# Chemigation

Chemigation refers to injecting a chemical into irrigation water and applying the chemical through the system to the crop or field. Applying chemicals with irrigation water is not a new concept; it has been used for years with furrow irrigation and anhydrous ammonia, or with flood irrigation on rice and different chemicals. However, chemigation is presently used most often in conjunction with sprinkler or drip irrigation systems.

The earliest work using chemicals through sprinklers was injecting fertilizer into the system and applying it with irrigation water (fertigation). Herbigation followed when herbicides were applied through a sprinkler system, generally center pivots. Other chemicals then started to be used—insecticides for insectigation, fungicides for fungigation, and nematicides for nematigation. Eventually, all of the terminology was combined and "chemigation" was the result.

There are advantages and disadvantages of applying chemicals through an irrigation system. **Consider these pros and cons carefully before using chemical injection methods**. The following discussion concerns center pivots, but the chemigation method can be adapted to other types of systems.

## Advantages of Chemigation

- *Uniformity of application*. Center pivots have good uniformity built into them, and factory design usually gives excellent distribution of water. If a system lacks good uniformity, check the nozzling.
- *Prescription applications.* Applying the chemicals with a measured amount of water puts the chemical at the desired location in the soil.
- *Economics.* Applying chemicals through chemigation is often less expensive than are conventional application methods.
- *Timeliness.* Chemicals may still be applied when other methods cannot be used due to soil wetness or other limiting conditions.
- *Incorporation and activation.* Chemicals are incorporated and activated when applied with the large volumes of water, even from light irrigations.
- *Reduced compaction.* Soil compaction occurs in a controlled traffic pattern, taking place at the drive towers with sprinkler systems rather than over large areas of the field as seen with conventional spray equipment.
- *Crop damage.* Clearance by the pivot helps prevent crop damage that can occur from conventional ground-application equipment.
- *Operator hazards.* Because an operator is not riding on the system, there is less potential for human contact with the chemical (due to drift, frequent filling, or other exposure).

## Disadvantages of Chemigation

- *Higher management.* Chemical application requires skill in system calibration and knowledge of the irrigation and chemical-injection equipment.
- *Additional equipment.* Injection equipment, safety devices, and storage equipment are needed.
- *Environmental hazards.* Contamination of water sources is possible if the proper safety equipment is not used. Runoff from chemically laden water to other areas is possible. **Personal injury could occur if warning signs are not posted around the well and field when chemicals are being used**.

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- *Increased application times.* Under center pivots, application time might be longer than some conventional methods. This also allows for more interference by unfavorable weather conditions.
- *Unnecessary water applications.* If a person is locked in to chemigation, there may be times that chemical applications need to be made but it is too wet or windy to apply the desired amount of water needed for proper chemical application. Excess water can also cause compaction; even with light application, crusting of the soil surface may become a problem.

## Chemigation Safety Equipment

When any chemical is applied through an irrigation system, there are safety devices that must be used on the irrigation system and the injection equipment. The safety equipment protects against contamination of the general water supply and chemical spills from the chemical supply tank. The following are suggested to help protect the water supply and the injection chemical.

### *Interlock*

The irrigation pumping plant and the chemical injection pump must be interlocked or connected so that if the irrigation pumping plant stops, the chemical injection pump also stops. This prevents pumping the chemical mixture from the supply tank into the irrigation pipeline after the irrigation pumping plant stops. (See **Figure 1** for internal combustion engines and **Figure 2** for electric motors.)

For internal combustion engines, the chemical injection pump can be belted to the drive shaft or an accessory pulley of the engine. Other alternatives include operating the injection equipment off the engine electrical system (12 v), or using the power source (oil or electric) of the sprinkler-system drive. **In all cases, it is essential that if the irrigation water supply stops, the chemical injection also stops.**

For an electric motor-driven irrigation pump, a separate, small electric motor is usually needed to power the chemical injection pump. Controls for the two electric motors need to be interlocked so both motors stop when the motor on the irrigation pump stops. All wiring must conform to the National Electric Code. Some agricultural chemicals are flammable and require the use of explosion-proof motors and wiring. If you are injecting a pesticide, consult the label for specific information before use.

