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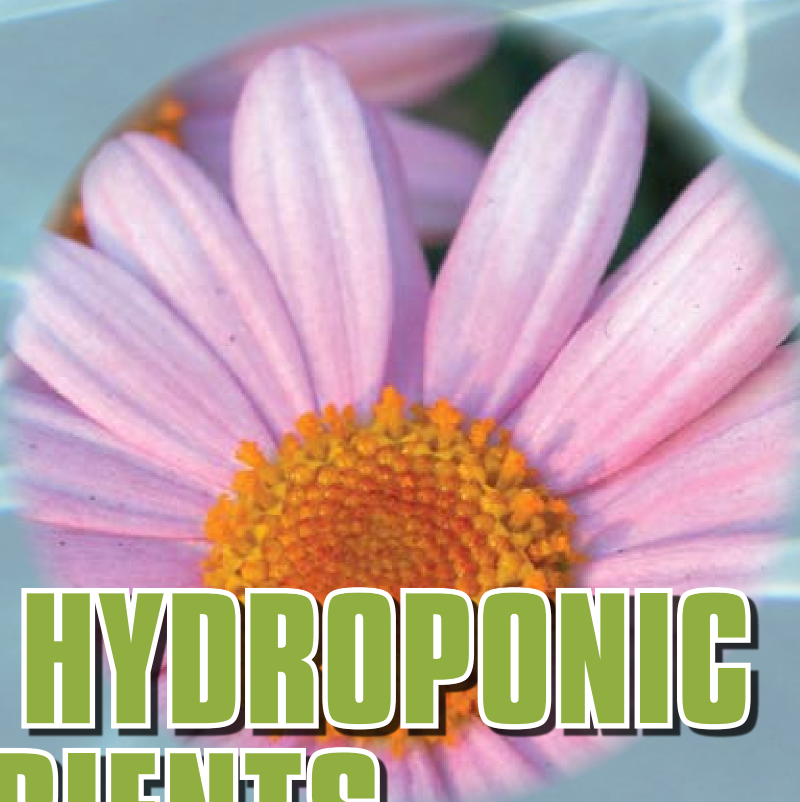


CHOOSING HYDROPONIC NUTRIENTS

PART 2: NUTRIENT CONCENTRATION, pH BUFFERING CAPACITY, EASE OF USE AND SOLUBILITY

In Part 1, which appeared in the previous issue of Maximum Yield, the essential nutrients and nutrient balance were discussed, two of six key factors in choosing hydroponic nutrients. The remaining four factors are discussed here.

Overall Nutrient Concentration

Conductivity can be used to compare the relative overall nutrient concentration of different brands and to roughly verify the concentration claim made on the label. This is done by measuring the conductivity value of the nutrient when diluted 100-fold (10 mL into 1,000 mL) with distilled water. Hence, add the following volumes to 1,000 mL of distilled water:

1-parts: 10mL of nutrient.

2-parts: 5 mL of part 'A' + 5 mL of part 'B'.

3-parts: Collect 10 mL according to the ratio of parts used to achieve a given formulation type; for example, 10 mL of bloom formulation may comprise 4 mL part 'A' + 4 mL part 'B' + 2 mL part 'C'.

Typically, the best 2- and 3-part products yield between 2.4 and 3.0 mS (cF 24 to 30). In comparison, some 1-part products yield around 2.0 mS (cF 20) and others far exceed 3.0 mS (cF 30).

However, because the conductivity of different mineral salts varies, this method can contain a degree of error. The error depends on how much the ratio of nutrient species in the different brands vary from each other, together with the type of mineral salts used. For example, judging a PK additive against a full-spectrum bloom formulation would not be a fair comparison because phosphorus shows relatively low activity with conductivity electrodes; a conductivity measurement would underestimate the PK specification. However, when comparing solutions of similar nature (e.g., bloom versus bloom), it is probably the easiest and quickest way of obtaining a good estimate of relative nutrient concentration.

pH Buffering Capacity

A high pH buffering capacity is an advantage because it ensures minimal initial and ongoing pH maintenance, especially where high alkalinity make-up water is used. This feature is extremely beneficial because lack of pH control is a common cause of nutrient failure. As a rule of thumb, a high-quality bloom formulation should require virtually no initial pH adjustment, even when used with high-alkalinity/hard water; i.e., after dilution with make-up water, the pH should always fall well within the range 4.5 to 6.5. Unfortunately, many brands fail to offer this feature.

