Citric Acid for High Alkalinity Water

by Sue Bottom, sbottom15@hotmail.com

If you are one of those lucky individuals with low to moderate alkalinity water, count your blessings and turn the page for the next article. This article is for those of us that struggle to raise orchids with high alkalinity water that has correspondingly high total dissolved solids. High alkalinity and high salt content in water creates a series of problems for orchid growers. Think of alkalinity as liquid lime, so every time you water with high alkalinity water, you are liming your orchids. Potting media can become so alkaline that trace elements are not easily absorbed by roots leading to nutrient deficiencies. Salts build up in the potting mix and on roots from the repeated wetting and drying cycles. At high concentrations, salts damage roots and limit their ability to absorb moisture and nutrients. Hard water can form films on leaves that limit photosynthesis.

1. If you notice white calcium staining on your orchid leaves, you have hard water that probably has an excess of bicarbonate alkalinity. At a minimum, flushing salts away from the roots is necessary so make a practice of double watering your orchids. You may also consider adding citric acid to your irrigation water to reduce bicarbonate alkalinity. If you soften your household water with a sodium salt-based system, remember never to apply softened water to your orchids or any other plants because it contains toxic levels of sodium.

Within limits, your choice of fertilizer and potting media can help maintain the desired slightly acidic conditions around orchid roots. However, once the alkalinity of your water exceeds 150 to 200 ppm, acidic reaction fertilizers and acidic potting mixes may not be enough. Potential solutions include collecting rainwater, installing a reverse osmosis system or even injecting acid into your water.

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3. The 4 acre pond behind the house is fed by springs and rain with alkalinity in the 100 ppm range depending on rainfall, much preferable than the 350+ ppm alkalinity well water. With any surface water supply, there is always the concern that naturally occurring pathogens (like water molds, Botrytis, Fusarium or Rhizoctonia) will contaminate the pond water. The water was run through a UV filter but the water is so tannic that the UV system was probably ineffective. We elected not to constantly inject disinfectants, fearful of their impact on the beneficial microbial population.

The Search for Good Water. When we first moved to St. Augustine we used well water for watering the orchids. Within about six months, white deposits formed on leaves and the orchids started to decline. After analyzing the well water, the problem became obvious, the 350+ ppm alkalinity was too high for good growth. A rainwater collection system was considered, but the big pond behind the house was already collecting rainwater so why not use this big natural cistern? Pond water turned out to be a blend of rainwater and spring water. It seemed like a perfect solution, with alkalinity ranging from 40 to 130 ppm depending on rainfall. Bacteria and fungal spores were always a concern with the pond water. Pond water was filtered to remove solids and then run through a UV filter in an effort to kill pathogens. The dark coloration of the pond water caused by the presence of tannic acids (from decaying leaves) probably limited the effectiveness of the UV treatment. Some of the rots and flower blighting in the greenhouse were likely caused by contamination carried in with the pond water. It was time for another mid-course correction in the search for good quality irrigation water. Pond water treatment options like injecting copper or quaternary ammonium compounds or ozonation were considered, but the cost and potential for unintended consequences suggested we find another solution.

2. The use of strong mineral acids and disinfectants requires a complex injection system to properly meter and control the injection rate, like this system at a commercial orchid nursery.

Commercial orchid growers with high alkalinity water sometimes install acid injection systems to neutralize excess alkalinity with strong mineral acids. These acids must be used with great care and are just too dangerous for the normal hobbyist. Weak organic acids, such as vinegar and citric acid, also neutralize excess alkalinity and are much safer for hobbyists. While it is more expensive than the mineral acids, the ease of handling citric acid together with its ability to be mixed with fertilizers without causing compatibility problems or contributing excess nutrients are huge pluses. Citric acid could be the hobbyist's solution for waters with alkalinities in excess of 200 ppm.

Injecting citric acid seemed to be a good option, but at what cost? A 50 lb bag of food grade citric acid from BulkApothecary.com soon arrived at a cost of about $70 for a 6-month supply. We have been using citric acid for over a year and the results and the growth response has been fantastic. The plants are throwing off multiple leads, the blooms are larger and those reliable spring bloomers are blooming a second time in the fall. My major problem is the way the plants are growing out of their pots at an unprecedented rate, nice problem to have.