### *Irrigation Pipeline Check Valve and Vacuum-Relief Valve*

Check and vacuum-relief valves (anti-siphon devices) are needed in the irrigation pipeline. They keep water and/or a mixture of water and chemical from draining or siphoning back into the irrigation well and polluting the groundwater. Both of these valves are between the irrigation pump discharge and the place of chemical injection into the irrigation pipeline (**Figure 1** and **Figure 2**).

The check valve must have positive closing action and a watertight seal and must be easy to repair and maintain. Install the valve with fittings that allow easy removal for maintenance and repair. The vacuum-relief valve allows air into the pipeline when the water flow stops. This prevents the creation of a vacuum (behind the check valve) that could lead to siphoning.

### *Inspection Port*

Locate an inspection port between the pump discharge and the mainline check valve. This port allows for a visual inspection to determine if the check valve leaks. Inspect at least once a year. In many cases the vacuum-relief valve connection can serve as the inspection port.

### *Chemical Injection Line Check Valve*

A check valve in the chemical injection line is needed for two purposes: to stop flow of water from the irrigation system into the chemical supply tank and to prevent gravity flow from the chemical supply tank into the irrigation pipeline after an unexpected shutdown. Without a check valve, if the injection pump stopped, irrigation water could flow back through the chemical line into the chemical supply tank, overflow the tank, and cause a spill around the irrigation well. The spilled chemical then could eventually move through the soil to the groundwater or run off into nearby surface water. It would be desirable for this check valve to have a minimum opening (cracking) pressure of 10 psi to prevent gravity flow from the chemical tank, through the injection pump, and into the irrigation pipeline. It should be constructed of chemical-resistant materials.

### *Hoses, Clamps, and Fittings*

Keep all hoses, clamps, and fittings in good repair and inspect these components *at least* annually. All components in contact with the chemical or chemical mixture (from the strainer to the point of injection on the irrigation pipeline) should be constructed of chemical-resistant materials.

### *Chemical Suction Line Strainer*
A strainer on the chemical suction line is necessary to prevent clogging or fouling of the injection pump, check valve, or other equipment.

### *Low-Pressure Drain*
An automatic low-pressure drain should be placed on the bottom side of the irrigation pipeline. In the event that the mainline check valve leaks slowly, the solution will drain away from, rather than into, the well. The drain should discharge at least 20 feet from the well, and the flow should be directed away from the well. A hose or pipe may be needed to direct the discharge the desired distance from the drain. The preferred location of this drain is between the irrigation pump and the mainline check valve. With some systems, placement of this valve may be more feasible downstream of the mainline check valve; however, it should always be located on the irrigation pipeline before the point of chemical injection.

### *Additional Protection Solenoid Valve*
A normally closed solenoid valve can be electrically interlocked with the power unit or motor driving the injection pump. This valve, located on the inlet side of the injection pump, provides a positive shutoff on the chemical injection line. Therefore, neither the chemical nor the water could flow in either direction if the chemical pump were stopped.

## Management Practices for Chemigation

### *Flushing Injection System*
Flush the injection system with clean water after use to prevent accumulation of precipitates and contamination of the equipment.

### *Flushing Irrigation System*
After injection is completed, operate the irrigation pump for at least 10 minutes to flush the chemical from the irrigation system. If the irrigation system quits automatically, flush the system as quickly as possible after the shutdown is discovered, and extend the flushing period to a minimum of 30 minutes.

### *Monitoring*
Periodic monitoring of the irrigation system and chemical injection equipment helps assure proper operation during any chemical application.

### *Agitation*
Some form of mechanical agitation should be used where required to prevent precipitation of chemicals in the tank. Paddle-wheel agitation at 60 rpm may work the best.

### *Calibration Check*
Check the pivot for application uniformity and overall flow rate to make sure the pivot system is performing as specified. A uniformity coefficient of at least 77 percent is expected.

### *Drive Units*
It may be desirable to purchase high-speed drive units on a new system or to convert an old system so you can make lighter applications of water (where desirable with some chemicals).

### *Chemical Compatibility*
Check compatibility of the chemical with the water supply to assure there will not be precipitate that could clog nozzles on the system. High pH coupled with high concentrations of calcium or magnesium in water can cause calcium and magnesium phosphates to precipitate out when using phosphate fertilizers. Likewise, water that is high in bicarbonates could cause precipitation of calcium carbonate when using calcium nitrate. Many issues like these can be addressed by adjusting water pH.

