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FERTIGATION - The Next Frontier

by

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The irrigation industry has experienced major changes over the past 20 years. To mention just a few items:

1. Irrigation management and water supply decisions are now often based on consideration of the environment, rather than on economics.
2. Drip irrigation was in its infancy 20 years ago; now we have drip irrigation, microirrigation, and SDI (subsurface drip irrigation) for both permanent and field/row crops.
3. In many states, the predominant method of irrigation has switched from surface irrigation to drip/micro irrigation.
4. The definition of "sprinkler irrigation" has changed dramatically. Not only do the sprinklers themselves often look different, but concepts such as LEPA are now commonplace in many areas.
5. The concepts of irrigation efficiency and distribution uniformity (DU) are much better understood. Contracts often call for a new irrigation design with a high DU, and field evaluations of existing irrigation systems are standard in some areas. In some areas, high irrigation efficiencies are mandated by water allocations which are determined by an irrigation efficiency and the crop evapotranspiration.
6. Irrigation scheduling with the help of computers, weather data, soil moisture sensors, and/or plant stress indicators is an accepted practice.

So what is new on the horizon? Now that we understand the concepts of maximizing irrigation efficiency, how can we not only maintain, but also increase, crop yields with less water and less acreage? The answer lies in improved nutrient management combined with proper irrigation water distribution and management.

Just as irrigation dealers presently should specify pressure relief valves and air vents on all pipelined irrigation systems, future irrigation designs will incorporate a new generation of FERTIGATION (fertilization through the irrigation system) hardware. And farmers will use sophisticated techniques to monitor plant nutrient status and to determine the proper level of nutrients to spoon feed through fertigation.

Benefits

The benefits of good fertigation are very real and will become increasingly important. The manufacture of nitrogen fertilizers is very energy intensive. The Cal Poly ITRC, on behalf of the California Energy Commission, recently documented the energy associated with various irrigation practices. The energy required to manufacture the fertilizer can equal the combination of all other energy inputs (pumping, tractors, pipe manufacture, etc.) in vegetable fields. Good fertigation practices can reduce fertilizer applications. In general, the ITRC has found that with SDI (buried drip on vegetables) under good management:

1. The fertilizer application is reduced about 25%.
2. The yields increase.

The net result is that the yield per unit of fertilizer (or water) is increased - this is a true measure of improved "efficiency".

One can quickly understand that the lower fertilizer applications, coupled with increased yields (i.e., increased intake of fertilizer by the plants), also result in less groundwater contamination with nitrates. This is a major consideration for long term, sustainable irrigated agriculture.

The most sophisticated fertigation management in California is presently done with vegetables and lettuce. Many of the growers are more interested in the improved crop quality than in increased yield; they can reduce some disease problems, improve taste and color, improve the size or shape, and lengthen the shelf life of their products if they fine tune their fertigation programs.

Irrigation Systems

Although fertigation is used with virtually all types of irrigation systems, its advantages are most pronounced when it is combined with fairly high frequency irrigation management. That means solid-set sprinkler system, linear moves and center pivots, and all types of drip/micro irrigation. Such systems allow managers to finely tune and spoonfeed both water and nutrients. Just as water schedules can be adjusted daily or weekly to match weather demands, fertilizer dosages and types can be adjusted as frequently to match plant demands.

Good fertigation management requires that managers look beyond the supply of nutrients in the soil. They must also look at the availability of those nutrients to the plant. If an irrigation system only provides water once per week or two weeks, the top foot or so of the root zone is quite dry immediately before an irrigation. Many of the important plant nutrients (e.g., phosphorus) are predominately in this top layer, and they cannot move into the plant roots if the moisture content is reduced. High frequency irrigation allows the manager to make certain that if the nutrients are in the soil, they are also available to the plant.

Irrigation System Distribution Uniformity

As long as the fertilizer is completely dissolved and is applied in moderately low dosages, the fertilizer will be distributed as evenly as the water. High irrigation system DU's (greater than 85%) are very important for finely tuned fertigation practices.

