Three Reasons to Broaden Your Fertigation Knowledge

While the benefits of fertigation are being recognized by more irrigation managers today than ever before, the staff of Irrigation Business & Technology thought perhaps that many farmers and managers of large urban landscapes aren't fully aware of the full variety of fertilizer products that can be applied through irrigation systems. Others may have tried fertigation without success.

The following list of chemicals for fertigation and guidelines for their use were prepared by Dr. Charles M. Burt, director of the Irrigation Training and Research Center at California Polytechnic State University in San Luis Obispo and were presented by him during the Irrigation Association International Irrigation Show in San Diego, CA last November. Dr. Burt sees fertigation as a helpful tool to farmers as well as managers of large landscapes, such as golf courses, parks, and large commercial sites. Modern farmers and landscape managers often enlist the assistance of soil fertility specialists to assure maximum yield and quality. Fertigation enables irrigation systems to deliver the soil consultant's prescription with the greatest accuracy and least disruption.

By Charles M. Burt, P.E., Ph.D.

There are numerous considerations in deciding what chemicals to fertigate. They include cation-anion balance, the form of fertilizer, solubility, compatibility and the pH of both the water and the soil. Because nitrogen fertilizer is injected more widely than any other nutrient, special attention is given to it here. However, fertigation is also practical for applying gypsum, phosphorus and potassium.

Cation-Anion Balance

The total number of nutrient cations (positively charged ions) in a plant must equal the total number of nutrient anions (negatively charged ions) in a plant. The ammonium ion (NH_4^+) will be in competition with other cations for uptake. The nitrate ion (NO_3) will be in competition with other anions for uptake.

A plant receiving nearly all of its nitrogen in the form of ammonium might become low to deficient in potassium (K^+), calcium (Ca_2^+) and magnesium (Mg_2^+). The plant will compensate for the positive charge by absorbing more phosphate (H_2PO_4) and sulfate (SO_4^{-2}) than normal. In addition, a plant that takes up primarily ammonium nitrogen will produce a more acidic root environment because the roots release H+ ions to balance the charge from taking up NH_4^+ ions.

Selecting the Correct Nitrogen Form

Nitrate moves more freely in the soil solution than ammonium, making it easier to get into the roots. But, nitrate must be converted to ammonium before the plant can use it. If the ammonium is needed in the root system, it will be used in the roots before any ammonium will be translocated to the stems and leaves. Nitrate, when taken up by roots, is immediately moved upward in the plant to the stems and leaves. In order for the nitrogen to be used by the plant for growth, the plant must convert the nitrate to ammonium. This occurs in the stems and leaves with the help of enzymes.

Young plants (less than three weeks) have not yet developed the enzymes necessary to convert the nitrate to ammonium, so they prefer ammonium. This is why many growers use fertilizer combinations with ammonium early in the season.

Once plants get older, there is generally a faster visual response to nitrate applications because of the immediate movement of nitrate into the leaves. And, as mention above, nitrate moves more freely in the soil than ammonium.

A balance of nitrate and ammonium nutrition is recommended for optimal plant growth. In most cases, ammonium should not exceed 50 percent of the total nitrogen supply and nitrate should not exceed 60 percent.

Urea is normally converted to ammonium carbonate within a few hours or days after application to the soil, so its action is similar to ammonium in terms of nutrition. Ammonium, which is not taken up by plant roots or volatized, is eventually converted to nitrate.

Fertilizer Solubility

Only 100 percent water soluble dry fertilizers should be used for fertigation systems. Conditioners that are used to prevent fertilizer pellets from absorbing moisture can create plugging problems. Whenever possible, purchase the "solution grade" form of these products.

Most dry solid nitrogen fertilizers will absorb heat from the water when they are mixed, since cold water will not hold the same amount of soluble material as warm water. Consequently, it can be difficult to dissolve as much fertilizer as needed. Dry fertilizer products that significantly lower the temperature of the water in which they are dissolved include urea, ammonium nitrate, calcium nitrate, and potassium nitrate.

Fertilizer Compatibility

If different fertilizer solutions are to be injected simultaneously into the irrigation system, you should perform a jar test beforehand to gauge compatibility. If the two solutions turn cloudy when mixed, there

is a chance that injection of the chemicals will cause line or emitter plugging. Make sure you use the same dilution of fertilizer for the jar test that is to be used for fertigation.

Injectors should be installed upstream from filters

Basic Mixing Rules

Compatibility can be affected by the order and way you mix things. Follow these basic mixing rules at all times.