It took several months to work through all the details, outlined in the following paragraphs. The basic chemistry of the citric acid reaction in water is outlined in Sidebar 1.

Determine Whether Citric Acid Will Work for You. If you have high alkalinity water and are comfortable with basic chemistry, here is what you can do to see if citric acid might be a solution for your water quality issues.

Step 1 - Quantify Your Alkalinity Level. The first step is documenting the alkalinity level in your water. Send a sample of your water to a commercial water quality laboratory (like QAL Labs or JR Peters) to set your baseline. There are strip tests and colorimetric titration tests that are easy to use in the field and give quick results, but they are not as accurate as a laboratory analysis. You can use the quick test methods as verification checks on your system, but to set your baseline, spend the $40 to get laboratory test results. The lab results will also let you know if you will need calcium and magnesium supplements or whether sodium or some other element is present at toxic levels.

EMW-400 : Water Irrigation Suitability

Components		Results mg/L	meq	Target Ranges (mg/L)	Acceptable (mg/L)
MAJOR CATIONS					
Potassium	K	6.03	0.15		<100
Calcium	Ca	148.56	7.43	25 - 75	<150
Magnesium	Mg	7.21	0.60	10 - 30	<50
Sodium	Na	37.17	1.62	0 - 20	<50
MAJOR ANIONS					
Phosphate	PO4	1.35	0.04		<90
Sulfate	SO4	7.07	0.15	0 - 120	<240
Chloride	Cl	65.00	1.81	0 - 20	<140
HCO3 Alkalinity	HCO3	460.67	7.55		
CO3 Alkalinity	CO3	0.00	ND		
Ammonium Nitrogen	NH4-N	0.80			<10
Nitrate Nitrogen	NO3-N	1.40			<75
pH	pH	6.94		5.50 - 7	4-10
Soluble Salts	EC	0.95		0.20 - 0.80	0-1.5
Total Alkalinity	CaCO3	377.60		40 - 160	0-400
Iron	Fe	0.31		< 1	<4
Manganese	Mn	0.02		< 1	<2
Boron	B	0.05		< 0.10	<0.5
Copper	Cu	0.01		< 0.10	<0.2
Zinc	Zn	0.01		< 0.50	<1
Molybdenum	Mo	0.01		< 0.10	<0.2
Aluminum	Al	0.09			

4. The lab report for my well water shows it to have a very high bicarbonate alkalinity even though the pH is very slightly acidic. The well water contains calcium, sodium, chloride and soluble salts in excess of target ranges as well as a deficiency of magnesium. The laboratory target ranges given by the laboratory are based on generic guidelines for irrigation water, not specific to orchids.

Step 2 – Set Your Target End Point. Select a target bicarbonate alkalinity for your orchids, ideally in the 80 to 120 ppm range. Water in this range of bicarbonate alkalinity should have an approximate pH of between 5.8 and 6.2 (Argo and Fisher 2008). Do not try to lower alkalinity levels too much below 100 ppm. Leaving some residual buffering capacity in the acidified irrigation water is a more forgiving approach. It will allow some breathing room for seasonal variations in alkalinity without running the risk of over acidification.

Step 3 – Calculate Your Hypothetical Addition Rate. There is little published information about using citric acid to acidify water, but one excellent source provides a recommended addition rate as a function of water alkalinity (Bailey and Bilderback). Table 1 gives you an estimate of how much citric acid is required to lower the pH of your irrigation water to 5.8 (roughly correlative to an alkalinity of 80 ppm). You can use this estimated addition rate to decide how much citric acid to order, using a weight to volume conversion factor of 1.15 cups/lb (600 ml/kg).

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Table 1 – Theoretical Citric Acid Addition Rates Based on Alkalinity			
Irrigation Water Alkalinity (ppm as $CaCO_3$)	Amount of Citric Acid to Add to Reduce Water pH to 5.8		
	tsp/gal	ml/gal	ml/l
150	0.09	0.46	0.12
175	0.11	0.54	0.14
200	0.13	0.62	0.16
225	0.14	0.70	0.18
250	0.16	0.77	0.20
275	0.17	0.85	0.23
300	0.19	0.93	0.25
325	0.20	1.01	0.27
350	0.22	1.08	0.29
375	0.24	1.16	0.31
400	0.25	1.24	0.33
Based on 0.26 gm/gal-meq/l alkalinity to reduce irrigation water pH to 5.8 (Bailey and Bilderback).			

