

production

FERTIGATION

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Fertigation is the injection of fertilizers through the irrigation system. Microirrigation systems are well-suited to fertigation because of their frequency of operation and because water application can be easily controlled by the manager. Applying fertilizers through a microirrigation system:

- Allows fertilizer distribution to be as uniform as the water application.
- Allows flexibility in timing fertilizer application.
- Reduces the labor required for applying fertilizer, compared to other methods.
- Allows less fertilizer to be applied compared to other fertilization methods.
- Can lower costs.

FERTILIZER SOLUBILITY

In order to be injected, fertilizers must be soluble. Fertilizers delivered as a solution can be injected directly into the irrigation system, while those in a dry granular or crystalline form must be mixed with water to form a solution. Fertilizer materials differ widely in water solubility, with solubility depending on the physical properties of the fertilizer as well as on irrigation water temperature and pH. Dry fertilizers are mixed into a tank containing water until the granules or crystals are dissolved and the desired concentration is reached. The solution is then injected into the irrigation system. With use of solutionizer injection machines, the injected material may be in a slurry form, which goes into solution once it is mixed with the irrigation water.

NITROGEN SOURCES

The fertilizer most commonly injected is nitrogen, with many soluble nitrogen sources working well in fertigation. Following is a list of common nitrogen sources, with information on their use in fertigation:

Anhydrous ammonia or aqua ammonia

These nitrogen sources cause an increase in water pH, which may result in a precipitate if calcium or magnesium is present in the irrigation water along with comparable levels of bicarbonate. Volatilization of nitrogen (loss to the atmosphere) may also occur when anhydrous or aqua ammonia is used.

Urea

Urea is relatively soluble in the irrigation water and is not strongly held by soil particles, so it moves deeper into the soil than the ammonia products. Urea is transformed by hydrolysis into ammonium, which is then fixed to the soil particles.

Ammonium sulfate

Ammonium sulfate, ammonium nitrate, and potassium nitrate are all relatively soluble in water and cause only a slight shift in the soil or water pH.

Calcium nitrate

Calcium nitrate is relatively soluble in water and causes only a slight shift in the soil or water pH. If the water is high in bicarbonate, however, the calcium content may lead to precipitation of calcium carbonate (lime).

Ammonium phosphate

Ammonium phosphate can also cause soil acidification. If calcium or magnesium levels are high enough in the irrigation water, precipitates may also form, which can clog the drip emitters. (See the discussion under phosphate sources below, for precautions in using ammonium phosphate.)

PHOSPHATE SOURCES

Using phosphate fertilizers may cause chemical or physical precipitate clogging. The calcium

and magnesium content and the pH of the irrigation water should be considered, since calcium phosphate and magnesium phosphate precipitates may form when the water pH is higher than 7.5. Acidifying the water with sulfuric acid or using phosphoric acid keeps the irrigation water pH low and minimizes precipitation problems.

Phosphorous is quickly fixed to soil particles and does not move readily into the soil profile, but it has been found to move more easily under microirrigation than under conventional irrigation methods.

POTASSIUM SOURCES

Injecting potassium fertilizers usually causes few problems, but caution should be observed if potassium fertilizers are mixed with other fertilizers. Potassium, like phosphorous, is fixed by soil particles and does not move readily through the soil profile.

Potassium is usually applied in the form of potassium chloride, but for crops sensitive to chloride, potassium sulfate or potassium nitrate may be more appropriate. Potassium sulfate is not very soluble and may not dissolve well in the irrigation water.

INJECTION DEVICES

Chemicals are often injected through irrigation systems, particularly microirrigation (drip and microsprinkler) systems. This process, known as chemigation, allows a manager to apply chemicals at any time without the need for equipment in the field. Chemigation both increases the efficiency of chemical application -- resulting in decreased chemical use and cost -- and reduces the hazard to those handling and applying the chemicals. It is also less potentially harmful to the environment, compared to air applications, for instance, which may allow chemical wind drift. However, chemigation can still cause environmental damage, particularly when the chemicals injected move readily with the irrigation water. Over-irrigation resulting in deep percolation can contaminate groundwater when a mobile chemical is injected.