1. Always fill the mixing container first with 50 to 75 percent of the required water when mixing dry, soluble fertilizers.
2. Always add the liquid fertilizer materials to the water in the container before adding dry, soluble fertilizers. The additional fluid will provide some heat, in case certain nitrogen sources reduce the temperature of the solution.
3. Always add the dry ingredients slowly with circulation or agitation to prevent the formation of large, insoluble or slowly soluble lumps.
4. Always put acid into water, not water into acid.
5. When chlorinating water with chlorine gas, always add chlorine to water, not water to chlorine.
6. Never mix an acid or acidified fertilizer with chlorine, whether the chlorine is in the gas form or liquid form, such as sodium hypochlorite. A toxic chlorine gas will form. Never store acids and chlorine together in the same room.
7. Do not attempt to mix either anhydrous ammonia or aqua ammonia directly with any kind of acid. The reaction is violent and immediate. Neither of these two materials should be used in drip irrigation systems.
8. Do not attempt to mix concentrated fertilizer solutions directly with other concentrated fertilizer solutions.
9. Do not mix a compound containing sulfate with another compound containing calcium. The results will be a mixture of insoluble gypsum.
10. Always check with the chemical supplier for information about insolubility and incompatibility.
11. Be extremely cautious about mixing urea sulfuric fertilizers (e.g. N-Phuric) with most other compounds. Urea sulfuric is incompatible with many compounds.
12. Many incompatibility problems tend to disappear if chemicals are spoon fed.
13. Do not mix phosphorous containing fertilizers with another fertilizer containing calcium without first performing the jar test.

14. Extremely hard water (usually contains large amounts of calcium and magnesium) will form insoluble substances when mixed with phosphate, neutral polyphosphate or sulfate compounds.

Nitrogen

Nitrogen is the element consumed in the largest amount by plants. It is also soluble and mobile in the soil, so it is subject to leaching. Plant quality and yield depend upon sufficient nitrogen in the soil during critical growth phases.

When anhydrous ammonia or aqua ammonia fertilizers are injected into irrigation water, the ammonium is quite water soluble. However, the pH of the water rises and some of the ammonia escapes and volatilize into the atmosphere.

Liming Effect with Ammonia Fertilizer - The high pH of the irrigation water will also cause the calcium and magnesium ions in the water to precipitate out of solution as lime in a very finely divided form (calcium and magnesium hydroxides and carbonates). This occurs frequently in the northwest portions of Mexico, Arizona and the Imperial Valley of California, where aqua ammonia and anhydrous ammonia are commonly injected.

The harder the water is, the more lime precipitates can clog drip lines and filters, as well as valves, gates and sprinklers. The precipitate that is applied by the irrigation system in the water will tend to clog soil pores over time, reducing the soil's infiltration rate.

Precipitation caused by water with high pH, is commonly overcome by using long-chain linear polyphosphate water conditioners, such as rose-stone (Calgon) and other products marketed for this purpose. These products are added to the water upstream of the point of fertilizer injection.

Phosphorus

Phosphorus is fairly stable in soils and consequently is often present in sufficient quantities. This can be verified with a soil test. Plant demand for phosphorus is greatest during germination and establishment.

Solubility - Many water soluble phosphate fertilizers can have precipitation problems when injected at high application rates into hard irrigation water. They include: monoammonium phosphate (MAP), phosphate (12-61-0), diammonium phosphate (DAP 21-53-0), monobasic potassium phosphate (0-52-34), phosphoric acid, urea phosphate, liquid ammonium polyphosphate (10-34-0) and long-chain linear polyphosphates.

Many farmers who inject phosphorus through drip and microirrigation systems should use acidic forms of phosphorus fertilizers rather than neutral forms. Phosphoric acid injection will be effective only as long as the pH of the fertigated water remains very low. As the pH rises with the addition of phosphoric acid, the phosphate precipitates with the calcium and magnesium. Some growers supplement

phosphoric acid injections with urea sulfuric acid to insure that the irrigation water pH will remain low (3.0 or lower). Caution should be exercised with either of these practices because low pH values (below 5.5) can increase corrosion of metal hardware, increase toxicity of certain micronutrients, or damage plant roots.

Potassium

Potassium has been associated with improved disease resistance and drought tolerance in plants. It is more mobile in soil than phosphorus and more likely to be deficient, especially where regular irrigation is necessary.