Step 4 – Bench Scale Testing. Before you start watering your orchids with acidified water, do a bench scale test where you add small amounts of acid to a fixed volume of water and measure the pH and alkalinity. For my bench scale testing with a 400 ppm alkalinity, I used a ¼ tsp measuring spoon and 3 gallon bucket (something akin to a 1 ml measuring spoon and 10 liter bucket). Fill the bucket with your water, add small amounts of citric acid, stir for a minute and test the water for pH using a good quality meter (like the Bluelab combo meter) and alkalinity using alkalinity test strips (like the Hach strips) until you reach your target pH. Do not bother with the more expensive alkalinity titration kits. My sample results are given in the alkalinity sidebar 2, which also contains a discussion of the erroneous alkalinity results given by titration tests when acidifying with weak organic acids. These test results will let you establish the tentative acidification rate for your water. My bench scale testing correlates well with the Bailey and Bilderback theoretical acidification rate.

Step 5 – Adding the Acid to the Irrigation Water. If you have a system to inject fertilizer into your irrigation system, you simply add citric acid to the fertilizer mixing tank. Fill your mix tank three quarters full with water, add the proper amount of citric acid to meet your goal, then add any fertilizer you wish to use and complete filling the tank with water. Mix the solution thoroughly to make sure all solids are dissolved. The addition rates per unit capacity of your mixing tank for siphonex and Dosatron systems are provided in Sidebar 3, based on the theoretical Bailey and Bilderback rate that you should confirm for your water quality via bench scale testing.

If you do not have a plumbed system in which you inject fertilizers into your irrigation stream, you will have to work out the easiest way to add citric acid to your water. If you water with a hose, you might consider buying one of the siphon systems. This will make fertilizing easier and you would just add the citric acid to the suction line tank.

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If you are growing indoors and have to move everything to the kitchen sink to water, you could water as is your normal practice, and then pour the citric acid/fertilizer solution through the pot. You would use the addition rates in Table 1. To reduce the alkalinity from 350 ppm to approximately 80 ppm and a pH of 5.8, you would add 0.22 tsp/gal or just under 1/4 tsp to a gallon jug of water, equivalent to bit more than 1 ml/gal or 0.3 ml/l. Add your fertilizer and then drench the pot one last time. If the quantities involved are smaller than your measuring spoons, you might consider shopping on–line at a scientific or medical supply site for spoons that can measure amounts as minute as 0.05 ml (sometimes called 0.05 g, the ml, cc and g units are all equivalent for substances having the same density as water).

Step 6 Verify Your Assumptions. When you first start using citric acid, proceed cautiously and use maybe 70% of the calculated amount and then verify your assumptions by taking pH and alkalinity readings on the treated water. Target a pH in the range of 5.8 to 6.2 and alkalinity in the 80 to 120 ppm range. If your initial results suggest more acid is necessary to meet your target goals, keep increasing your citric acid addition rate with subsequent batches until your treated water falls within the desired range. Use a good, calibrated pH meter to verify your assumptions with each batch of acidified water. The Water Works pH and Total Alkalinity strips are handy, although they are not as accurate or reliable as a good pH meter and Hach alkalinity test strips. If you notice the pH is drifting upward or downward from your expectations, adjust your citric acid rate accordingly. You may see normal seasonal variations in your water quality and these simple tests will prevent you from over or under acidifying your water.

5. Keep careful records of the impact of citric acid addition rates. A Bluelab combo pH and conductivity meter was used to measure the pH of untreated and acidified water. The pH meter was used to verify proper acid addition rates with a target goal of 5.8 to 6.2.

6. WaterWorks pH and total alkalinity test strips and Hach alkalinity test strips are reasonably accurate at the lower alkalinity levels to give you a general sense of the alkalinity of acidified water, but don't rely upon them to verify your target pH or alkalinity goals.