### *End Guns*
Check the uniformity and application under the end gun and shut it off if it is not desirable. Uniformity should match the system; however, in most cases it is recommended to shut off the end gun during injections.

### *Chemical Labels*
Follow label directions on all chemicals when injecting them. If a chemical is not specifically labeled for use through center pivot or for chemigation and a failure occurs, the user is probably liable.

### *Runoff*
Manage the irrigation system to prevent runoff of the water-chemical mixture. If runoff does occur within the field, take precautions to prevent the runoff from leaving the field. With a given sprinkler package on a center pivot, reducing the size (or depth) of the application (i.e., making a faster revolution) reduces the potential for runoff. As a general rule, the water application rate should not exceed the soil's infiltration rate.

### *Application to Surface Water*
Avoid application of chemicals near permanent or semi-permanent surface water areas. Such application may affect wildlife, other non-target plants and animals, or ground and surface water quality.

Figure 1

## Minimum Requirements for Anti-Pollution Devices And Arrangement of Equipment for Applying Chemicals Through the Irrigation System

**(Engine Drive)**

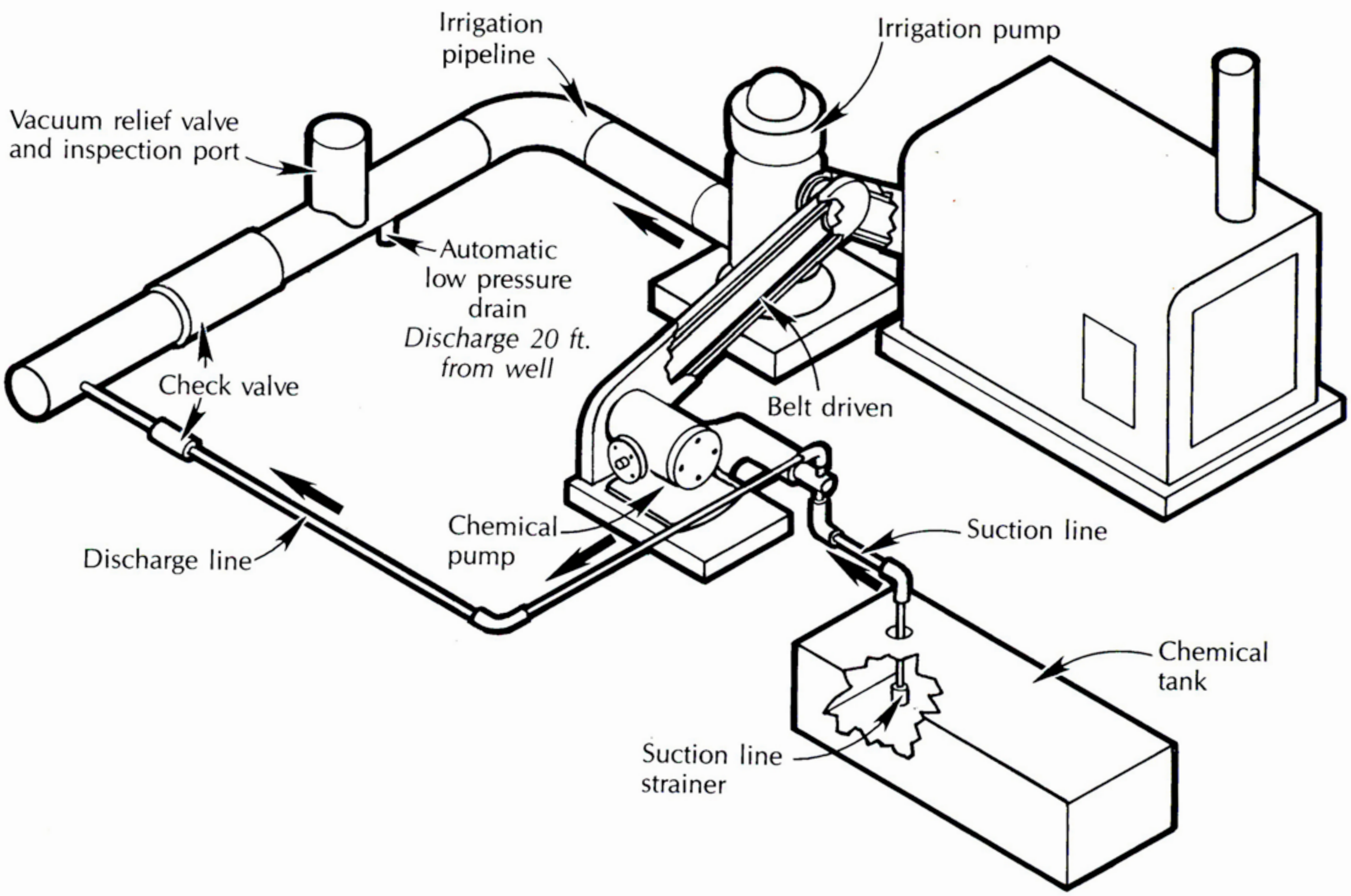
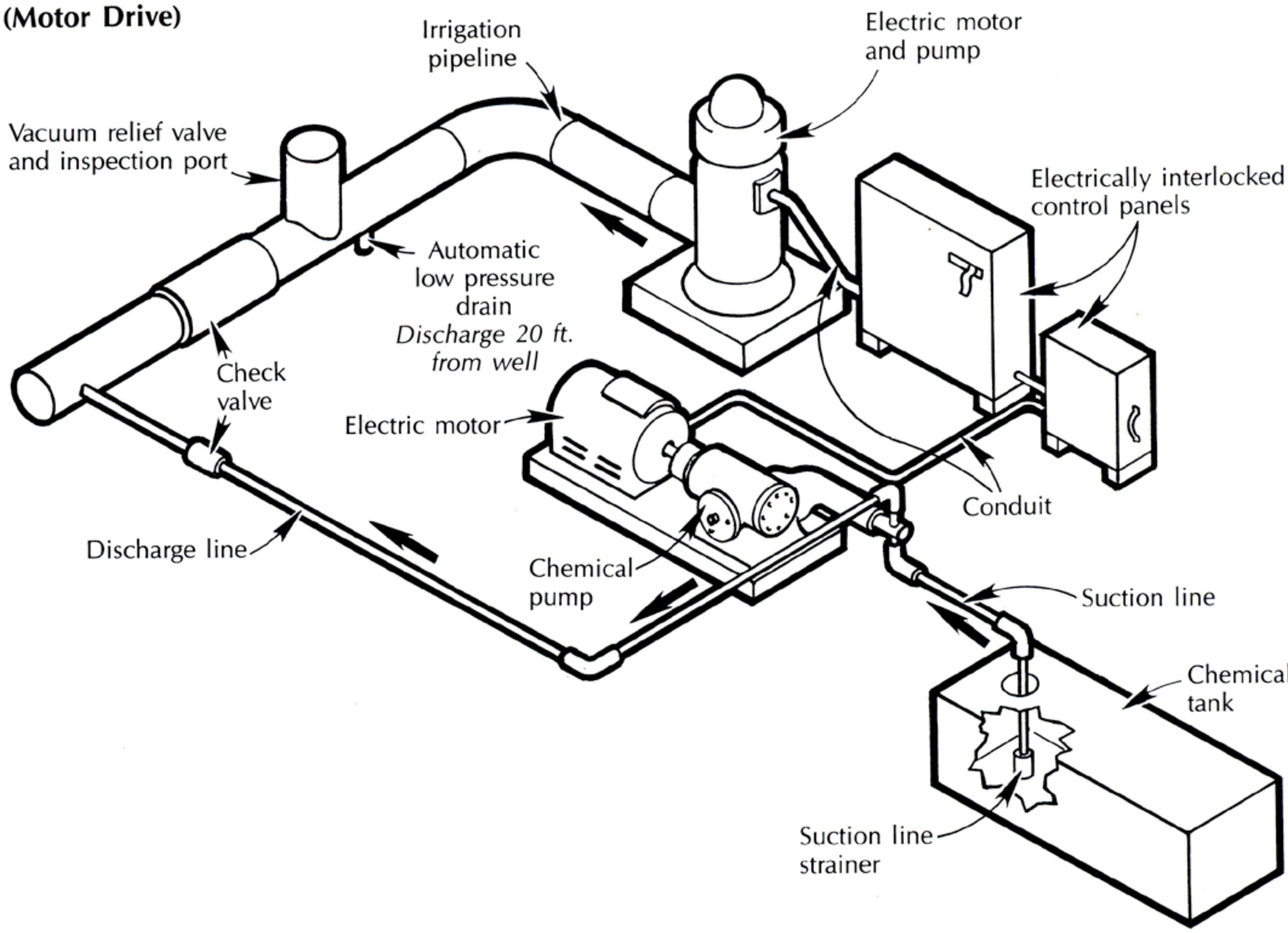