Many different substances can be injected through irrigation systems, including chlorine, acid, fertilizers, herbicides, micronutrients,

nematicides, and fungicides. Of these, fertilizers are the substances most commonly injected. Chlorine or acid injection is used in microirrigation systems to prevent clogging caused by biological growths (algae and bacterial slimes) and chemical precipitation (particularly calcium carbonate).

Irrigators wishing to inject chemicals have a variety of injection equipment from which to choose, including differential pressure tanks, venturi devices, positive displacement pumps, small centrifugal pumps, and solutionizer machines.

Differential pressure tanks

Differential pressure tanks, often referred to as "batch tanks," are the simplest of the injection devices. The inlet of a batch tank is connected to the irrigation system at a point of pressure higher than that of the outlet connection. This pressure differential causes irrigation water to flow through the batch tank containing the chemical to be injected. As the irrigation water flows through the batch tank, some of the chemical goes into solution and passes out of the tank and into the downstream irrigation system. Because the batch tank is connected to the irrigation system, it must be capable of withstanding the operating pressure of the irrigation system.

While relatively inexpensive and simple to use, batch tanks have the disadvantage that as irrigation continues, the chemical mixture in the tank becomes more and more dilute, decreasing the concentration in the irrigation water (Figure 17a). If a set amount of a chemical, such as fertilizer, is to be injected and concentration during the injection is not critical, use of batch tanks may be appropriate. If the chemical concentration must be kept relatively constant during injection, batch tanks are not appropriate.

Venturi devices

Venturi devices (Figure 17b) -- often referred to as "mazzei injectors"-- consist of a constriction in a pipe's flow area, resulting in a negative pressure or suction at the throat of the constriction. "Mazzei" is a trade name for a particular brand of venturi injector. Venturi

injectors are also available from other manufacturers.

The venturi injector is frequently installed across a valve or other point where between 10 and 30 percent of the pressure is lost because of friction in the venturi. This means that the inlet of the venturi injector must be at a pressure 10 to 30 percent higher than the outlet port. Because of these significant pressure losses, the injector should be installed parallel to the pipeline so that flow through the injector can be turned off with a valve when injection is not occurring. The injection rate of a venturi device is determined by the size of the venturi and the pressure differential between inlet and outlet ports. Injection rates as high as 700 gallons per hour are possible with large venturi devices.

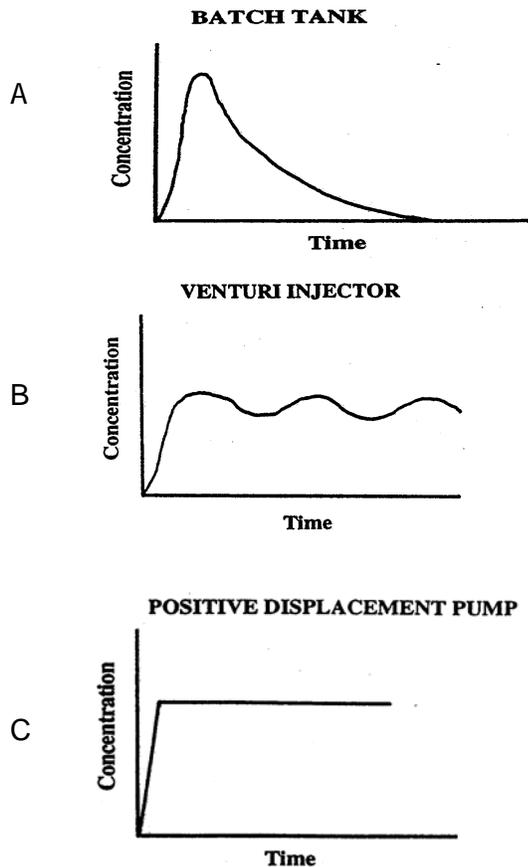


Figure 17a. Chemical concentration levels during injection using a batch tank, venturi injector and positive displacement pump.

Venturi injectors can also be installed with a small centrifugal pump which draws water from the irrigation system, increases its pressure while moving the water through the venturi, and then returns the water and chemical back into the irrigation system.