After Acidifying. Once you have completed your preliminary tests, you have set your acid addition rate and can start acidifying your water. By now, you are very proficient with your pH meter. It is time to verify that the acid addition is actually accomplishing your goal of having a slightly acidic root zone for best nutrient uptake.

Verify Your Root Zone pH. The simplest way to determine the pH around your roots is by using a pour thru test. About 30 to 60 minutes after you have watered, pour enough distilled water through the pot so you collect about ¼ cup (50 ml) of the drainage and test it for pH. If the pH is in the desirable 5.5 to 6.5 range, your program is working. If the drainage is alkaline with a pH much over 7.0, you may want to consider an occasional acid treatment where you acidify your irrigation water down to a pH of 5.1 to correct the media pH.

Rethink Your Fertilizer. If you were using an acid generating fertilizer like a 21-5-20 high in ammonium nitrogen before you started neutralizing, you may want to change to or alternate with a high nitrate fertilizer like a 15-5-25 more suitable for your acidified water. Pour thru test results can guide you in this decision. If the pH is hovering around 7, keep using your acid generating fertilizer. If it is in the 6 range, you can switch over to high nitrate fertilizer. Add Epsom salts to your fertilizer regimen, if necessary to maintain a calcium to magnesium ratio in the range of 2 to 4 parts calcium to 1 part magnesium.

My Mid-Course Correction. After 6 months of acidification, the pour thru test results routinely showed a higher than expected pH (7.3 to 8.0) and a low EC (<0.5) suggestive of nutrient deficiencies. While there was very strong growth in most orchids, there was also some leaf yellowing on the older leaves that appeared to be some sort of nutrient deficiency, was it iron deficiency from the high root zone pH? A nitrogen deficiency because of competition with the microflora? I reached out to Dr. Paul Fisher at the University of Florida, who offered these helpful observations:

> *Your media is very unbuffered to pH change. The acidity or basicity of the fertilizer depends on the nitrogen form and also the concentration (the more ppm ammonium, the more acidic). So at only 50 ppm N, there is little acidity from the 21-5-20. There may be enough alkalinity in the water at pH 5.8 to bounce the pH back up to the 7.3 to 8 range. You could try dropping to pH 5.1 – should not harm the plant, and may be enough to reduce subsequent pH rise. Just by increasing fertilizer concentration, pH is likely to drop.*
>
> *Even though you are neutralizing alkalinity, the result is not the same as having a purified water source (which you would have with a reverse osmosis system). For example, in the water test you show a high level of calcium and fairly high chloride. So the calcium and chloride could antagonize uptake of some nutrients. When water is more contaminated with other ions, it is sometimes necessary to increase fertilizer concentration so that nutrients can outcompete these ions. The most common high pH problems relate to deficiency of iron, boron, or manganese. All of those pH-related nutrient deficiencies will show in new growth. Overall nutrient deficiency (including N) tends to be on older growth.*

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This advice led to the final adjustment, a one-time watering with a 5.1 pH water to adjust the media pH and doubling the fertilizer addition rate to provide about 100 ppm nitrogen to provide sufficient mineral nutrition. Each batch of acidified water is tested for pH, so it is a simple matter to run a pour thru test on a random pot after watering to verify the combination of citric acid and fertilizer is working on an ongoing basis.

7. This delightful biofilm developed on the Dosatron feed bucket containing fertilizer and citric acid after sitting about a week, something that never happens if only fertilizer concentrate is in the bucket. A second Dosatron was ultimately added, one for the citric acid and one the fertilizer.

Positive and Negative Effects. The plant response to citric acid is very impressive. There are multiple leads on new growths, new growths are taller and fatter than prior growths, and plant vigor is robust. There are more and larger flowers, and plants are flowering more frequently than they have in the past. My unproven hypothesis is the citrate is enhancing the symbiotic relationship between the orchid roots and rhizosphere microflora improving nutrient uptake. For those with a highly organic potting mix, this increased microbial action might cause premature degradation of the substrate. There are some white markings on the leaves from the calcium and magnesium in the water, but it is not excessive. The alkalinity (largely bicarbonates) is reduced via the acid reaction, but not the hardness (a measure of calcium and magnesium content). While the acid will dissolve some of the built-up calcium residue on the leaves, after every watering the leaves dry and whatever calcium is present in the water remains. In the early days of testing, too low pH water caused some chemical burns on the edges of flowers but this does not seem to be a problem at a pH of 5.8.

