Fertigation for Pecan Orchards

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More and more agricultural producers are using their irrigation systems to apply chemicals. This practice, termed chemigation, can be an effective application method provided the chemical is suited for the practice and the irrigation system is properly engineered. Today, chemigation can be broken down into newly created terms like fertigation, herbigation, fungigation, insectigation, and nemagation. Fertigation, the practice of applying fertilizer with irrigation water, is the most widely used form of chemigation. Fertigation actually began several centuries ago when farmers simply dumped animal manure into irrigation canals.

Conventional ways of applying dry fertilizer to pecan orchards are giving way to liquid fertilizers that apply nutrients through irrigation water. This process (fertigation) may have the advantage of reaching the whole root systems of pecan trees. Current technology allows the application of most essential nutrients through orchard drip or flood irrigation systems.

There are five factors to consider when applying fertilizer in irrigation water: mobility of the fertilizer nutrient in the soil; irrigation water quality-fertilizer combination effects; fertilizer cost and effectiveness; crop demand schedule for the nutrient; and weather factors.

Irrigation water quality can be affected favorably by applying a suitable nitrogen fertilizer in irrigation water. Because of the acidizing effects of some nitrogen fertilizers, applying nitrogen in marginal irrigation water may help to reduce the negative effects of high sodium and salt content by freeing exchangeable calcium in the soil. The calcium can then exchange for the adsorbed sodium, allowing the sodium salts to be leached from the soil. In addition, the acidifying effect of applying nitrogen fertilizer in irrigation water may increase the availability and retention of plant micronutrients.

UAN (urea-ammonium nitrate) solutions and ammonium thiosulfate are pressureless liquid fertilizers suitable for application through irrigation systems. Anhydrous ammonia is a high-pressure liquid that becomes a gas at atmospheric pressure. It may be applied by bubbling it into an irrigation canal at a point upstream of the field or border. The bubbler must be placed under at least six inches of flowing water in the ditch or canal, and the ratio of anhydrous ammonia to water should not exceed 100 parts per million (ppm). When any chemicals are applied through a drip irrigation system, New Mexico law requires the use of a safety backflow prevention device to prevent the flow of chemicals back into a well or public water system.

One source of nitrogen is not better than another. However, several characteristics should be considered before choosing a fertilizer for a specific purpose. Solubility, effect on soil pH, form of N, and associated nutrients are some of these considerations. Quality, rather than cost, should be the deciding factor in fertilizer selection.

Ammonium sulfate is associated with lowering soil pH, thus preventing cotton root rot, to which pecans are susceptible. As a result, ammonium sulfate is often preferred for pecans. For application in irrigation water, ammonium thiosulfate would replace ammonium sulfate.

In general, pecan trees are slow to respond to nitrogen fertilizer applications. By applying nitrogen in the first irrigation water before bud break, pecan trees will have an ample supply during their greatest growth period and may show a quicker response. The amount of fertilizer needed by a pecan tree depends on its size, age, production, and soil type. In general, 150–200 lb/ac of actual nitrogen is recommended in established orchards. Cultural practices also influence the amount of fertilizer needed. Nitrogen fertilizers may be applied in split amounts with irrigations from March through July. Do not apply nitrogen to young trees after June because it may delay leaf fall and result in winter injury. For detailed information on fertilizer requirements and timing, obtain NMCES Guide H-602, “Pecan Orchard Fertilization.”

If nutrients, especially nitrogen, are applied too early, they may be leached by spring rains or volatilize. Nutrient application with irrigation water can be done more often when the pecan trees have a heavy crop that requires large amounts of nitrogen and water, eliminating early applications when there is a greater risk of losing nitrogen.

FLOAT CONTROL VALVE APPLICATION

Liquid fertilizer can be injected into an irrigation ditch using a float control valve. A normal flood irrigation for a pecan orchard would be 4–6". If the ditch carries 2,000 gpm, the time needed to apply a 6" irrigation to 10 acres is 13.5 hr. This is calculated using the formula:

$$t = ad/q$$

where

t = hr
a = acres
d = inches to be irrigated
q = ft^3/second [450 gpm = 1 ft^3/second].