**Figure 2**

## Minimum Requirements for Anti-Pollution Devices And Arrangement of Equipment for Applying Chemicals Through the Irrigation System

**(Motor Drive)**



## Chemigation Pumps

There are three injection units used for chemigation. The two mechanical units are piston pumps and diaphragm pumps. The third unit is a venturi meter that creates suction from velocity changes through the throat of the meter.

The piston and the diaphragm pumps can be powered by belt drive or electric motor. Both pumps can be adjusted for flow rate within a designed range. After adjusting the calibration on a pump, always recheck the calibration with actual measurements of material used or supplied. Also make sure all components in the pumps—pistons, seals, hoses, and couplings—are resistant to the chemicals they are being used with, and always clean and flush the pump after use.

The venturi meter is a tube with a reduced diameter in the throat, creating a vacuum that pulls the chemical into the water stream. Venturi meters require a constant water supply from an external water source or a bypass with a small booster pump of some water from the system.

When using a venturi, an additional pump or booster pump must be used for steady flow (through the venturi) at a higher pressure than the pivot. A small valve is used on the suction line to regulate the injection rate. Variation in flow rate from the water supply creates a change in the vacuum pressure and a resulting change in the rate of injection.

All three pumps are satisfactory for injection of chemicals. Diaphragm pumps are often more popular because of ease of calibration, lack of external leaks, and maintenance of calibration. Regardless of which is used, calibrate the pump for the volume to be injected, and clean the pump carefully after use. If chemicals stay in the pump, the useful life can be shortened and problems can arise from failure of seals, hoses, or other mechanical parts. No pump is any better than the time taken to calibrate and maintain it properly.

## Calibration

Accurate calibration of injection equipment is essential for safe and proper application. Small differences in injected material make large differences in the total amount of chemical applied and could cause failure or overapplication.

### *Injector Calibration*

450 gallons/minute = 1 acre-inch/hour
27,000 gallons = 1 acre-inch

1. Determine the total acres to be irrigated.
2. Determine the amount of chemical to be applied per acre.
3. Multiply the value from step 1 by the value from step 2. This value is the total amount of chemical needed.
4. Determine the desired revolution time (for a pivot system).
5. Divide the value from step 3 by the value from step 4. This value is the injection rate (units/time) required.

To check calibration, use a stopwatch and container of known-volume graduations. To determine the amount of material per minute, use the following formulas:

If using a milliliter graduated cylinder: gallons/hours x 63.09 = ml/minute

If using an ounce graduated cylinder: gallons/hours x 2.133 = oz/minute

Example: Use 32 percent urea ammonium nitrate (UAN) to apply 10 pounds N/acre through a 1320-foot center pivot covering 125.5 acres at 900 gallons per minute. The fertilizer goes on with 0.50 inch of water.
32% (UAN) weighs 11.06 lb/gal and has 3.54 lb N/gal
10 lb N/acre / 3.54 lb N/gal = 2.82 gallons of fertilizer will be used per acre

125.5 acres x 2.82 gal of fertilizer/acre = 354 total gallons of fertilizer solution

It takes 31.3 hours to apply 0.5 inch on the whole circle.
354 gallons / 31.3 hours = 11.3 gal/hour injection rate

For calibration, 11.3 gal/hr x 2.133 = 24.12 oz/min of fertilizer solution.

## Management Considerations for Fertilizer Use

Of the chemicals possible for use in chemigation, fertilizers are the best suited for commercial use in Mississippi. Methods for applications of herbicides, fungicides, and insecticides are advancing rapidly.