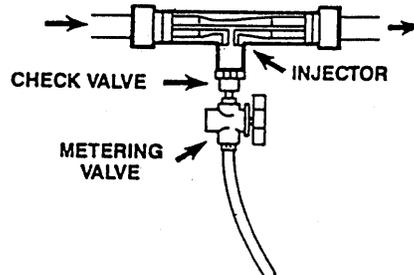


Figure 17b. Venturi device.

Venturi devices are inexpensive and relatively simple to operate, but they do not inject chemicals at as constant a rate as positive displacement pumps. Injecting with venturi devices may be sufficiently accurate for applications such as fertilizer injection, however.

Positive displacement pumps

Positive displacement pumps are piston or diaphragm pumps that inject at precise rates. The pumps are powered by electricity or gasoline or are driven by water. The water-driven pumps can be installed in locations that lack power. When a constant and precise injection concentration is needed, positive displacement pumps are preferable (Figure 17a).

Positive displacement pumps are the most expensive of the injection devices, with costs for electric pumps running \$750 or more.

Centrifugal pumps

Frequently, a centrifugal pump is used for the injection of fertilizers. These pumps have a greater flow rate than do the positive displacement pumps or most venturi injectors, which makes them appropriate for higher injection rate applications. The centrifugal pumps can be either electrically- or gas engine-

driven. Using the centrifugal pump in conjunction with a flow meter can be helpful in controlling the injection rate.

Solutionizer Machines

Solutionizer machines were developed to inject materials that are not readily soluble. Their most common use is for injecting finely ground gypsum through the irrigation system, but they are also used for injecting fertilizer products such as potassium sulfate.

The solutionizer machines inject a slurry of material into the irrigation line where it then mixes and goes into solution. In microirrigation systems, it is important that these materials be injected upstream of the system filters to ensure that insoluble materials are filtered out and do not clog the emitters. For example, gypsum materials, which are 95% pure, may still contain up to 5% insoluble materials. This would mean that for every 100 lbs. of gypsum material injected, 5 lbs. of insoluble material might be present. Dry fertilizer materials may also contain significant insoluble material.

INJECTION POINT

The injection point should be located so that the injected fertilizer and the irrigation water can become thoroughly mixed well upstream of any branching of the flow. Because of concerns over fertilizers being flushed out when the microirrigation system filters are backwashed, the injection point should be downstream of the filters. To ensure that no contaminants are injected into the microirrigation system, a good quality screen or disk filter should be installed on the line between the chemical tank and the injector.

The system should be allowed to fill and come up to full pressure before injection begins. Following injection, the system should be operated to flush the fertilizer from the lines. Leaving residual fertilizer in the line may encourage clogging from chemical precipitates or organic sources such as bacterial slimes.

CHEMIGATING UNIFORMLY

Once injection begins, the injected material does not immediately reach the emitters. There is a "travel time" for water and injected chemical to move through a microirrigation

system. Measurements made in commercial orchards indicate that this travel time may range from 30 minutes to well over an hour, depending on the microirrigation system design. To ensure that application of any injected material is as uniform as the water applications, the following steps should be taken:

Step 1: Determine the travel time of chemicals to the farthest point hydraulically in the microirrigation system. This is a one-time determination and can be done by injecting chlorine into the microirrigation system (a good maintenance procedure anyway) and tracing its movement through the system by testing the water for chlorine with a pool / spa test kit.

Step 2: The injection period should be at least as long as it takes the injected material to reach the end of the last lateral line (determined in Step 1). A longer injection period is usually preferable.

Step 3: Once injection is stopped, the irrigation should continue for a period of time as long as it took the injected material to reach the end of the farthest lateral (determined in Step 1). A longer, post-injection, irrigation period is usually preferable.

Make sure, especially with injected materials that easily travel with the water (e.g. nitrate materials), that there is no over-irrigation which moves water (and injected material) through the root zone. Such over-irrigation could waste the injected material and lead to groundwater contamination.

