Fluid JOURNAL
Official Journal of the Fluid Fertilizer Foundation
Late Spring 2008
Vol. 16 No. 3, Issue #61

Dr. Thomas A. Ruehr

Fluids Key To Nutrient Efficiencies In Irrigation Management

Lend themselves to application through micro-sprinkler and drip irrigation systems.

Summary: One of the major challenges for the fluid fertilizer industry today is 1) helping crop consultants understand what causes increased yields and 2) what to do in helping growers to respond by applying more nutrients (and often more different nutrients) to maintain optimum crop production systems. Micro-sprinkler and drip irrigation are moving our thinking away from classical production practices and closer to a system of hydroponic growth whereby constant nutrient additions are necessary with the water supplied to ensure optimum crop growth.

Growers have found fluid fertilizers a better choice for delivering nutrients to many western U.S. soils due to the convenience of application through micro-sprinkler and drip irrigation systems. The loss of solid ammonium nitrate (due to terrorism concerns) has increased the availability and use of urea ammonium nitrate (UAN) in California in the past few years.

Major irrigation firms are focusing more upon the nutrient aspects of their products. Several companies have realized simply installing an extensive irrigation system does not guarantee the system will function properly or will ensure grower success with nutrient management.

One of the most important aspects of successfully using fluid fertilizers with irrigation systems is understanding the importance of proper water management. This water management can be considered in two forms: 1) the frequency of water application and the level of moisture in the soil, and 2) the overall quality of the water and ways to improve the water quality for improved irrigation efficiency and water management.

Water needs

Application frequency. A common problem is over-application of water with micro-sprinkler and drip irrigation systems. It is important for growers to use various tools to predict the appropriate amount of water needed by the crop. In California, this means using the California Irrigation Management Information System (CIMIS) through the state-maintained website (http://www.cimis.water.ca.gov/cimis/data.jsp). The important thing about using this information is the hourly update of data from various weather stations around the state. These data are based upon accurate Evapo Transpiration (ET) values. In semi-arid and arid regions where the soil surface is dry, it is often tempting to irrigate when the subsoil moisture is adequate. Using ET values ensures excess moisture will not exist. Over-irrigation can lead to excessive accumulation of soluble iron, manganese and hydrogen sulfide, plus encourage more disease organisms.

Quality considerations. A major problem of water quality exists in the Western U.S. where snow melt water is used. A similar problem can occur anywhere rainwater is collected in reservoirs. The problem is water that's too pure. Such water with a low electrolyte level allows the clay and humus particles to swell with water, leaving the soil pores near the soil surface plugged. Correction for the problem is to add sufficient gypsum to bring the EC of the treated water to above 0.3 mmhos/cm. Gypsum should be treated with acid to ensure pH is about 6.5.

Another water problem is the presence of calcium carbonate. Calcium and bicarbonate ions will react when the water dries in the soil pores, forming insoluble lime inside existing soil pores. Over time, these pores become clogged and can no longer transmit water. Adding some acid to the lime will correct the problem. Ideally, water pH should be reduced to 6.5.

A third problem may exist, depending upon the fluid fertilizer injected into the irrigation system. This problem occurs from injecting potassium (K) fertilizers and with ammonium (NH_4+) and less problems with urea injection. The urea fertilizer will convert into ammonium carbonate when it contacts the urease enzyme in the soil as the urea treated water moves into the soil.

The major problem is due to the presence of a high concentration of monovalent cations surrounding the drip emitters and micro-sprinklers. Potassium, ammonium, and sodium ions act in a similar manner. Water penetration is strongly reduced along with reduced aeration and root penetration. This problem is worse the lower the electrical conductivity (EC) of the irrigation water.

This problem can be alleviated by hard water (containing an abundance of calcium and magnesium ions) helping to push these monovalent potassium and ammonium ions away from the drip emitter. Injection of gypsum will help. Injection of calcium nitrate or calcium ammonium nitrate solutions will provide sufficient calcium to move the potassium or ammonium farther away from the drip emitters.

