of surrounding soil—teeming with microbes, humates, and other pH stabilizing agents—does a good job of offsetting pH changes. Natural soils thus act as natural pH buffers. That's why, in outdoor gardens, where the soil itself contributes to a more stable, consistent pH, changes in pH are more gradual than in a hydroponic gardens.[1]

In hydroponics, however, pH stability is a challenge. It is an intense gardening method where the concentration of nutrients and their absorption rate by plants are much higher than in soil. As a result, chemical and biochemical processes influence the pH to a much higher degree than in natural soils or traditional agriculture. The natural stabilizers and buffers in the nutrient solution, mainly phosphates, are weak, so indoor gardeners have to check the pH of the nutrient solution regularly and adjust it when it goes below or above the sweet spot. What a hassle.

pH buffers and stabilizers: the secret to pH balance

As already mentioned, in biochemistry, including agrochemistry, the pH of the nutrient solution and growing medium is balanced and maintained by pH buffering and stabilizing agents. But which stabilizers

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1 However, even in outdoor gardening, the pH often needs to be adjusted with soil amendments that are appropriate for specific crops. For example, lime is applied to certain soils to increase pH for lawns, and sulfuric fertilizers are sometimes applied to reduce pH for blueberries or azaleas, which prefer more a more acidic pH range.

and buffers, and how much, are needed? Unfortunately, there is no easy answer.

Every pH buffer and stabilizer has its own optimal pH range where it works best. For example, phosphate stabilizes the pH in the area of 7.2. Other ions with pH buffering properties which are present in conventional nutrient systems are even less effective at stabilizing the pH near the sweet spot.

So, growers need guardrails of sorts along the nutrient highway to ensure that after the initial reaction that adjusts the pH within the sweet spot, it stays locked within that pH range. In this way, the pH will not be allowed to drift too far one way or the other along the pH scale. This serves as a kind of failsafe mechanism, providing you with further peace of mind while safeguarding your valuable crops.

The task assigned to the scientists at Advanced Nutrients was to research every available option for stabilizing and buffering the pH of the nutrient solution and growing medium. They were asked to develop a pH buffer and stabilizer that worked well in maintaining the pH within the sweet spot without an excessive amount of acids or alkalis.

One problem they encountered was the fact that every pH stabilizing agent has a limited pH-balancing capacity. For example, a weak stabilizer or buffer can handle only minor deviations from the optimal range caused by a small amount of acids or alkalis. By contrast, a strong stabilizer or buffer, with a large pH-balancing capacity, can keep the pH equalized even when large amounts of acids or alkalis are present in the nutrient solution.

Unfortunately, pH buffers and stabilizers cannot be strengthened at will in hydroponics. Cultivating crops involves more than pure chemistry.

Another factor is cost. Sophisticated stabilizers and pH buffers having all the desired properties, including low plant toxicity, are costly. Therefore, increasing their concentration can make a fertilizer prohibitively expensive.

More serious problems arise when plant biology comes into play. For example, the optimal pH inside a plant's tissues is higher than outside the plant—generally in the range of pH 7.2–7.5. Fortunately, plants have their own mechanisms that keep the pH within this range. But by adding only a small portion of the wrong external pH buffer or stabilizer, you can destroy your plants' internal pH-balancing system. The result is damage or even death to the plant.

Yet another problem arises when you look at your plants' microscopic root tips. These fragile tips pump hydrogen ions into their immediate vicinity to make the pH more acidic. Here the pH can drop to

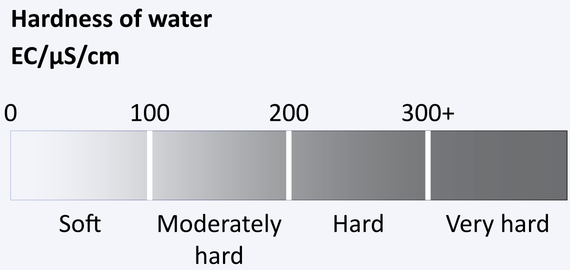

Figure 3. Water mineralization—or, in colloquial terms, its “softness” or “hardness”—is usually measured in electroconductivity (EC).

as low as 4. This acidic pH level exists just around the tips. However, it is crucial for overall development and growth of root mass (Nye, 1981). Adding too much pH stabilizer or buffer can destroy the ability of these tender root tips to create the desired acidic micro-environment. If that happens, overall root development will be slowed, resulting in poor yield.

Enter pH Perfect® Technology, making pH maintenance easy and effective

While isolating pH buffering and stabilizing agents suitable for hydroponics, the research team realized they would have to compromise between chemistry and biology.
For example, they wanted to find pH stabilizers and buffers that would allow growers to use any source of low-mineralized water. The resulting proprietary pH buffering agents and stabilizing mechanisms became the foundation of a new system aptly called pH Perfect® Technology.

