Adjusting Alkalinity with Acids

Acids have been and always will be an excellent tool for growers to exert better control of irrigation water alkalinity (mostly bicarbonates and carbonates) and growing media pH. Once the role of alkalinity is understood, the grower may consider the following practical step to control alkalinity using acids through an injector system.

Acid Type

The acids commonly available to growers include phosphoric, sulfuric, nitric, and citric. Table 1 lists criteria for choosing the right acid for your situation: relative safety, neutralizing power, cost, and nutrient content. In our experience, the most effective and widely used acid is sulfuric acid; however, this is one of the most hazardous acids to use. For low amounts of alkalinity removal, phosphoric acid may be the acid of choice. However, we do not advocate adding more than 2.25 fluid ounces of this acid to 100 gallons of water, because of the amount of P one would add. Nitric acid is theoretically ideal because it adds nitrate nitrogen; but it fumes and is highly oxidizing, making it very difficult to handle. Citric acid is a weak organic acid and a solid, making it safer than the other three; but it is much less effective, and therefore more expensive to use.

Use the Correct Injector

Once you choose an acid to use, make sure your injector can handle the task. Read the injector manual to get this information or call the manufacturer of the injector. *Note: Some injector manufacturers state that a maximum of 5 percent acid can be used. This equates to approximately 6 fluid ounces of acid/gallon of water - an uncommonly high concentration of acid.*

Calculate the Amount of Acid to Use

We suggest using enough acid to reduce water alkalinity to within a target range. Table 2 provides suggested target alkalinity ranges based on container size. First, have your water analyzed for alkalinity. You can have a lab test your alkalinity or you can use a kit to measure it yourself (alkalinity test kits can be purchased through greenhouse or scientific supply distributors). Then, calculate the amount of acid needed to get the water into your target alkalinity range. (Current alkalinity - desired alkalinity = alkalinity to be neutralized). Table 1 lists the amount of acid to use for a certain ppm of alkalinity per 100 gallons of water. Now you are ready for your pilot calibration run.

Table 1. Characteristics of acids used to neutralize water alkalinity.

Acid type	Typical strength	Relative hazard	Nutrient content (ppm)[z]	Neutralizing power	Specific gravity	ml acid/ppm alkalinity/100gal[x]
Phosphoric	75%[w]	Moderate	25.6 P, as PO_4	45.0[u]	1.381	0.70
Sulfuric	93%v	High	43.6 S, as SO_4	136.0	1.835	0.23
Nitric	63%	High	14.6 N, as NO_3	52.3	1.381	0.56
Citric	100%	Low	None	N/A	N/A	N/A

[z] Nutrient content when 1 fl. oz. is added to 100 gallons of water. Make appropriate adjustment to fertilizer program.

[y] Amount of alkalinity (mg CaCO3/liter) neutralized when 1 fl. oz. of acid is added per 100 gallons of water.

[x] Conversion factor of strength of acid at the specific gravity stated. Example: If you have an alkalinity of 250 and you want to target 150, then you need to neutralize 100 mg $CaCO_3$/liter. If you use sulfuric acid, then 100 x 0.23 = 23 milliters (ml) /100 gallons. 23 ml needed/29.6ml/fl. oz. = 0.77 (0.75 fl. oz.)/100 gallons. Rates will depend on exact strength and specific gravity.

[w] Phosphoric acid comes in many strengths, but 75% is most common. Use heavy free grade or food grade, if possible.

[v] 93% sulfuric acid is also known as 66 be' (Baume') acid. Battery acid electrolyte is recommended by some and is about 35% strength.

[u] Assumes about one-third of acid is effective since phosphoric acid does not completely dissociate.

Safety First

Acids are hazardous chemicals. When concentrated acids are mixed with water, a tremendous amount of heat is generated (which can even distort or melt plastic). Improper mixing can result in bodily injury. *Always wear the proper safety equipment when using acids.* This includes safety glasses, face shield, rubberized apron or coveralls, and acid-resistant gloves and boots. You should be able to find

safety equipment distributors in the Yellow Pages under "Safety". Federal and state safety laws and codes should be followed for storing, mixing and handling acids.

Proper Mixing

Use acid-resistant containers for containing the acidic stock solution. Heavy duty polyethylene trash cans are adequate.

Always mix acid to water. Fill the stock container to about half the final volume you wish to mix with water. (Note: Since this is a pilot run, you do not want to make up a full amount of acidified stock solution because you may wish to adjust the amount of acid or to add fertilizer to the stock solution later.) Measure the acid carefully using a good measuring vessel. Then add acid to water, slowly and carefully to the center of the water surface. If dispensing acid from a large drum or container, you should invest in an acid-resistant, hand-activated pumping/dispensing device ("Industrial Suppliers in the Yellow Pages"). During and after adding acid to the water, *you must stir the acid in the water*. Acid is heavier than water, so don't think it will mix easily just because it's a liquid. Stir! Avoid splashing!

Table 2. Suggested alkalinity guidelines (mg $CaCO_3$/liter)[z].

Container size	Acceptable alkalinity	Concern level[y]
Plugs	60-100	<40, ><40, >120
Small pots	80-120	<40, >140
4-5" pots	100-140	<40, >160
>6" pots	120-180	<60, >200

[z] Alkalinity levels recommended through Scotts Testing Lab. Actual levels may vary depending on crop type and desired plant response.

[y] Low levels may result in media pH decrease, and high levels may result in media pH increase. These trends are highly dependent upon fertilization rate.

Pilot Run or "Calibration" Measurement

After you have prepared the acidified stock solution, you should then determine if you have attained the target irrigation water alkalinity for your application. Run the injector at the appropriate dilution ratio for 5 to 10 minutes, then take a sample. It's best to run the water you wish to test into a 5-gallon bucket and take a sample out of the 5-gallon bucket. Test the alkalinity. Make adjustments as necessary. Once you are done, it is prudent to send another sample of the acidified water to an analytical lab to obtain a full test. This informs you if anything else has changed besides alkalinity.

Now the Fertilizer

Many growers want to use one injector and mix acid with fertilizers. The use of phosphoric, nitric and citric acid is compatible with moist water-soluble fertilizers. Sulfuric acid is not compatible with calcium-containing fertilizers like calcium nitrate or formulations like 15-0-15 and 17-0-17 in concentrated form.

Mixing Fertilizer with Acid

If you are diluting the acid out of a separate injector, disregard this step. Remember, you only put in some of the acid to carry out the calibration run (half volume of stock solution). Add the remainder of the acid for the total amount of acid you wish to make. You may add more water, allowing "room" for fertilizer addition. Add the fertilizer carefully to avoid splashing, and add enough water to attain your final volume -- mix thoroughly. Again, test the injection of the acidified nutrient solution to make sure the irrigation water is within the target alkalinity range. You're done!

[a] Original article authored by Rick Vetanovetz and Shannen Ferry, The Scotts Company, Marysville, OH