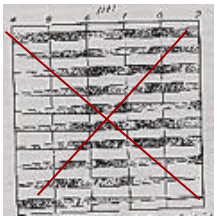
pH Management of Hydroponics Solutions

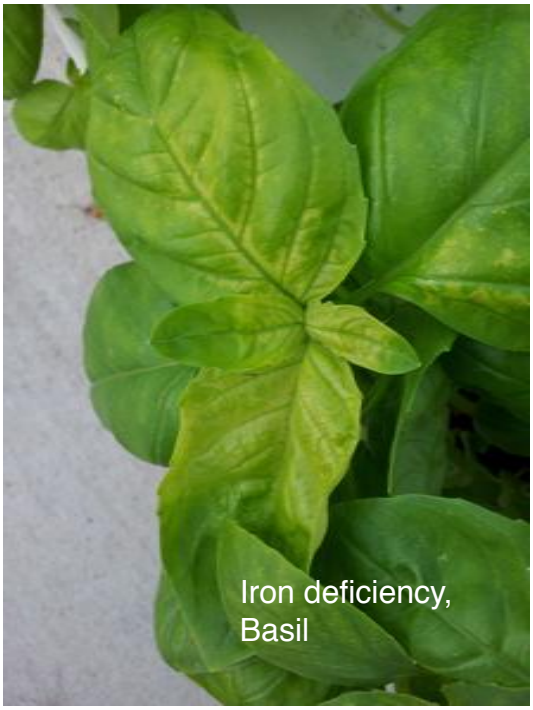
A question often asked is what is the best pH for a particular crop nutrient solution. The answers given in many texts, and often by advisers to growers, are frequently based on misunderstood information. Many refer to the availability of nutrients to plants at different pH's based on research by Troug (1946) [Proc. Soil Sci. Soc. Am., 11:305-308] even using graphic illustrations of his findings in one form or another, generally showing a bar graph with wide portions in the pH area where the element is most widely available to the plant. I have seen similar representations said to show the availability of trace elements in a hydroponics solution. This graphic representation of availability of trace, and sometimes the major elements, only applies to plants being grown in mineral (clay based) soils. It is not relevant to hydroponics solutions.



As plants use nutrients their roots release bicarbonate that raises the pH of nutrient solutions. By the early 1990's I had observed that the published and advised pH at which crops were grown did not correspond to my observations. At the time phosphoric acid was being used to routinely acidify hydroponics solutions and was causing imbalances in nutrient solutions and blockages due to precipitates. It made sense to replace the phosphoric acid entirely with nitric acid which could, by monitoring pH, be added at a rate related to plant use replacing Nitrogen (N) used in growth periods and so maintain a better balanced solution free of unwanted precipitates. I had a small experimental green house and was able, over three seasons, to observe the effects of progressively lowering the pH on a wide range of vegetable and ornamental crops. Lowering the pH well below then accepted levels had no adverse effects on any plants. I was hesitant to recommend that growers lower their pH, below pH5 at that time, until NASA, in their tests and computer modeling, were able to state hydroponics solutions were satisfactory as low as pH 4.0. I had no critical data for any lower pH but, due to occasional field observations of injury when acid dosing malfunctioned, injury may occur somewhere below pH3.

I was also concerned that many tomato growers crops had manganese and iron deficiencies in winter over the same period their pH rose above pH6.0. This was the minimum pH advised at that time and still persists in many texts. One method of raising the pH used was to add caustic potash and this would be immediately followed by tomato and lettuce plants turning 'white' from iron or manganese deficiency and sometimes older leaves had small black spots associated manganese toxicity.

I can now confirm that all plants grow well in hydroponics solutions from pH 4 upwards to pH6.0. This pH range has no influence on their nutrition. Nitric is generally the preferred acid with adjustment sometimes being needed with smaller additions of phosphoric acid. To retain iron in solution, and available to plants, it is complexed by common chelates. With rapidly growing plants the pH of the root zone may even be higher than pH6.0, so it is best to run systems no higher than pH 5.6-5.8



Notes prepared by D A Slade, Grower Consultancy Services, for Pure Hydroponics Limited.

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The selection of the upper pH level depends on the nature of the chelates used. Most nutrient recipes use chelates that precipitate immediately at pH6.8 but also do so slowly from pH6.2, and increasingly so as the pH increases towards 6.8. Once precipitated they do not return into solution. Chelates stable at higher pH's are available but, since it is the root zone pH that is important, chelates that are stable in pH7 solutions still require a lower pH in the catchment tank to stay in solution in the root zone area.

So here was the answer as to why many plants suffered from iron deficiency in winter. The caustic potash added to maintain a recommended pH between pH6.0-7.0, increased the pH and inactivated the available iron. Other problems also occurred with blockages due to the precipitate. The iron chelate was often mixed with the A Tank salts to avoid other problems. Use of the phosphoric acid resulted in precipitates of calcium phosphates that resulted in poor plant health.

Recommendations:

All hydroponics crops can be grown at a pH from pH4 to 6.0. Do not exceed pH6.0. Follow mixing directions for the A and B solutions carefully. Keep the B tank pH well below pH6.0. Do not use caustic potash to increase solution pH's. It causes iron and manganese losses from solutions. Allow the plants to bring the pH up. In most hydroponics systems use nitric acid only in summer to correct the solution pH.

In run-to-waste and media systems, if a separate acid monitoring system is not used, add the acid to the B tank. In this case the pH of the media, in which the 'run-to-waste' plants are growing, must determine the solution pH. Keep the media between pH4.0 and 6.0. (These recommendations apply to soiless media.) Most growers find an operating pH of about 5.6 is easy to maintain. If there are problems with higher solution pH levels, usually due to very hard and alkaline water, recipes can be prepared that enable plants to grow under more alkaline (higher pH) conditions without iron deficiency but these may be more costly.

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