**It must be noted that fertigation is not foliar feeding.** With fertigation, almost 100 percent of the applied fertilizer ends up in the soil. This is in contrast to foliar feeding where the fertilizer with small amounts of water is applied to the plant foliage where it remains until it is used by the plant or washed off by rain or irrigation.

When using fertilizers with an irrigation system, at least four questions should be considered.

1. **Are additional plant nutrients needed?**
The decision to apply post-plant fertilizers is in some ways the most difficult aspect of chemigation. The decision is always somewhat subjective and it can be difficult to collect data to aid in making the decision. With cotton and corn, nitrogen is the nutrient most likely needed in a post-plant application. Pre-plant application of phosphorus and potassium is almost always adequate for a complete growing season.

   A decision to apply nitrogen after planting may be based on a history of yield responses with post-plant nitrogen applications by more conventional methods, the appearance of deficiency symptoms, or the results of tissue testing for nitrogen. Tissue testing for nitrogen has had poor acceptance in Mississippi because water stress interferes with the test results. Properly irrigated crops should be less subject to this complication.

2. **Is selected material suitable for application with an irrigation system?**
The simplest fertilizer materials for water injection are true solutions such as urea ammonium nitrate (UAN) at 32 percent N by weight. The chemical forms of these nutrients are compatible with typical irrigation-water chemistry and do not damage foliage in the diluted form. They have good soil mobility so that they will be moved into the rooting zone with the irrigation water.

   Anhydrous ammonia ($NH_3$) can react with irrigation waters that are high in carbonate and bicarbonate, causing precipitation of lime from the water. This can contribute to clogging of the system. Anhydrous is also more volatile than other forms of nitrogen, which will result in a greater loss of nitrogen to the atmosphere. Also, many sprinkler companies don't recommend injecting anhydrous through the system.

   Some forms of high-grade soluble phosphate materials do not react with water to form large amounts of precipitates. These can be applied with water. Phosphates present another kind of problem because they are not mobile in the soil and stay close to their point of application. With sprinkler-applied water, the phosphate stays near the soil surface where there are few roots. The result is that, even though the material can be applied to the soil by the irrigation system, it has limited plant availability.

3. **Is material economical?**
There are several forms of N, P, and K that are chemically well-suited for irrigation application. For example, some forms of calcium nitrate and calcium nitrate solutions are compatible with sprinkler injection and have good plant availability. However, their cost is much higher than other nitrogen materials (particularly UAN solutions) that work as well. Cost and availability of the material to be applied are important considerations to the producer.

4. **Is the operation economical?**
Equipment and operating costs of adding chemical injection to an existing sprinkler system are minimal compared to costs associated with conventional ground applications. Unfortunately, many Mississippi fields are only partially covered by irrigation systems and conventional application equipment must be available for the non-irrigated parts of the fields. Maintaining conventional application equipment for non-irrigated portions of a farm may detract from the economics of water application of fertilizers or other chemicals.

## Water Application

Once a grower has decided to apply a fertilizer through an irrigation system, he or she should consider how much water to use in the application. Sprinkler irrigation systems are designed to apply water uniformly to the soil, but small differences in soil infiltration rate within a field may result in movement of water from one part of a field to another. This redistribution of the water is not just the wholesale runoff from a large area but the redistribution of water within relatively small areas of the field. The result is uneven amounts of available water in the soil, and these show up as hot spots or areas where rank growth occurs. The same uneven distribution of nutrients can occur. Distribution is better if the fertilizer is applied with smaller amounts of water (half- inch or less). A quarter-inch application of water per acre is equivalent to applying 6,790 gallons of water (with the chemical) on each acre.

## Summary

Chemical application with irrigation systems is a safe and effective practice—provided the chemicals and system are managed properly and safety precautions are taken. Regulations adopted in the future at the federal, state, or local level may change requirements for chemical application. Keep abreast of future technology developments and regulatory requirements to assure that effective chemical applications are made and that adequate protection is provided.

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**Publication 1551**
Extension Service of Mississippi State University, cooperating with U.S. Department of Agriculture. Published in furtherance of Acts of Congress, May 8 and June 30, 1914. GARY B. JACKSON, Director
(POD-03-12)