Acid Substitutes and pH Reduction

An evaluation of the new acid-replacement products for improving water quality and the soil rootzone environment.

BY BRIAN WHITLARK

Given the increase in the use of reclaimed water for irrigation, some turf managers seek alternative acidification products advertised to improve water quality. Materials historically used for industrial cleaning are now being used to acidify irrigation water that contains bicarbonates and sodium. Although the benefits of using traditional acidifying agents such as sulfuric and N-pHuric acid are well known, the implications of using acid-substitute materials is unclear and warrants further investigation.

BENEFITS OF ACIDIFYING

The success of acidifying materials applied to soil will depend on many factors, but first and foremost, the soil must contain calcium carbonate (lime) to react with the acid. In the absence of lime, the acid will disassociate to produce H^+ ions and subsequently will reduce soil pH, which may or may not be the desired result. When lime is present and reacts with acid, gypsum ($CaSO_4$), carbon dioxide (CO_2), and water are produced. The calcium (Ca^{+2}) from gypsum can then replace sodium (Na^+) on soil exchange sites.

When acid is applied to irrigation water that contains appreciable bicarbonates (HCO_3^-) or carbonates (CO_3^{-2}), the acid neutralizes this alkalinity and minimizes or prevents Ca^{+2} precipitation and associated infiltration reduction. The effectiveness of such applications depends largely on the neutralizing power of the product, the presence of HCO_3^- and CO_3^{-2} in the soil and water, and the product rates. Benefits typically seen with acid injection or acid materials applied to the soil (either directly or through injection) are summarized below.

- Increased nutrient availability.
- Reduced adjusted Sodium Adsorption Ratio of irrigation water and Exchangeable Sodium Percentage in soil.
- Increased water infiltration.
- Reduced calcite formation at the soil surface (reducing or eliminating calcite layer formation is listed as a benefit, but research data suggest such sealing is unlikely).
- Reduced calcite formation at the soil/gravel interface in greens.
- Reduced soil pH below 7.0 may indirectly increase resistance to soil pathogens, such as take-all patch.

Many golf course superintendents in the desert Southwest inject soluble fertilizers, wetting agents, and, in some cases, acidification products to reduce the pH of the water.

INCREASED USE OF ACID-REPLACEMENT PRODUCTS

There are many reasons given for switching to synthetic acid or acid-replacement products. Manufacturers tout that their products reduce bicarbonates, improve water infiltration, leach salts, are non-corrosive, are user-friendly, add "energy" to water, do not add sulfur, and won't damage irrigation components and pump stations. In some cases, such benefits may outweigh the additional costs commonly associated with these products. In fact, several superintendents claim that the switch to synthetic acids is due to their non-corrosive nature, offering enhanced safety when compared to caustic acids. Several turf managers noted that the most sensible application for acid-replacement products may be to buffer alkaline water in the spray tank, so as to enhance efficacy of fertilizer and pesticide applications.

AGRONOMIC BENEFITS?

The scientific evidence regarding acid-substitutes is limited, but there have been several field evaluation projects conducted in cooperation with superintendents in various regions of the country. In a 2008 study, Dr. Larry Stowell and Dr. Wendy Gelernter conducted a trial investigation using

Table 1

Gallons of product per acre-foot of water required to reach the target pH of 6.5 for irrigation water collected at two Arizona golf courses and city of Phoenix tap water.

Product	Irrigation Water Fountain Hills, Ariz.	Irrigation Water Scottsdale, Ariz.	City of Phoenix Tap Water
Sulfuric Acid	12.7	5.2	5.9
N-pHuric Acid	40.4	17.6	21.8
Product A	162.9	81.5	104.2
Product B	65.2	39.1	32.6
Product C	1,368.6	456.2	456.2

Table 2

Cost of each product required to reach the target pH of 6.5 for irrigation water collected at two Arizona golf courses and city of Phoenix tap water.

Product	Cost Per Gallon of Product*	Irrigation Water Fountain Hills, Ariz.	Irrigation Water Scottsdale, Ariz.	City of Phoenix Tap Water
Sulfuric Acid	$4	$51	$21	$23
N-pHuric Acid	$3.25	$131	$57	$71
Product A	$5	$815	$407	$521
Product B	$4.75	$310	$186	$155
Product C	$50	$68,429	$22,810	$22,810

Eximo (a popular acid-replacement product) and Dispatch (wetting agent). Gypsum was applied at 17 lbs. per 1,000 sq. ft. to each of six greens, while three of the six greens were additionally treated with Eximo at 2 oz. per 1,000 sq. ft. and Dispatch at 3 oz. per 1,000 sq. ft. Soil samples revealed that the addition of Eximo and Dispatch did not enhance either Na^+ or HCO_3^- removal.