CHEMIGATION SAFETY

Appropriate care should be exercised when handling all fertilizer materials and the safety of personnel should be of highest priority. Environmental safety associated with fertigation should also be a priority. Fertigation regulations vary from State to State. In California, chemigation safety regulations apply only to labeled chemicals, not to fertilizers. While there are no California State regulations concerning fertigation, there may be local regulations so they should be checked and followed. The same safety equipment required for injection of labeled chemicals is

also very useful for environmental protection when fertigating.

Figure 17c is a sample chemigation layout, which has safety devices for preventing environmental contamination. There are also

numerous other approved layout configurations that incorporate different injectors and other safety devices. The safety devices in figure 17c include:

Positive Displacement Pump Injection System

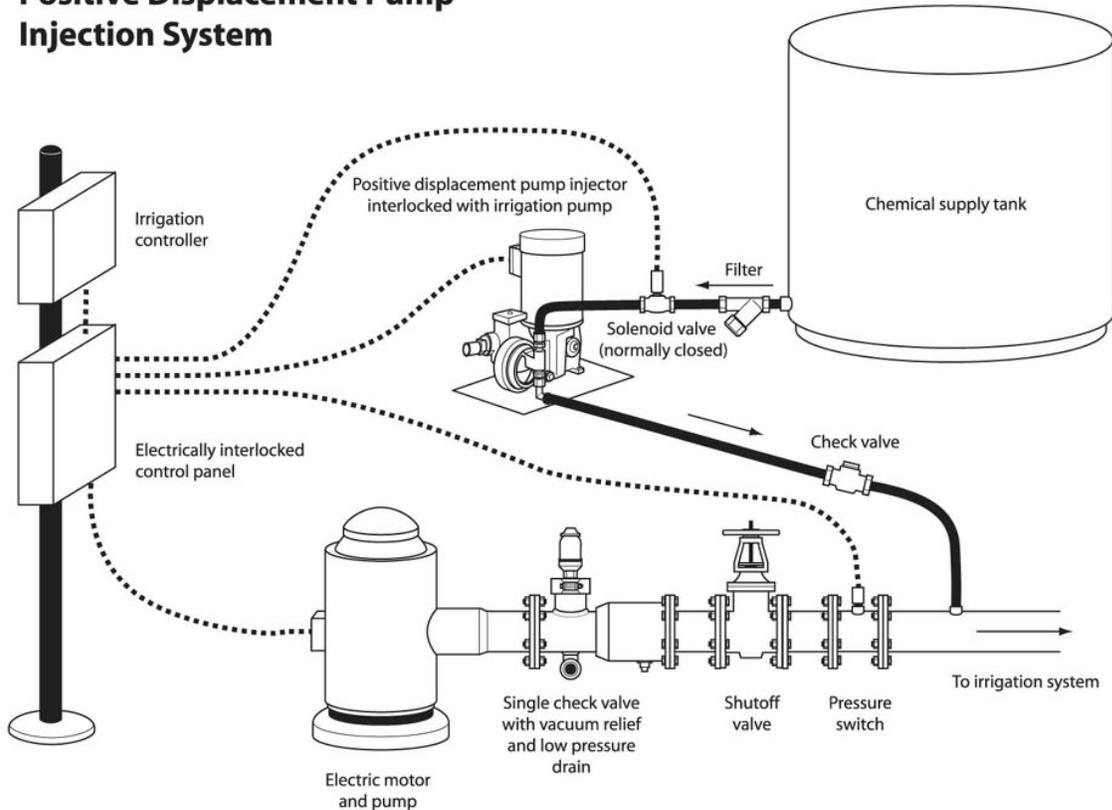


Figure 17c. Typical layout of chemigation injection system.

- Chemigation check valve – this check valve, located between the water source and the injection point, prevents chemical from moving back to the water source. The check valve has a one-way, spring-loaded flap inside, which allows water to pass only downstream. The chemigation check valve also has an air vent/vacuum relief valve and a low-pressure drain upstream of the one-way flap closure (fig. 4). The vacuum relief valve prevents a vacuum from forming that could draw chemical through the closed check valve. If some chemical does leak past the closed check valve, it will drain out the low-pressure drain that is

open when the irrigation system is shut down, but closes when the irrigation system is pressurized.