Special considerations. A special consideration occurs for buried drip irrigation. In this case, emitters must have a slow release herbicide embedded into the plastic of the emitter or a herbicide must be injected to prevent root penetration into the drip lines. This is particularly important for buried drip lines used for prolonged crop growth.

A common problem with drip irrigation is the failure of the grower to ensure the drip emitters and fan jets of micro-sprinkler irrigation are maintained in an open and fully operational condition. This is a particularly serious problem where permanent crops may result in the death of a full tree before the grower becomes aware of this problem. Using acid injection is the best way to overcome this problem in most systems.

Reduced or under-irrigation can create a problem with salt intrusion. The normal drip irrigation system results in a wetting pattern allowing the water and salts to move downward and outward from the drip zone. However, with under-irrigation, insufficient water is applied and salt at the edge of the wetted pattern can enter into the root zone, harming crop growth on soils lacking adequate drainage.

Water-use efficiency

Advantages. Obviously, drip and micro-sprinkler irrigation systems use less water because the total mass of soil contacted by the water is usually only about one-tenth of the total compared to conventional furrow or sprinkler irrigated systems. Efficiency generally depends on the overall management provided by the grower. The application of fluid fertilizers through a micro-sprinkler or drip irrigation system can be no more efficient than the application of the water itself.

Watching EC and ET. Growers who fail to treat their water for problems of EC conditions risk surface water runoff and soil erosion of flat land. Growers must account carefully for ET of the crop to assure optimum water-use efficiency.

Field workers must be responsible for making appropriate connections, changing fertilizer injection tanks, and adjusting for appropriate flow rate.

Nutrient-use efficiency

Water application. Water can be distributed more evenly throughout the plant root zone in a pattern more similar to the actual pattern of normal root growth. This greatly enhances the potential for deeper root growth and greater use of the native nutrient conditions in the subsoil. However, growers must realize this and compensate by applying replacement nutrients. Otherwise, the deeper subsoil can be effectively mined by this greater root exploration, resulting in reduced yield over time.

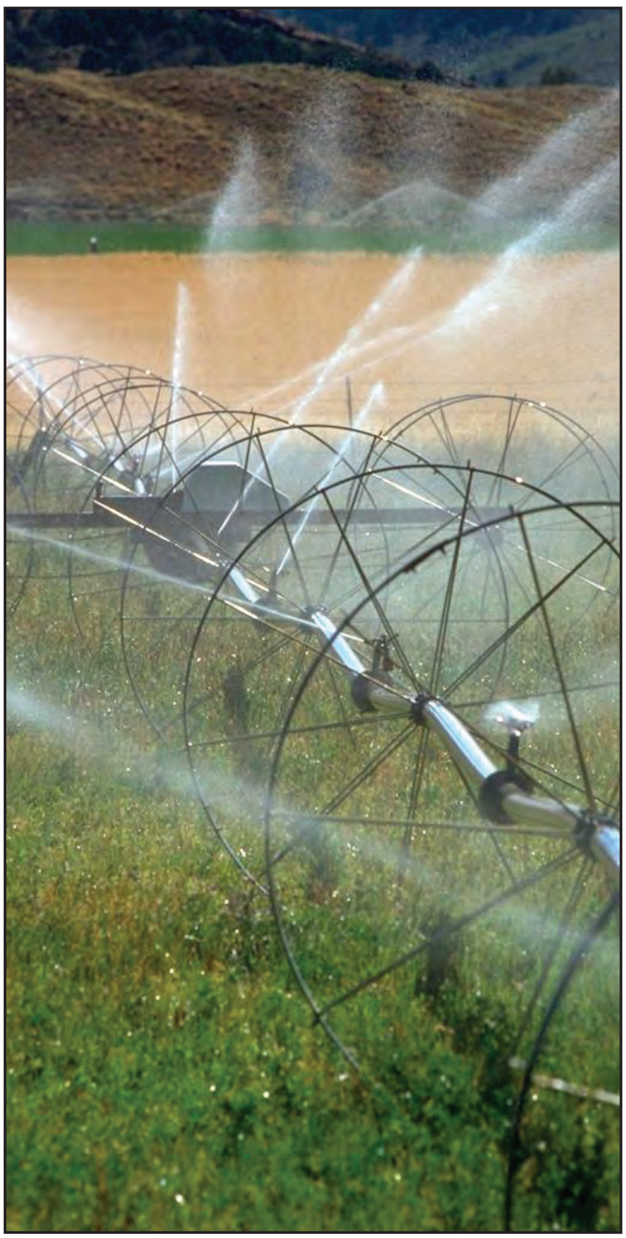
Fertilizer injection. Less energy is required in applying the fertilizer. This becomes a major savings in tractor fuel expense and increasingly a savings in time and labor. Many micro-sprinkler and drip irrigation systems have become automated with sensing devices to determine the amount of water being applied and the amount of fertilizer being injected on a continuous basis, frequently with solar collectors in the field to power the monitoring devices.