All potassium fertilizers are water soluble. Potassium sulfate (K_2SO_4) can be run through various gypsum injecting machines by itself, but it might form a mealy substance if it is run together with the gypsum in high-calcium waters.

Potassium thiosulfate (KTS) is compatible with urea and ammonium polyphosphate solutions in any ratio. Potassium thiosulfate should not be mixed with acids or acidified fertilizers. When blended with UAN solution, a jar test is recommended before mixing large quantities. Under certain mixing proportions, particularly when an insufficient amount of water is used in the mix, potassium in KTS can combine with nitrates in the mix to form potassium cyanide crystals. If this happens, adding more water should bring the crystals back into solution.

Trends in Fertilizer Use

The type of fertilizer applied in the irrigation water varies depending on region and crop. For the most part, the most popular fertilizers for fertigation are CAN-17, AN-20, UN-32, urea sulfuric acid, and specialty formulations.

Complete fertilizers (i.e. 8-8-8, 4-1010, 51-15-5) are popular for applications on vegetables, fruit, trees, and vines. Growers are also using more complicated formulations containing micronutrients to achieve greater crop quality and yields. For example, some growers in the Salinas Valley are apply zinc, manganese, iron and copper on lettuce to improve yields, increase head uniformity, and increase head size. Some fertilizer dealers blend their own specialty mixes to provide special blends at competitive prices. Other dealers are selling "concentrated water soluble fertilizers" that vary in grade (1510-30 or 6-30-30). These fertilizers are completely water soluble and are similar to Miracle GrowTM. Because of their cost, their use is limited to a variety of specialty crops, such as in nurseries.

Because nitrogen fertilizers are most commonly applied by fertigation systems, additional information is provided below for the most popular forms of nitrogen fertilizer.

Ammonium Nitrate Solution, AN-20 (20-0-0) - Ammonium nitrate fertilizer dissolved in water. It has a density of 10.5 pounds per gallon. This product is commonly used for fertigation. Under no conditions

should concentrated AN-20 be mixed with concentrated urea sulfuric acid, concentrated sulfuric acid, concentrated hydrochloric acid, or concentrated phosphoric acid.

Urea-Ammonium Nitrate Solution, UN-32 (32-0-0) - Urea-ammonium nitrate solutions are marketed as 32 percent nitrogen solutions in warmer agricultural climates and as 28 percent nitrogen solutions in cooler regions. They should not be combined with CAN-17 or solutions prepared from calcium nitrate. A thick, milky-white insoluble precipitate forms and can plug irrigation emitters.

Calcium Ammonium Nitrate, CAN- 17 (17-0-0-8.8CA) - This special nitrogen fertilizer is high in nitrate nitrogen, low in ammonium nitrogen, and supplies calcium. It is used on crops that have a high calcium requirement. Moreover, certain crops, such as pepper, strawberry, tomato, and eggplant, appear to produce higher yields of higher quality fruit when fertilized with predominately nitrate nitrogen fertilizer programs. CAN-17 should not be applied as a major source of calcium since the crop will be fertilized with excessive amounts of nitrogen. It can be combined with ammonium nitrate, magnesium nitrate, potassium nitrate, and muriate of potash (0-0-60). It should not be combined with any product containing sulfates or thiosulfates.

Urea Solution (23-0-0) - Urea is sold as a dry fertilizer (46-0-0) or a liquid solution (23-0-0). Generally, growers purchase urea solution for fertigation, although they can make their own solution by dissolving solid urea in water. Urea makes solutions extremely cold when it is being dissolved. Urea is noncorrosive.

Urea Sulfuric Acid - Urea sulfuric acid is an acidic fertilizer which combines urea and sulfuric acid. By combining these two materials, many disadvantages of using these material individually are eliminated. The sulfuric acid decreases the potential losses from ammonia volatilization at the soil surface and ammonia damage in the root zone by urea alone. Urea sulfuric acid is safer to use than sulfuric acid alone.

Urea sulfuric acid is used as follows:

1. To add nitrogen to the soil.
2. To acidify irrigation water. This reduces the amount of carbonates and bicarbonates in the water and helps keep drip lines clear of calcium carbonate deposits.
3. To clean irrigation lines. Once lines have become plugged, urea sulfuric can be injected to clean them.
4. To acidify the soil.
5. To increase availability of calcium in soils with free lime.
6. To prevent soil crusting, thus improving germination and soil structure.

Charles M. Burt is director of the Irrigation Training and Research Center at California Polytechnic State University in San l.uis Obispo. He can be reached at (805) 543-4907.