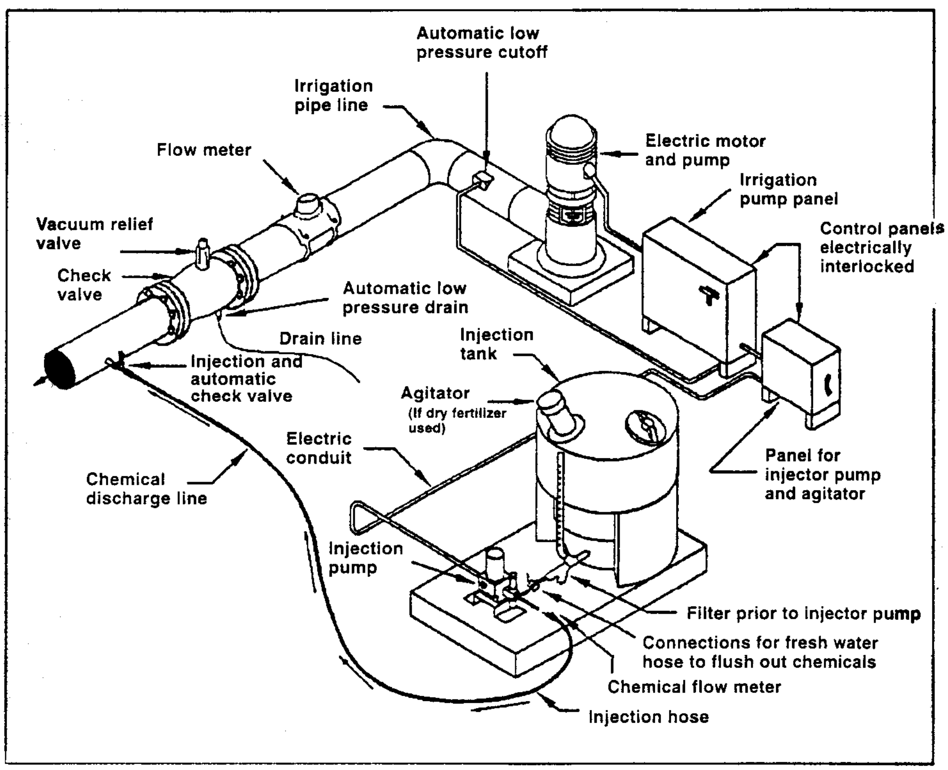
Legalities and Safety

Certain hardware items are required by the US Environmental Protection Agency (USEPA) for most agricultural fertigation systems. Specifically, they are required if there is a possibility of fertilizer backflow into a well. Local agencies (counties, water districts, states) may have additional hardware requirements. Nebraska goes even further and requires an inspection of the fertigation site, plus training for applicators.

In many areas of the U.S., enforcement of USEPA regulations is minimal or non-existent. As fertigation becomes more common and sophisticated, and as it is accompanied by more chemigation of insecticides, fungicides, and nematicides, the enforcement will become standard. Irrigation dealers should familiarize themselves with the regulations and become actively involved in installing the required hardware on new systems and retro-fitting existing systems.

Certain hardware should be installed even in cases where there is no hazard of contaminating groundwater or drinking water supplies. Equipment should be installed to prevent fertilizer tanks from overflowing, exploding, or draining, and to prevent the buildup of high pressures which could cause hoses to burst. Systems should also be installed with a means of limiting the amount of fertilizer which can be injected, to prevent over-application of chemicals.

In other words, an irrigation dealer should not just sell a "chemical injector". An irrigation dealer should sell a "chemical injection system" which includes all the essential safety devices, plus which is simple to adjust and operate. Figure 1 below illustrates a configuration with essential hardware.



A fertigation installation with necessary hardware.

Injector Locations

There are three basic locations for injectors. Some growers use all three locations.

1. Upstream of filters. This is the best location for the majority of fertilizer applications, because any contaminants or precipitates can be caught in the filter before entering the field. The injection system should be inter-connected with the filter backflush controller so that the fertilizer injection is temporarily halted during backflushing.