Apply the formula to the example:

$$t = ad/q$$

$$t = 10 \times 6 / (2{,}000/450) = 13.5 \text{ hr.}$$

In this example, if 40 lb of N/acre are recommended for one irrigation, then 400 lb N must be applied (10 acres) in 13.5 hr or 30 lb N/acre hr. Assuming the fertilizer to be used is 33% N and has a density of 11 lb/gal, then the application rate is 2.72 gal N/hr (30 lb of N ÷ 11) or 8.26 gal fertilizer/hr (90.9 lb ÷1 11) for 30 lb of N/acre/hr. A float control valve can be connected to the fertilizer supply tank and set to apply the correct flow rate. The concentration of fertilizer in water or soil is measured in parts per million (ppm) on a weight basis, which means lb of fertilizer/lb of water. The weight of the water and the concentration of nitrogen in the water (ppm) are calculated by the following formulas:

Flow rate in ditch X density of water = weight of H_2O/hr

Example:

60 min X 2000 gpm X 8.3 lb/gal = 996,000 lb H_2O/hr (or weight of irrigation water/hr)

(Nitrogen rate per hour ÷ weight ofwater/hr) = ppm

Example:

(30 lb N hr ÷ 996,000 lb H_2O/hr) = 0.000030 = 30 ppm

FERTILIZER INJECTION IN PRESSURIZED SYSTEMS

Dry fertilizer broadcast on the soil surface cannot be moved into the root zone effectively when the trees are drip irrigated because only a small area of soil is wet by drip emitters. However, fertilizer can be applied effectively through the irrigation system and this method is recommended. Excellent injection equipment is available that usually can be connected into the main pipeline so the fertilizer can be routed selectively to all trees in the orchard. To prevent emitter plugging, fertilizer must be injected upstream from the filter so all undissolved fertilizer material and precipitates will be contained by the filter. Select an injector that operates properly on the electrical voltage, water pressure, and water flow rate available in the orchard, and has adequate capacity to apply the fertilizer needs of pecan trees.

Highly soluble nitrogen fertilizers such as potassium nitrate, calcium nitrate, ammonium nitrate, ammonium polyphosphate, liquid uran, and urea nitrogen can be applied by the drip irrigation system. First, dissolve or mix dry fertilizer material in water to make the proper concentrate, making certain all fertilizer is in solution. Liquid nitrogen such as uran and urea normally can be applied undiluted by the irrigation system. Check for precipitate formation that can clog the emitters and filter by mixing appropriate amounts of the fertilizer solution and irrigation water prior to injection. A precipitate frequently forms when anhydrous ammonia is added to irrigation water because the pH of the water is raised and calcium and magnesium carbonates can precipitate. Other nitrogen fertilizers may also produce precipitates at high concentrations, especially with lower quality water.

Begin fertilizer injection when the irrigation system is applying water at the normal rate. Check the application rate by timing the injection of a specific quantity of material. Complete injection before the irrigation cycle ends in order to move fertilizer out of the irrigation system and into the root zone. One to three hours may be required to move fertilizer material to trees at the ends of lateral pipelines, especially where only one emitter is used for each tree.

Injector pumps come in three types. One type uses a piston or diaphragm mechanism at either a fixed or adjustable rate. The injection rate is not a function of flow rate. The second type is a piston-type proportional injector that pumps a proportional rate of fertilizer/water. A third type of is a venturi, which has an injection rate that is a function of pressure and flow rate.

ADJUSTABLE RATE INJECTOR

On an adjustable rate injector, the length of the piston stroke changes. The stroke length is set at a proportional rate of 0-10% of the maximum injection rate based on piston diameter. Injection rates vary from 0.18-163 gph. If nitrogen is injected continuously with the water, then the injection rate should be set to have approximately 30 ppm of N in the water. The 30 ppm is estimated by calculating the total weight of water applied to pecans to satisfy evapo—transporation over the time period fertilizer is injected and then dividing this number into the recommended seasonal nitrogen application. However if nitrogen is to be injected only periodically, then the injection rate should be high enough to inject the fertilizer in a reasonable time.

Example: How long to run the injector to apply 1 lb of N per inch of tree from March to July.

