Fertigation for citrus trees

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Microirrigation is an important component of citrus production systems in Florida. For citrus trees, microirrigation (Figure 1) is more desirable than other irrigation methods for several reasons: water conservation, fertilizer management efficiency and freeze protection. Research has shown that when properly managed, water savings with microirrigation systems can amount to as much as 80 percent compared with subirrigation and 50 percent compared with overhead sprinkler irrigation. Research has also shown the important advantage of microsprinklers for freeze protection of citrus.

Microirrigation combined with fertigation (Figure 2) — applying small amounts of soluble fertilizer through irrigation systems directly to the root zone — provides precise

Figure 1. Microsprinkler irrigation of citrus trees.

Figure 2. Fertigation system for citrus trees.

Figure 3. Fertigation system including backflow prevention devices.

timing and application of water and fertilizer nutrients in citrus production. Fertilizer can be prescription-applied in small doses and at particular times when those nutrients are needed. This capability helps growers increase fertilizer efficiency, reduce nutrient leaching by excess rainfall or over-irrigation, and should result in reduced fertilizer rates for citrus production. The two most common nutrients applied to citrus through fertigation are nitrogen and potassium.

Florida state law requires that backflow prevention equipment (Figure 3) be installed and maintained on irrigation systems that have fertilizer injection capability. The function of the backflow prevention device is to prevent contamination of ground or surface water by the applied chemicals. Therefore, before injecting fertilizer into any irrigation system, make sure all required backflow prevention devices are in place and working properly.

The time required for water to travel from the injection point to the farthest emitter is generally 20 to 30 minutes for most microirrigation systems. Therefore, a minimum injection time of 30 to 45 minutes is recommended. This time should be sufficient to achieve uniform distribution of nutrients throughout the irrigation distribution system. After fertigation, continue to run water for at least 30 minutes to completely flush the fertilizer from irrigation system lines and emitters to minimize clogging potential. Keep in mind that excessive flushing time beyond 30 minutes can leach plant nutrients below the root zone.

FERTILIZER SOLUBILITY

Before injecting fertilizer solutions, a "jar test" should be conducted to determine clogging potential of the solution. A sample of the fertilizer solution should be mixed with irrigation water in a jar (at the same dilution rate that is used in the irrigation system) to determine if any precipitate or milkiness occurs within one to two hours. If cloudiness does occur, there is a chance that injection of the chemical will cause line or emitter plugging.

When urea, ammonium nitrate, calcium nitrate and potassium nitrate are dissolved, heat is absorbed from the water and a very cold solution results. Consequently, it may not be possible to dissolve as much fertilizer as needed to achieve the desired concentration. It is often necessary to let the mixture stand for several hours and warm to a temperature that will allow all the mixture to dissolve.

Nitrogen. Urea, ammonium nitrate, calcium nitrate, potassium nitrate, ammonium sulfate and ammonium thiosulfate are very soluble in water.

Phosphorus. Most dry phosphorus fertilizers (including ammonium phosphate and superphosphates) cannot be injected into irrigation water because they have low solubility. Monoammonium phosphate (MAP), diammonium phosphate (DAP), monobasic potassium phosphate, phosphoric acid, urea phosphate, liquid ammonium polyphosphate and long chain linear polyphosphates are water soluble. However, they can still have precipitation problems when injected into water with high calcium concentration.

Phosphoric acid is sometimes injected into microirrigation systems. It not only provides phosphorus, but also lowers the pH of the water, and this can prevent the precipitation problems previously mentioned. This practice will be effective as long as the pH of the fertilizer-irrigation water mixture remains low. As the pH rises due to dilution, phosphates precipitate. One approach that is sometimes successful is to supplement the phosphoric acid injections with sulfuric or urea sulfuric acid to assure that the irrigation water pH will remain low (between a pH of 4 and 5). Phosphoric acid should only be injected when the combined Ca and Mg concentration of the water is below 50 ppm and the bicarbonate level is less than 150 ppm.

