Fluid Fertilizers As Soil And Water Amendments

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The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Spring 2016 • Vol. 24, No. 2, Issue #92

Summary: *Due to economic response considerations, urea-sulfuric acid (USA) fertilizers should be used only for immediate response as a band application and only comprise a small portion of the total amendment needed. More economical sources, such as elemental sulfur and/or gypsum, should be selected for broadcast applications to provide the majority of sodium remediation activity. True fluid calcium and acid containing fertilizers offer use flexibility, convenience and near-immediate results when used properly.*

A variety of specialty fluid fertilizers are currently available on the market today that not only provide essential plant nutrients but play dual roles as water and/or soil amendments. They represent two unique product groups: fluid fertilizers containing calcium and fluid fertilizers containing acids. Though all fertilizers that contain either urea or ammoniacal nitrogen have a net acidic soil reaction, for the sake of this discussion, only the acid fertilizer will be presented.

Their role

Fluid calcium fertilizers can be an effective tool to remedy soils that seal from being irrigated with water that is too pure (very low dissolved salts) and as an aid to bulk soil amendments such as gypsum in mitigating high sodium content in agricultural soils or irrigation water.

Agricultural land supplied with irrigation water originating from melting snow-pack, results in soils frequently forming *structural crusts* that impede water filtration. This is a chronic problem on the east side of California's San Joaquin Valley. As very low salinity water passes through the soil, calcium ions are stripped from cation exchange sites. Reduced soil calcium diminishes

Table 1. Infiltration rate as influenced by various physical and chemical treatments (Lindcove, 1986)

Treatments	Avg. Infiltration Rate (inches/hour)
Calcium nitrate, undisturbed	0.18 a
Gypsum, disturbed	0.17 a
Gypsum, undisturbed	0.15 ab
Polyacrylamide, disturbed	0.11 bc
Polyacrylamide, undisturbed	0.11 bc
Control, disturbed	0.10 bcd
Control, undisturbed	0.09 cd
Non-ionic surfactant, disturbed	0.08 cd
Non-ionic surfactant, undisturbed	0.06 d
LSD .05	0.05
Numbers followed by the same letter are not significantly different (P = 0.05)	