Given:
1) Tree: 1" diameter
2) Fertilizer solution: 33% N
3) Emitters: four 1 gph emitters per tree
4) Number of trees: 400
5) Fertilization period: 20 weeks
6) Density of fertilizer: 11 lb/gal
7) Concentration of injected N: 250 ppm (250×10^{-6})
8) Density of water: 8.33 lb/gal

Solution:
1) If the fertilizer is to be injected weekly from March to June, then the injected amount is lb of fertilizer/number of weeks.

$$\frac{1 \text{ lb N}}{20 \text{ wk}} = \frac{.05 \text{ lb}}{\text{wk}}$$

2) Calculate the weight of water applied per hour for one tree. Flow rate of

$$4 \text{ gph} \times 8.33 \text{ lb/gal} = 33.3 \text{ lb/hr of } H_2O.$$

3) Calculate the lb of N in the water if the injection rate (concentration) is 250 ppm. The lb of N/hr is equal to the concentration in ppm times the weight of water per hour (flow rate).

$$= 250 \times 10^{-6} \text{ lb N/lb } H_2O \times 33.3 \text{ lb/hr } H_2O$$
$$= .008 \text{ lb N/hr}$$

4) The time to run the injector pump is the amount of fertilizer to apply divided by the application rate.

$$.05 \text{ lb} \div .008 \text{ lb/hr} = 6.25 \text{ hr}$$

5) The injector setting concentration (to achieve 250 ppm of N) in the water is calculated from the concentration of N ppm divided by the percent of N in the fertilizer.

$$\frac{(250 \times 10^{-6} \text{ lb N / lb } H_2 0}{(0.33 \text{ lb N / lb fertilizer})} = 758 \times 10^{-6} \text{ lb fertilizer / lb } H_2 0$$

6) Fertilizer injectors inject a specific volume of fertilizer. Convert the concentration on a weight basis to a volume basis by multiplying the concentration by the density of water and dividing by the density of the fertilizer.

$$\frac{(758 \times 10^{-6} \text{ lb fertilizer/ lb } H_2O \times 8.33 \text{ lb gal } H_2O)}{(11 \text{ lb fertilizer/ gal fertilizer})}$$

$$= 573 \times 10^{-6} \text{ lb fertilizer / gal fertilizer}$$

$$= 573 \text{ ppm (volume basis)}$$

7) Calculate the injector rate by using the known flow rate of the specific system, times the concentration of the fertilizer on a volume basis.

$$400 \text{ trees} \times 4 \text{ gal / hr} = 1600 \text{ gal / hr}$$
$$1600 \text{ gal / hr} \times 573 \times 10^{-6} \text{ gal fertilizer / gal } H_2 0$$
$$= 0.92 \text{ gal fertilizer / hr}$$

8) Select an injector with a flow rate range within the injection rate. As an example, an adjustable injector has a flow rate of 0.2 to 1.96 gph.

9) Set the scale adjustment on the injector by dividing the needed injection rate of the fertilizer by the maximum injector setting.

$$\frac{0.92 \text{ gal fertilizer / hr}}{1.96 \text{ gal / hr}} = 0.47 \text{ (or 4.7 on a scale of 10)}$$

PROPORTIONAL INJECTION

On a proportional injector type, the size is based on the flow rate of the injector, which is rated in gpm. The flow rate of the system is:

1. 1,600 gal/hr = 26.6 gpm

2. An injector with a flow rate range of 2.2–40 gpm will handle the flow rate needed.

3. Calculate the injector proportional rate. The concentration of fertilizer on a volume basis is 573 ppm (.00057), a ratio of 1:1745. This is a problem because most proportional injectors have a range of 1:500 to 1:50.

4. Dilute the fertilizer by four so the fertilizer plus water mixture should be injected at 2,292 ppm, which is 1:436.

5) Turn on the proportional injector 6.25 hr each week.

VENTURI FLOW METER

For a venturi flow meter, select an injector that will inject 1.0 gal/hr or greater. The venturi flow meters have an adjustable valve to decrease the flow rate. If the irrigation system flow and pressure are constant, then the venturi injector rate will be constant for a given fertilizer density. The best way to set a venturi is by installing the inlet tube in a graduate cylinder and measuring the injection rate by timing the rate at which the graduate cylinder empties, then adjust the injector intake valve to achieve the proper flow rate.

A computer program from the University of Florida titled SOLUFERT will help the grower through some of the steps needed to have the right concentrations used in fertigation. This program is available from Dr. Fedro S. Zazueta or Allen G. Smajstra, Agricultural Engineering Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida, 32611, (904) 392-2468.

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