Potassium. Most potassium fertilizers are water soluble, and injection of K through microirrigation systems has been very successful. The problem most often associated with potassium injection is solid precipitants that form in the mixing tank when potassium is mixed with other fertilizers. The potassium sources most often used in microirrigation systems are potassium chloride (KCl) and potassium nitrate (KNO_3). Potassium phosphates should not be injected into microirrigation systems.

Calcium. Fertilizers containing calcium should be flushed from all tanks, pumps, filters and tubing prior to injecting any phosphorus, urea-ammonium nitrate or urea sulfuric fertilizer. Calcium should not be injected with any sulfate form of fertilizer because it combines to create insoluble calcium sulfate, or gypsum.

Micronutrients. Several metal micronutrient forms are relatively insoluble and therefore are not used in fertigation. These include the carbonate, oxide or hydroxide forms of zinc, manganese, copper and iron. The sulfate form of copper, manganese and zinc is the most common and usually the least expensive source of micronutrients. These metal sulfates are water soluble, but through fertigation they are not very successful in alleviating a micronutrient deficiency.

SOME COMMON FERTIGATION MATERIALS

Ammonium Nitrate Solution (20-0-0). NH_4NO_3-H_2O is ammonium nitrate fertilizer dissolved in water with a density of 10.5 pounds per gallon. It is the most widely used nitrogen source for Florida citrus.

Urea-ammonium Nitrate Solution (32-0-0). $(NH_2)_2$2CO-NH_4NO_3: Urea-ammonium nitrate solution is manufactured by combining urea (46 percent N) and ammonium nitrate (33 percent N) on an equal nitrogen content basis. The combination of urea and ammonium nitrate contains the highest concentration of nitrogen of all the nitrogen solution products. When urea-ammonium nitrate solutions are combined with calcium nitrate, a thick, milky-white insoluble precipitate forms, presenting a potential plugging problem.

Calcium Nitrate (15.5-0-0-19 Ca) $5Ca(NO_3)_2$-NH_4NO_3-$10H_2O$: This fertilizer is high in nitrate-nitrogen (14.5 percent) with 1 percent ammonium-nitrogen, and it supplies calcium. The product can be combined with ammonium nitrate, magnesium nitrate, potassium nitrate and muriate of potash (KCl). It should not be combined with any products containing phosphates, sulfates or thiosulfates.

Ammonium Thiosulfate (12-0-0-26) $(NH_4)_2S_2O_3$ is used as both a fertilizer and as an acidulating agent. When applied to the soil, *Thiobacillus* bacteria oxidize the free sulfur to sulfuric acid. The acid then dissolves lime in the soil and forms gypsum. The gypsum helps to maintain a good, well-granulated, aerated and porous soil structure. Ammonium thiosulfate is ideal for treatment of calcareous (high lime) soils. It is compatible with neutral or alkaline phosphate liquid fertilizers and nitrogen fertilizers. Ammonium thiosulfate can be applied in liquid mixes or by itself. Ammonium thiosulfate should not be mixed with acidic compounds because it will decompose into elemental sulfur and ammonium sulfate at pH less than 6. Application to neutral and acidic soils (without free lime) may result in a pronounced drop in soil pH over several weeks. The extent of the pH drop in these types of soils depends upon the total amount of this fertilizer applied, the cation exchange capacity of the soil and the buffering capacity of the soil. (Most Florida citrus soils are very weakly buffered.)

Phosphoric Acid (0-54-0) H_3PO_4 has a density of approximately 14.1 pounds per gallon. The acid is a syrupy liquid that requires storage in polyethylene, fiberglass or stainless steel (No. 316) tanks. Phosphoric acid can be used in many formulations of nitrogen, phosphorus and potassium mixes. Phosphoric acid should never be mixed with any calcium fertilizer; it will form insoluble calcium phosphate, which can plug irrigation lines.

Potassium Chloride (0-0-62) Potassium chloride (KCl) or muriate of potash is the least expensive source of potassium and is the most popular K fertilizer applied through fertigation. It may not be desirable for use on citrus if irrigation water or soil contains a high salt concentration.