But developing a groundbreaking pH buffer and stabilizer wasn’t the whole answer. It required many years of field testing to determine the proper concentration for pH Perfect base nutrients.

From a technical standpoint, the water they used had an EC of less than 160 µS/cm—equivalent to roughly 100 ppm, depending on the specific conversion chart you use.

How well does it work?

If you use RO water or water with EC up to 160 µS/cm (Figure 3), or approximately 100 ppm, pH Perfect base nutrients will guarantee the sweet spot. (Read our pH Perfect efficacy report[2] proving the stabilizing and buffering performance of pH Perfect.)

You need to use RO water if you want to be absolutely safe. RO water is best suited for your delicate hydroponic equipment, in any case.[3] It will keep everything clean and in tip-top shape for months and years to come.

2 This efficacy report was submitted to and accepted by the fertilizer regulatory authorities of the State of California.
3 We recommend you use an RO filtration system engineered for use in hydroponics. Such a system should include a carbon filter at one of its stages to ensure that chloramines and other chemicals are fully removed from your water.

An unplanned event even demonstrated that pH Perfect is capable of saving your harvest when an unexpected disaster occurs. During experiments with pH Perfect Technology in an Advanced Nutrients' research facility, the RO system failed. Instead of starting a new experiment, the scientists continued the experiment with highly mineralized tap water.

To everybody's surprise, there were no victims of this crash test. Plant growth slowed a bit and the pH drifted slightly above the optimal range, but thanks to the minimal deviation even at a high EC/ppm and the superior chelation in pH Perfect base nutrients, the crops survived the shock. After a couple weeks, the RO system was repaired, and even despite the unplanned event, the plants yielded a strong harvest.

Conclusions

- In biology, the pH level can make the difference between life and death. In gardening, the pH level can make the difference between a good and a disappointing harvest.[4]

- Modern varieties of the plants you grow were obtained by crossbreeding wild varieties with already existing cultivated varieties adapted to a slightly acidic pH. As a result, irrespective of their wild ancestors, virtually all hybrids are also adapted to this pH level.

- Keeping the pH of the nutrient solution and growing medium within the sweet spot is especially difficult in hydroponics. Intensive chemical and biochemical reactions lead to deviations in pH from the optimal range that are much more pronounced than in natural soils.

- pH can be balanced with stabilizers and buffers. The natural pH buffers and stabilizers present in hydroponic nutrients and growing media, such as phosphate ions, are weak and cannot maintain a stable, consistent pH. The Advanced Nutrients research team has invented a much more efficient pH stabilizing and buffering system that is non-toxic for your crops.

- pH Perfect Technology is certified to work best with low-mineralized water having an EC of less than 160 µS/cm—roughly equivalent to 100 ppm. In most cases, pH Perfect delivers good results in water having an EC of up to 320 µS/cm—approximately 200 ppm.

- Advanced Nutrients recommends that RO water be used with pH Perfect base nutrients. However, an accidental crash test demonstrated that pH Perfect

4 It is also worth mentioning that improved nutrient uptake means more of the nutrients you paid good money for will be utilized by the plant, rather than going to waste down the drain.

Technology, as well as the level of chelation in pH Perfect base nutrients, can help to protect your crops even when the RO system is damaged.

What's the bottom line?

If you use any pH Perfect base nutrient as directed, you will never again have to monitor and adjust your pH. The pH Perfect Technology automatically brings the pH of the nutrient solution into the sweet spot for optimal growth and flowering—and keeps it there for at least one week.

What's more, the supplements of the Bigger Yields Flowering System® (soon to be described in a separate white paper) are perfectly tuned to work seamlessly with pH Perfect base nutrients.

You no longer have to hassle with pH meters and pens. Relax and rest assured that the pH of the nutrient solution and growing medium is right on target, providing optimal growing conditions and nutrient absorption for your plants.

pH Perfect lives up to its name, making hydroponics easier and safer for any type of grower.

* * *

pH Perfect® Technology is included in Advanced Nutrients pH Perfect base nutrients: pH Perfect Grow, Micro, Bloom; pH Perfect Sensi Grow A & B; pH Perfect Sensi Bloom A & B; and pH Perfect Connoisseur A & B. To learn more about how pH Perfect base nutrients and the Bigger Yields Flowering System® can give you bigger harvests, dial Advanced Nutrients Tech Support at 1-800-640-9605 or visit the Advanced Nutrients website.

Read more white papers and special reports on the Hydroponics Research website at www.hydroponicsresearch.eu.

Share this white paper now with friends, coworkers, and family.

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