In another evaluation, Keith Happ, senior agronomist in the Mid-Atlantic Region of the USGA Green Section, collaborated on a trial conducted at two courses, spraying Eximo at rates of 32 oz. and 64 oz. per acre on a tee, fairway, rough, and green. The soil at one test site has no CO_3^{-2}, HCO_3^-, or Na^+ problems, while the second irrigates with poor-quality water, where Na^+ and HCO_3^- are regularly applied through irrigation. Each site received three treatments of Eximo at two-week intervals. Soil samples revealed no difference between treated and non-treated areas, not even at the elevated rates. No differences in turf quality were observed.

A recent evaluation project in Tucson, Arizona, tested the injection of Burst (an acid-substitute) through the irrigation system, and evaluated Eximo sprayed on greens. The superintendent has since abandoned the Burst program due to cost and lack of either visual response or improvements in soil test results. Furthermore, the Eximo spray program, at either 32 oz. or 64 oz. per acre, did not result in any Na^+ or HCO_3^- reduction on greens.

COST EFFICIENCY

There are many commercial products available for acidifying water and soil, and essentially any of these materials may offer pH reduction to some degree. However, a common-sense approach leads one to choose a product that delivers the greatest acidity with the least amount of product. Some may argue that a major factor in the decision is product safety, an issue that should be given serious attention. Taking these factors into consideration, a simple laboratory experiment was done to evaluate the cost efficiency per unit of neutralizing power of several popular acid-substitute products compared to sulfuric and N-pHuric acid. Water samples were collected from golf courses in Scottsdale and Fountain Hills, Arizona, and from the city of Phoenix tap water. Three acid-replacement products were tested and compared to traditional treatments of sulfuric and N-pHuric acid for their ability to reduce the pH of each water source to a value of 6.5, a commonly used target when acidifying irrigation water. The amount of product required to reach the target pH is recorded in Table 1. Furthermore, the cost of each product to reduce each water source to the desired value is provided in Table 2.

As expected, the addition of sulfuric acid reached the target pH with the least amount of material. When sulfuric acid was added to the irrigation water collected from the golf course in Fountain Hills, which was the most highly buffered of the three water sources, the equivalent of about $50 per acre-foot was needed to lower the pH to 6.5. In comparison, the cost to treat the Scottsdale water source, which is significantly less buffered, was approximately $20 per acre-foot with sulfuric acid. Although the cost of N-pHuric acid was three times higher when compared to sulfuric acid, the use of N-pHuric was far less expensive than any of the acid-replacement products. Product B was the most economical of the acid-replacement products, but its cost is about 20 times more than sulfuric acid and over 2.5 times more than N-pHuric acid. If the course with the highly buffered water (Fountain Hills, Arizona) were to choose Product C, a carboxylic acid, to meet its pH reduction goals, it would require over $27 million, assuming the course uses 400 acre-feet of water per year. If the same course were to use sulfuric acid, about $20,000 per year would achieve the same effect.

FINAL THOUGHTS

As noted in the case studies, some turf managers choose to spray acid-replacements on greens only, significantly reducing costs when compared to those injecting over an entire golf course. However, that does not hide the fact that the acidifying power the acid-substitute materials offer is minimal, and the levels needed to achieve benefits are likely much higher than label rates and probably not economically pragmatic. Furthermore, when Na^+ is a problem in the soil, and water tests indicate high bicarbonates are contributing to the problem, it is necessary to acidify the irrigation water 24/7 to realize any benefits. Spraying an acid product at label rates, even weekly, will not likely provide any quantifiable advantages.

Employing strategic plans to modify soil and water chemistry through the use of acidifying agents is complex, and you should consult with your local USGA agronomist or university

The use of effluent water for irrigation is more common than ever, and this trend will continue. Acid injection may improve water quality, but it must be reviewed on a case-by-case basis.


Acid, fertilizers, and wetting agents commonly stored in the pump house may offer better water quality, improved infiltration, and enhanced turf nutrition when injected into the irrigation system.


This pump is used to deploy N-pHuric acid into the irrigation water when the flow from the pump station exceeds 300gpm.

personnel for guidance. Once a plan is outlined, the next step is to choose an acidifying agent that provides enough neutralizing power to justify the cost, while delivering an acceptable level of safety. Consider submitting a variety of acidifying products, along with a few gallons of your irrigation water, to a local laboratory to determine the quantity of material needed to adjust water pH to a given target level. Turf managers who try this approach find it eye-opening, and they make better agronomic (and economic!) decisions based on the results.

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BRIAN WHITLARK *is an agronomist in the Southwest Region of the USGA Green Section. He joined the staff in 2008 and visits courses in Arizona, California, Nevada, and portions of Mexico.*

Acid-replacement products are sometimes applied specifically to greens with a spray boom or walk-behind sprayer. The cost of such products often prohibits widespread use over the entire golf course.