Potassium Nitrate (13-0-46) Potassium nitrate is expensive, but the consumer benefits from both the nitrogen and the potassium in the product. It is an excellent choice of potassium fertilizer for areas where irrigation water salinity problems are present. It is less soluble than potassium chloride, but more soluble than potassium sulfate.

Potassium Sulfate (0-0-52) K_2SO_4 can be an alternative to KCl in high-salinity areas and provides a source of sulfur. It is less soluble than potassium chloride and potassium nitrate.

Potassium Thiosulfate (0-0-25-17 and 0-0-22-23) $K_2S_2O_3$ (KTS) is marketed in two grades and is a neutral to basic, chloride-free, clear liquid solution. This product can be blended with other fertilizers, but KTS blends should not be acidified below pH 6.0. The proper mixing sequence for KTS is first water, then pesticide (if any), and then KTS and/or other fertilizer. Potassium thiosulfate provides not only potassium, but the thiosulfate is oxidized by *Thiobacillus* bacteria to produce sulfuric acid. This acid reacts with calcium carbonate in the soil, which releases additional calcium for the plant. Thus, potassium thiosulfate use on calcareous soils not only supplies potassium and sulfur, but aids in increasing the availability of calcium to plants.

Urea Solid (46-0-0) and Urea Solution (23-0-0) Urea is sold as 46-0-0 dry fertilizer or as a liquid 23-0-0 urea solution. Commercial urea contains about 2.25 percent biuret, a byproduct that forms only during the manufacturing process. It can inhibit plant growth or damage plants. Urea with less than 0.25 percent biuret content should be used for foliar applications. Urea should never be mixed with sulfuric acid in the field. Mixing urea and concentrated sulfuric acid results in a strongly exothermic reaction and explosion may result if the heat is not properly dissipated.

Urea Sulfuric Acid. Urea sulfuric acid ($CO(NH_2)_2 \cdot H_2SO_4$) is an acidic fertilizer that combines urea and sulfuric acid. By combining the two materials into one product, many disadvantages of using these materials individually are eliminated. The sulfuric acid decreases the potential ammonia volatilization losses from the soil surface. Urea sulfuric acid is safer to use than sulfuric acid alone. Urea sulfuric acid is well suited for fertigation. It can also be used for other purposes such as acidifying irrigation water (reducing plugging potential from carbonates and bicarbonates), cleaning irrigation lines once they have been plugged and acidifying the soil.

CRYSTALLIZATION

Solution fertilizer salt-out, crystallization, or precipitation in storage tanks can be a problem during the winter. As a rule of thumb, the more complex the formulation, the greater is the tendency for salt-out. The most important factor affecting salt-out temperature of a fertilizer solution is its concentration of N and K. The higher the analysis of a solution, the higher is the crystallization temperature. For example, a 10-0-10 solution fertilizer made from ammonium nitrate and potassium chloride will salt out at about 60°F, while 8-0-8 and 6-0-6 solutions made from the same sources will salt out at about 41°F and 27°F, respectively. Solution fertilizer suppliers can provide salt-out temperatures for specific mixtures. If prolonged temperatures below the salt-out temperature are expected, crystallization should be prevented by diluting the solution with water.

FERTIGATION SUMMARY

◆ Fertilizer is placed in the wetted area where feeder roots are extensive.

◆ Fertilizer may be applied more frequently in small amounts so that it is available when the tree needs it.

◆ Increased fertilizer application frequency with lower rates can increase fertilizer efficiency and reduce leaching.

◆ Application cost is much lower than that of dry or foliar fertilizer application.

Through fertigation, comparable or better yields and quality can be produced with less fertilizer.

Microirrigation systems must be properly designed and maintained to apply water and fertilizer uniformly. Growers must know:

(1) which fertilizer formulations are most suitable for injection,

(2) the most appropriate fertilizer analysis for different age trees and specific stages of growth,

(3) the amount to apply during a given fertigation event, and

(4) the timing and frequency of applications.

Properly managed applications of plant nutrients through irrigation systems significantly enhance fertilizer efficiency while maintaining or increasing yield. On the other hand, poorly managed fertigation may result in substantial yield losses. Be sure that backflow prevention devices are in place and working properly.

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