   The downside of injecting upstream of filters is possible corrosion problems. These can be eliminated by one or all of the following, depending upon the situation:
   a. Filters should have excellent non-corrosive internal linings. There are tremendous differences between various manufacturers.
   b. Spoon-feed fertilizers rather than apply them in large, occasional dosages. Spoon-fed dosages are generally non-corrosive and are also better for plant nutrition.
   c. Filters can be equipped with anodes to prevent corrosion.
   d. 304 stainless steel is only corrosion resistant - 316 is required for very corrosive solutions or salinities greater than about 700 ppm.
   e. Acids should be injected downstream of the filters.
   f. All chemicals should be injected into the middle of the pipe so that they can be well mixed before entering the filters.

2. Downstream of filters. This is the recommended location for acids.

3. In-field. Some fields of vegetables or permanent crops are divided into many small blocks of different ages, maturity, or varieties. In such drip irrigated fields, a central injection system is generally used to apply compounds such as acids, gypsum, chlorine, and sometimes a base level of nitrogen. However, each block will have varying fertilizer needs depending upon the stage of growth and variety. An injection port is generally provided at each block valve, and a portable tank and injection pump is used to fertigate. In some cases, the irrigators are provided with a list of irrigation hours and fertilizer amounts for each block. Irrigators must be specially trained in procedures to prevent contamination of the system while connecting hoses. It is very easy to introduce dirt into the irrigation system with this configuration.

Selecting an Injector

To say that there is a "best" injector is similar to saying that one irrigation system is best for all crops, climates, and soils. Remember that the injectors described here do not by themselves constitute a "system", but require additional hardware. Here are some guidelines:

1. Stay away from Pressure Differential Tanks. They are expensive and cannot provide an injection at a constant rate.
2. If you use a venturi-type of injector, configure it with a small booster pump to provide the motive flow. Do not try to plumb it around an existing pressure differential in the piping system, as that pressure differential is often insufficient and will vary with time.
3. Never use a butterfly or gate valve to create a pressure differential to drive an injector. Although there are some cases where it is reasonable, it is a good idea to

avoid this practice completely. Often, an irrigator will dramatically decrease the DU of the irrigation system when the valve is temporarily and partially closed. The fertilizer will be applied, but the uniformity of distribution will be horrible.

4. There are some excellent automatic electric injectors which can be designed with a feedback mechanism to maintain a constant ppm of fertilizer. Although they have historically been only used in greenhouses, the advances in both pump hardware and microprocessor technology have made them economical for agricultural applications.
5. Water-powered pumps can be simple or complex, depending upon the manufacturer. However, they are easy to shut off automatically by installing an automatic volumetric valve on their source water hose. They typically inject about one gallon of fertilizer for each 2-3 gallon of drive water.
6. It is rare that one injector will be sufficient for all applications. Many growers use 4 to 6 injectors, each one calibrated for a different chemical and for different dosages. It is difficult to calibrate a large injector for a small dosage.
7. Don't purchase an expensive high pressure injection system if it is possible to legally and effectively inject the chemical into a low pressure point. A wide selection of injectors is available for non-electric, low pressure situations. These range from float boxes to gas pumps.

Compatibility

Some combinations of chemicals are dangerous. Others form precipitates when mixed together. In addition, many individual fertilizers can form precipitates when injected into the irrigation water. A few rules can help avoid such problems. These include:

1. Spoon-feed fertilizers. Precipitation problems are greater when the dosages are higher.
2. Always perform a "jar test" before mixing and injecting. The "jar test" is very simple - put the chemical or chemicals into a quart jar of irrigation water at the approximate dosages that will be used. Let the jar sit for 24 hours. If a milky or cloudy substance appears, there is likely to be a precipitate problem.
3. Thoroughly flush hoses and injectors after use and before using them with another chemical. Some fertilizers such as Urea-sulfuric acids are notorious for their incompatibility with other fertilizers. This is another reason to have multiple injector pumps at a site.
4. Always add acid to water, not vice-a-versa
5. Never mix chlorine with acid, as it will combine to make toxic chlorine gas.

Other

Details of fertigation hardware, fertilizers, nutrition, compatibility, and plant/soil/water diagnosis can be found in the brand new 250 page book entitled FERTIGATION published by the ITRC on behalf of the California Energy Commission. It is available for $34.95 plus shipping and tax from the ITRC along with other publications and software.