Impact on Microflora. Apparently, there is a lot more going on with our orchid roots than we know about. The roots of many plants actually exude organic acids including citric acid to help modify the root zone pH and provide a food source for the rhizosphere microorganisms that, in return, make nutrients more absorbable by the plants. Could the unreacted citrate in the fertilizer solution actually cause proliferation of the microflora in the rhizosphere enhancing nutrient uptake by the orchid roots? There is a lot of information available about the mycorrhiza (association between microorganisms and higher plants) of orchids in vitro, but much less information is available for the mycorrhiza of mature photosynthesizing orchids, a fascinating subject for future exploration.

Impact on Salts. The acidification of high alkalinity water reduces the amount of bicarbonates and carbonates in the water, and that translates into a lower conductivity or dissolved solids content. The basic reaction that occurs is the hydrogen ion from the acid reacts with the bicarbonate ion in the water to produce carbon dioxide and water. With my water, there is about a 25% drop in conductivity after acidification. Unfortunately, it is these

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remaining dissolved salts rather than the bicarbonate ion that pose the risk of salt build up in the media. Continue to flush your plants regularly to prevent the other ions from accumulating to potentially toxic levels around the roots of your plants.

You water quality is one of the most important determinants in how well your orchids grow. If you notice hard water stains on your orchid leaves, you can reasonably assume that your bicarbonate alkalinity is high and it is likely to increase the root zone pH over time making certain nutrients less available for uptake by the roots. Up to a certain point, you can use an acidic reaction fertilizer to help keep your root zone pH in the desirable slightly acidic range. If the fertilizer alone does not do the trick, think about adding some citric acid to your fertilizer program. You will have to spend a little time and some gray matter to quantify the addition rate. After that, it is a simple matter to spoon a little citric acid into your fertilizer solution. Do not be surprised if you see a slow and steady improvement in your plants from this simple adjustment.

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Sidebar 1 - Citric Acid for High Alkalinity Water – The pH Rebound Effect

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For those interested in the chemistry, here is a brief summary of how acid neutralizes the bicarbonates in your water. The carbonate system involves a complex equilibrium between gaseous carbon dioxide ($CO_{2,(g)}$), dissolved or aqueous carbon dioxide ($CO_{2,(aq)}$), carbonic acid ($H_2CO_3^+$), bicarbonate (HCO_3^-), and carbonate (CO_3^{-2}). The basic reaction that occurs when acid is added to water containing bicarbonate alkalinity is:

Acid + Bicarbonate Alkalinity → Carbonic Acid + Aqueous Carbon Dioxide + Water

The presence of carbonic acid and dissolved carbon dioxide cause the pH of the solution to drop into the acidic range. The aqueous carbon dioxide can convert to gaseous carbon dioxide and release to the atmosphere over time, or very quickly if the solution is agitated or aerated. The loss of this acidic compound causes the pH of the solution to increase, as shown in these test results.

		pH	Electrical Conductivity (EC) (mS/cm)	Total Dissolved Solids (TDS) (ppm)	Alkalinity (ppm $CaCO_3$)
Well Water		6.8	0.9	600	380
0.75 tsp of citric acid in 3 gallons of water (0.3 ml/l)	Day 1	6.0	0.6	400	120
	Day 2	6.2	0.5	340	80
	Day 3	6.7	0.6	400	100
	Day 4	7.0	0.6	400	100
1 tsp of citric acid in 3 gallons of water (0.4 ml/l)	Day 1	5.1	0.5	340	40
	Day 2	5.4	0.5	340	60
	Day 3	5.9	0.5	340	80
	Day 4	6.4	0.5	340	80

Note: Water quality testing was conducted for several days on batches of water to which citric acid was added. The pH and EC measured by Bluelab Combo Meter, TDS estimated by multiplying the EC by a factor of 670 and alkalinity measured by Hach test strip, which seems to provide a more accurate estimate than a titration test kit when using an organic acid to acidify your water, see the alkalinity sidebar for details .