Even if there is no expectation that chemicals other than fertilizer will be injected through the irrigation system, installation of a chemigation valve is a prudent move when fertigation is planned. Backflow of fertilizer to a well or other water source can result in surface and groundwater contamination. At a minimum, leaving room to plumb in a chemigation valve at a later date is wise. Retrofitting an irrigation system, which doesn't have room for a chemigation valve, can be expensive.

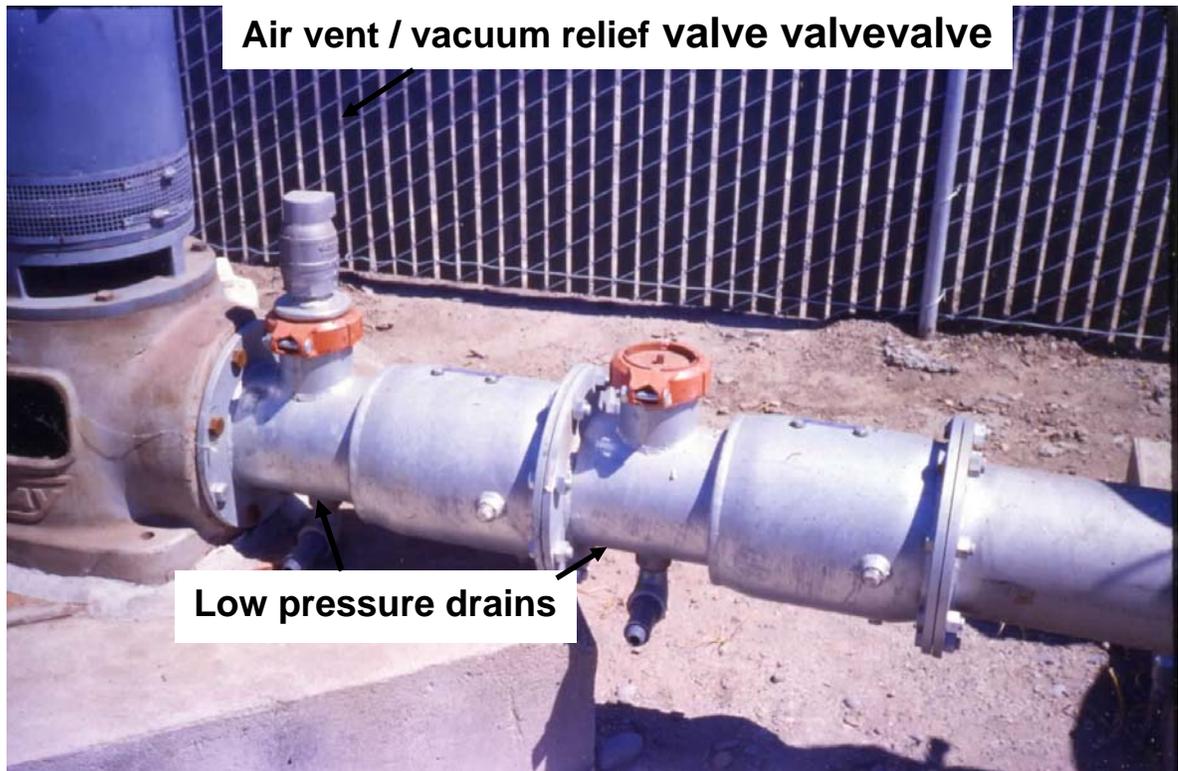


Figure 17d Double chemigation check valve protecting a well from backflow contamination. A double check valve is required in some States and is installed for safety redundancy.

- An electronic interlock between the water pump and the fertilizer injector pump prevents operation of the injector if water is not being pumped.
- A check valve in the line from the injector to the irrigation system prevents water from flowing back through the injector and overflowing the chemical storage tank.
- A normally-closed solenoid valve (or a normally-closed, hydraulically-operated valve) between the chemical tank and the injector keeps chemical in the tank from flowing into the irrigation system when it isn't operating.
- A pressure switch in the irrigation system, interlocked to the pump, will shut down the irrigation and injection systems if there is a break in the pipeline or some other cause for a drop in operating pressure.