New multiple head fertilizer injectors allow as many as four different fertilizers to be applied by a single injection device, simultaneously using different injection rates for each fertilizer.

It is critical to dedicate a specific fertilizer to its own tank location and injection port on an irrigation line.

Good design. The unexpected benefit of this is seen in recent micro-sprinkler and drip irrigation systems. This is explained by realizing a well-designed system first provides patterns most closely matching the ideal rooting pattern of normal crops. Second, water is being applied usually on a daily or every-other-day basis. This maintains the soil root zone in a condition near or slightly above the normal field capacity moisture condition, which is known to optimize plant growth.

Keeping moist. Normally, with furrow and sprinkler irrigation on a weekly or every-other-week basis, the soil dries out somewhat between irrigations. This process of soil drying results in an increase in soil moisture tension or suction in the root zone. This requires the plants to exert more energy for water absorption via the passive process of transpiration out of the plant leaves. This reduces the overall amount of water reaching the plant during these periods between irrigations.



Phosphate levels. With micro-sprinkler and drip irrigation, plus growers exercising superior management, crop roots are continually at optimum moisture. This means phosphate availability is maintained at optimum levels in the solution, thus optimizing plant growth and crop production.

These results are usually amplified by constant spoon feeding of ammonium polyphosphate fertilizer at the rate of about one part per million of phosphorus in the irrigation water. This level is below the solubility limit thereby allowing free movement of this phosphate through the irrigation system. This level ensures a higher level of phosphate is maintained in the soil solution throughout the entire plant root zone.

Consequently, growers using micro-sprinkler and drip irrigation have noted yield increases on the order of 15 to 20 percent compared to similar crops produced with conventional furrow or sprinkler irrigation with normal field drying between applications. In some instances, growers have reported both increased yield and improved crop quality as a result of optimum fertilization.

Another unexpected discovery is the fact most growers and researchers have not realized the full extent to which even slight moisture stress (via increase soil moisture tension) decreases the plant-available phosphate level. Because moisture and phosphate are maintained at near optimum levels with both drip and micro-sprinkler systems, the crop is no longer controlled by limited phosphate availability.

In addition, because the crop is growing more effectively with a higher level of phosphate promoting more growth, the plant is able to use almost all other nutrients efficiently. The result is the plant tissue of micro-sprinkler and drip irrigated crops will have a much higher concentration of other nutrients in the plant tissue plus requiring the grower to make special adjustments to total application amounts.

Growers who have benefited from this process may not fully understand why these systems operate as they do, but they will fully appreciate the profits gained by investing in them, as well as the fluid fertilizers they inject on a continuous basis throughout the crop growing season.

Dr. Ruehr is professor in the Earth and Soil Science Department at Cal Poly State University, San Luis Obispo, CA.