The Significance of pH 5.0 to 6.0

It is over this pH range that all growth factors produce optimal growth. If the pH is allowed to rise much above 6.0, more than half the essential nutrient species (especially calcium, sulfate, and the trace elements copper, iron, manganese, and zinc) can precipitate, thus becoming immobile and unavailable for transport by the water flow to the roots (*see Fig. 3*).

The precise pH at which precipitation of macronutrients starts is determined by the combined concentrations of calcium and sulfate. Except for fertilizers low in calcium and sulfate, this problem commonly occurs at pH values of around 6.5 for concentrations that would yield conductivities of 2.5 mS/cm in distilled water and pH 7.0 for 1.5 mS/cm. Hence, to avoid precipitation, higher nutrient concentrations generally must be held at lower pH values.

In spite of this precipitation problem, some references advocate pH values well above 6.5 for some plant varieties — a condition that risks depleted concentrations of the above-mentioned elements. This is incorrectly justified by quoting the chart in *Figure 4* as proof. As highlighted, it is important to realize that these data are based on soil culture.

Comment on Common Recommendation of pH 6.2 (or 6.3)

Although this is a commonly recommended pH value, it has no scientific basis. It appears to have gained a sort of mythology status from the early days of hydroponics, when the only cheap means for hobbyists to measure pH was by using the common bromothymol blue pH indicator sold by pet shops

Fig. 3 The need for high pH buffering

This is what can happen to a working nutrient solution when pH is above 7: Calcium, phosphorus, sulphate (and the trace elements copper, iron, manganese and zinc) can precipitate and become unavailable to the roots. This is a sample of a high quality hydroponic bloom formulation made EC 2.6mS and pH 7.5.

for pH maintenance of fish tank water. Because the lowest pH that be determined by that indicator is about 6.2, that value has unfortunately become an entrenched recommendation in some sections of the hydroponics industry.

Overview: pH Buffering Capacity

Do not underestimate the need to maintain pH under 6.5. A high pH buffering capacity will make it easier to achieve that result by allowing less frequent checking of pH, especially where high-alkalinity water is being used. It will minimize the time spent maintaining pH and help prevent poor results from what may otherwise be a good-quality nutrient.

Ease of Use

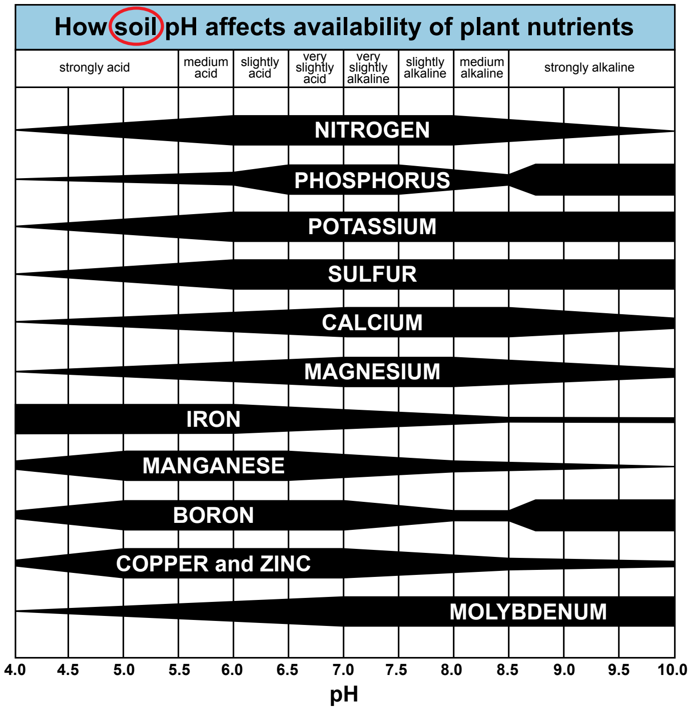
Dosing technique

In terms of simplicity, properly formulated 1-part products stand alone. Apart from the convenience of only needing one bottle, there are also virtually no dosing rules governing their use, provided sufficient pH buffering capacity is available.