At both citric acid addition rates, the pH dropped from the starting point and the acid neutralized most of the alkalinity, which in turn caused the EC and TDS levels to drop. Over time, as the system equilibrated with the atmosphere, the dissolved carbon dioxide evaporated from the acidified solution, causing the pH to rise. This increase in pH did not cause a material change in the alkalinity levels.

The purpose of acidification is to reduce the bicarbonate alkalinity down to around 100 ppm, not to simply drop the pH of the irrigation water. You use the pH of the acidified water (measured within several minutes of adding the acid) as a simple way of determining whether you have reduced the bicarbonate alkalinity to your desired level. With my water, I target a pH of 5.8 to 6.2 at the hose end, because this will reduce the bicarbonate alkalinity of my water down from around 400 ppm to somewhere between 80 and 120 ppm. You do not want to remove all the bicarbonate alkalinity because then there would be no buffering capacity so small changes in water quality could cause the root zone to become too acidic, with the potential for micronutrient toxicities. On the other hand, excess bicarbonates in the irrigation water can cause the substrate to become so alkaline that micronutrient deficiencies can occur.

There are many complex reactions and pH changes that occur in the root zone as a result of interactions between the potting mix, irrigation water, fertilizer and the root exudates. Your goal with acidification is simply to lower the bicarbonates to a reasonable level in your irrigation water to help maintain the root zone pH in the slightly acidic 5.5 to 6.9 range.

Sidebar 2 - Citric Acid for High Alkalinity Water – Alkalinity Tests

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In order to find the citric acid rate that is right for your water, a simple bucket test can be used where you add a measured amount of citric acid to a known volume of your water and then test the water. Measuring the pH and conductivity of water is simple if you have a good quality meter. The alkalinity test is a little more complex. There are test strips available which give reasonable approximations of alkalinity as long as the strips are fresh and you follow the instructions. There are also titration test kits considered to give more accurate results that involve adding drops of a strong mineral acid to the solution to which a dye has been added until you see a color change indicative of a pH around 4.3 to 4.5 where there is no alkalinity.

The results for my water are summarized below, with my preferred addition rates highlighted in bold. Argo and Fisher (2008) state "a solution pH of 4.5 should have 0 ppm alkalinity, pH of 5.2 should have about 40-ppm alkalinity, a pH of 5.8 at 80-ppm alkalinity, and a pH of 6.2 at 120-ppm alkalinity. However, this relationship between pH and alkalinity levels is prone to large amounts of error. The only way to know the exact amount of alkalinity that remains after acid injection is to measure it by using an alkalinity test." The testing done by titration and strips gave wildly different results, and the results from a commercial lab were even higher than the titration test results.

Citric Acid Addition Rate		pH	Total Alkalinty (ppm as $CaCO_3$)	
tsp in 3 gal	ml/l		HachTitration	Hach Strips
0	0	7.0	420	> 240
0.25	0.11	6.6	340	> 240
0.50	**0.22**	**6.2**	**300**	**150**
0.75	**0.33**	**5.8**	**220**	**100**
1.00	0.43	5.2	180	60
1.25	0.54	4.9	120	40
1.50	0.65	4.4	80	20

Thoroughly perplexed, I turned to Dr. Bill Argo, who explained the contradiction. The short version is total alkalinity is a measure of any substance present in the solution that will absorb a hydrogen ion. Typically, with most irrigation waters, the primary ion is bicarbonate so the measure of alkalinity is an indication of how much bicarbonate is present. When testing water that has been acidified by the weak organic citric acid, the titration method will measure the presence of citrate in the water in addition to the bicarbonate level you are trying to measure. When acidifying with weak organic acids, test strips may be the better choice to estimate the bicarbonate content. For the more technically minded, here is Argo's longer explanation:

> *There are two important characteristics about citric acid. Citric acid is a weak acid, and it has 3 acid groups. The pK values for each of the groups is 2.9, 4.3, and 5.2. So, for citric acid to acidify the solution (i.e., for one of the H+ to come off the citric acid), the solution pH must be at or above a pH of 2.9. For the second H+ to come off, the solution pH must be at or above a pH of 4.3; and for the third H+ to come off, the solution pH must be at or above a pH of 5.2.*
>
> *The reverse is also true. When you acidify a solution that contains citrate (the anion left over after the citric acid has lost the H+), it will re-absorb H+ on the first acid group when the solution pH reaches 5.2, the second when the solution pH reaches 4.3, and the third when the solution pH reaches 2.9. So, since the citrate is absorbing H+ as you lower the pH of the solution to 4.5 with the titration method, the citrate in the solution is being measured as total alkalinity, and giving you an erroneous result. While I don't like test strips to measure total alkalinity, in this case, it is probably giving you a better result than the titration method.*

Citations and Information Sources

Argo, Bill and Paul Fisher, *Understanding Water Quality*, Greenhouse Product News, October 2008.

St. Augustine Orchid Society

www.staugorchidsociety.org

Sidebar 3 - Citric Acid for High Alkalinity Water – Concentrates

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Amount of Citric Acid to Add to Siphonex System Bucket to Reduce pH to 5.8						
Alkalinity (ppm as $CaCO_3$)	Units in Volume Citric Acid per Volume Water in Mixing Tank					
	16:1 Ratio			20:1 Ratio		
	tsp/gal	ml/gal	ml/l	tsp/gal	ml/gal	ml/l
150	1.5	7.4	2.0	1.9	9.3	2.5
175	1.8	8.7	2.3	2.2	10.8	2.9
200	2.0	9.9	2.6	2.5	12.4	3.3
225	2.3	11.2	2.9	2.8	13.9	3.7
250	2.5	12.4	3.3	3.1	15.5	4.1
275	2.8	13.6	3.6	3.5	17.0	4.5
300	3.0	14.9	3.9	3.8	18.6	4.9
325	3.3	16.1	4.3	4.1	20.1	5.3
350	3.5	17.4	4.6	4.4	21.7	5.7
375	3.8	18.6	4.9	4.7	23.2	6.1
400	4.0	19.8	5.2	5.0	24.8	6.5

Note: The values above are the amount of citric acid to add to the mixing bucket with a siphonex system to inject fertilizer and chemicals into the irrigation system. For example, if your water has 300 ppm alkalinity, in a 16:1 Hozon siphon system, you would add 3.0 tsp/gal (3.9 ml/l) to the mixing tank. If the mixing tank is a 5 gallon bucket that you fill to capacity, you would add 15 tsp of citric acid to the bucket; or for a 20 liter bucket, you would add 78 ml. The Dramm siphonject operates at a 20:1 ratio, so with this system you would you would add 3.8 tsp/gal (4.9 ml/l) to the mixing tank. If the mixing tank is a 5 gallon bucket that you fill to capacity, you would add 19 tsp of citric acid to the bucket; or for a 20 liter bucket, you would add 98 ml.

Amount of Citric Acid to Add to Reduce pH to 5.8 Dosatron System Set to 100:1 Ratio			
Irrigation Water Alkalinity (ppm as $CaCO_3$)	Units in Volume Citric Acid per Volume Water in Mixing Tank		
	tsp/gal	ml/gal	ml/l
150	9.4	46.5	12.3
175	11.0	54.2	14.3
200	12.6	62.0	16.4
225	14.1	69.7	18.4
250	15.7	77.5	20.5
275	17.3	85.2	22.5
300	18.9	93.0	24.6
325	20.4	100.7	26.6
350	22.0	108.5	28.7
375	23.6	116.2	30.7
400	25.1	124.0	32.7

Note: The values above are the amount of citric acid to add to the mixing tank with a Dosatron system to inject fertilizer and chemicals into the irrigation system assuming the Dosatron injector is set to the rate of 100:1. For example, to reduce the alkalinity from 300 ppm to 100 ppm, you would add 18.9 tsp/gal (24.6 ml/l) to the mixing tank. If the mixing tank is a 5 gallon bucket filled to capacity, you would add 95 tsp or 2 cups of citric acid to the bucket; or for a 20 liter bucket filled to capacity, you would add 492 ml.