On the contrary, the success of 2- and 3-part nutrients is very dependant upon dosing technique.

Adding concentrated nutrient prematurely to too little water: With 2- and 3-part nutrients, the parts are kept separate for good reason — mix them together in concentrated form (or in too little water) and a white precipitate will form. Depending on the formulation, this can happen well within a minute or so. Try this for yourself. Mix an equal volume of each part in a glass, undiluted.

Fig. 4



Ref: NSW Agriculture, 1991, Australian Vegetable Growing Handbook.
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The precipitate you can see is typically a combination of calcium sulfate and calcium phosphate. Now, add excess water and see if it will dissolve. The longer you delay dilution, the more difficult (or impossible) dissolution becomes. Along with poor pH control this is a main cause of the white precipitate in nutrient tanks. To prevent this, always add the majority of water before adding any nutrient. In addition, always stir well before each subsequent part is added.

Order of addition: The addition sequence of each nutrient part can affect nutrient stability, particularly if the water has high alkalinity. Alkalinity (bicarbonate and carbonate) is that component of natural waters that causes high pH. Adding the nutrient dose to high-alkalinity water can decrease the stability of several nutrient species (including calcium, sulfate, iron, copper, manganese, zinc). Therefore, instead of pre-adjusting the pH of make-up water (an often very difficult task), it is preferable to first add that part of the nutrient that lowers pH the most. This will be the part that contains the phosphate. In 2-part nutrients this is usually part 'B'. The part without any phosphate will impart relatively little effect on pH. This part usually contains the iron, which is highly unstable at pH levels much above about 6.5. In 3-part nutrients the phosphate is sometimes dispersed across two bottles. Therefore, determine which contains the highest concentration of phosphate and add that first.

Add equal amounts of each part: If using a 2- or 3-part nutrient, avoid "roughly" measuring out the nutrient dose. Again, an excess of one nutrient species does not compensate for deficiencies in another. In the case of a 2-part, underdosing part 'B', for example, could cause a deficiency in more than half the nutrients required (i.e., P, K, S, and all of the trace elements, excluding iron). This problem also applies to 1-part nutrients. However, mathematically speaking, the problem is compounded with 2- and 3-part nutrient products because the target dose is roughly one-half to one-third (respectively) of what it would otherwise be if using a 1-part. Consequently, the likely percentage error is much greater. Also note that for this same reason the potential error is greatest for smaller tank volumes due to smaller target dose rates.

Ongoing Maintenance

The nutrient's pH buffering capacity is a function that manufacturers can incorporate to ensure ongoing ease of use. Refer to Section 4.

Overview: Ease of Use

Dosing technique is critical for maximizing the performance of a 2-or 3-part nutrient product. For fast and easy dosing, use a highly buffered, well-balanced 1-part. Otherwise, if choosing between 2- and 3-parts, ensure a high pH buffering capacity.

Solubility

Hydroponic nutrients should be fully soluble — clear, with no deposit. This prevents equipment failure (e.g., pumps, piping, emitters, and filters) caused by blockages and sludge buildup. This is a key consideration in NFT systems or where high-pressure aeration nozzles are used, because nutrient delivery failure can cause sudden crop loss, especially in hot weather.

Note that when nutrient species destabilize at high pH, they precipitate as a solid. Therefore, pH maintenance is critical for ensuring ongoing solubility, especially where high-alkalinity make-up water is used.

Further, ensure the trace elements copper, manganese, and zinc are chelated. The unchelated forms are susceptible to precipitating within the optimum pH range.

Finally, note that the source of white precipitate above the water line, on the surface of media and equipment (e.g., clay pebbles), is caused by salt deposition from evaporation. Notably, the amount of precipitation from this source is greater at higher (EC) nutrient concentration.

Overview: Solubility

To maximize the lifespan and reliability of nutrient delivery equipment, ensure that the nutrient is fully soluble over the recommended pH range. MY