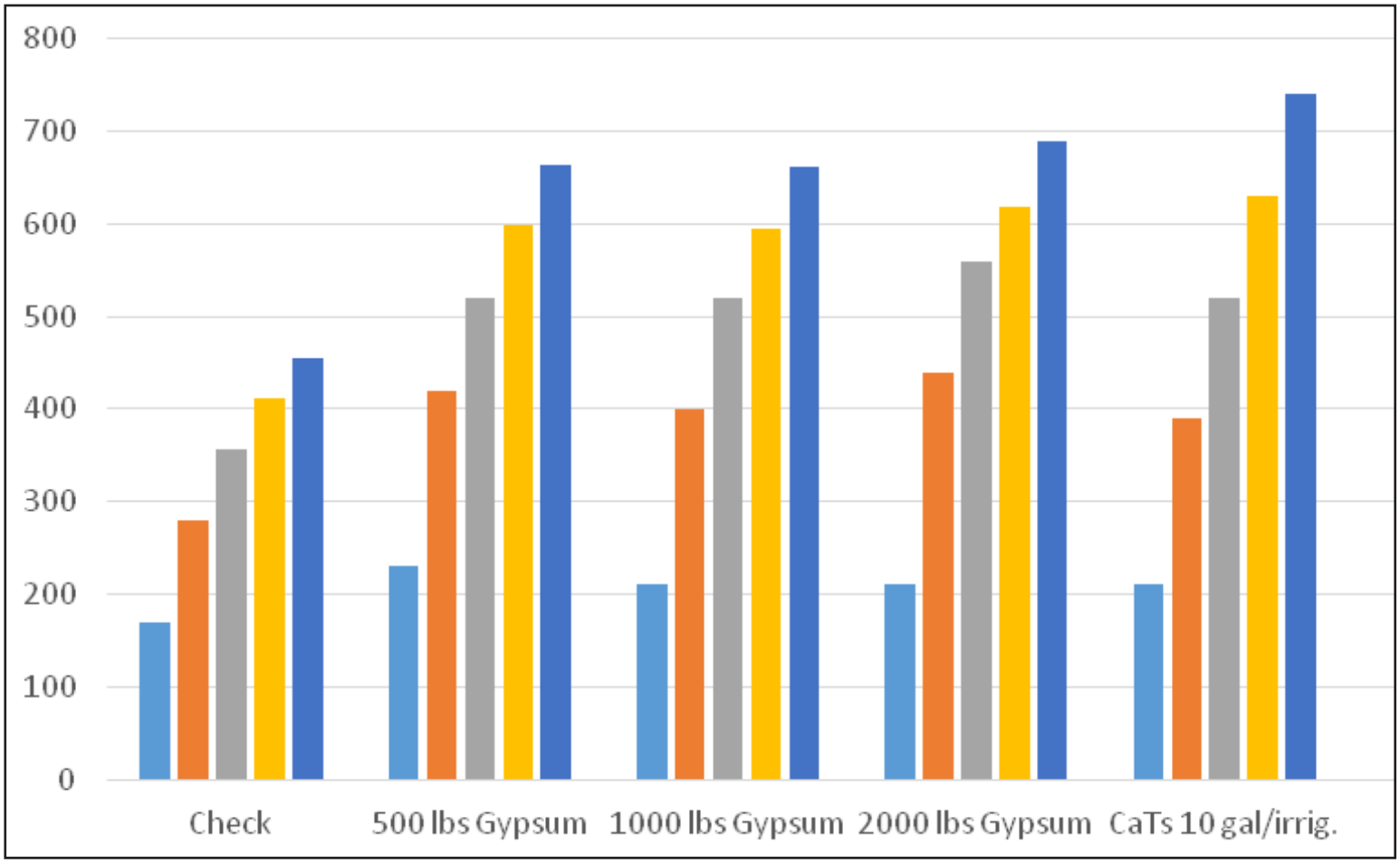

Fig. 1: *Sodium leached following gypsum or calcium thiosulfate application.*

aggregation and porosity, leaving a thin layer of impermeable crust at the soil surface. Irrigation water having an ECW less than 0.3 dS/m is a candidate for developing infiltration problems. Physically "picking" or "scratching" this crust will improve infiltration for only a brief period of time until the crust reforms. A long-term remedy is to introduce calcium ions back into the irrigation water, which will, in turn, improve water infiltration rates.

Table 1 presents average infiltration rates between June 11 and August 6, 1986 from a trial conducted by the University of California (Lindcove Research and Extension Center in Tulare County). The calcium nitrate, polyacrylamide, and non-ionic surfactant treatments were metered into the irrigation water, whereas the gypsum treatments were applied directly to the soil surface. Reference to "disturbed" in the table means the soil surface was physically disturbed prior to initiating the trial.

As presented in Table 1, the most effective treatments were those that provided soluble calcium. Use of fluid calcium fertilizers simplifies this practice by eliminating the need for specialized application equipment such as gypsum solutionizing machinery or separate trips over the field to spread dry gypsum.

Table 2: Common Fluid Calcium Fertilizer sources

Source	Analysis	lb./gal	Gal/ton	lb. Ca/gal
Calcium Ammonium Nitrate (CAN-17)	17-0-0-8.8 Ca	12.64	158.2	1.11
Calcium nitrate (CN-9)	9-0-0-11 Ca	12.2	163.9	1.34
Calcium thiosulfate	0-0-0-10S-6 Ca	10.4	192.3	0.63

Table 3. Properties of urea sulfuric acid (USA) formulations

Analysis	**10-0-0-18S**	**15-0-0-16S**	**28-0-0-9S**
Agrium	N-pHuric® 10/55	N-pHuric 15/49	N-pHuric 28/27
Verdegaal	US-10	US-15	US-28
% H_2SO_4	55	49	27
Lbs./gallon	12.8	12.65	11.8
Gallons/ton	156	158	169
Lbs. N/gallon	1.28	1.89	3.31
Lbs. S/gallon	2.31	2.03	1.06
pH	< 1.0	< 1.0	< 1.0
DOT Placarding	Yes	No	No

Another useful application of fluid calcium fertilizers is as an aid in combating soil and water sources that are high in sodium. A holistic approach to sodium management would include a bulk gypsum application in the fall

to take advantage of winter rains for leaching of sodium followed by in-season fluid calcium fertilizer injections to lower the Sodium Adsorption Ratio (SAR) of the irrigation water. This two-tier approach uses gypsum to remediate a sodic soil and fluid calcium fertilizers to reduce the effects of sodium carried in the irrigation water in-season.

A second trial conducted by the University of California Cooperative Extension in 2007 that compared the effects of water-run calcium thiosulfate ("CaTs") through the drip irrigation system to broadcast applied gypsum. The calcium thiosulfate was applied at 10 gallons per acres for five successive irrigations. Gypsum was applied at 500, 1,000 and 2,000 lbs./A. followed by five successive irrigations. Results presented in Figure 1 show parts per million (ppm) of sodium leached after each respective calcium product application/irrigation.

Figure 1 shows measurable amounts of sodium were leached with successive irrigations for all treatments, including the control. The data also indicate that the fluid calcium thiosulfate treatment was as or more effective than the gypsum treatments. This is due to the superior solubility of calcium thiosulfate compared to gypsum, which provides for more immediate results. In the long run, it would be expected the higher rates of gypsum would leach more sodium simply due to the higher load of soluble calcium that gypsum provides, but over a much longer period of time and with more water. Gypsum has a very low level of solubility (2.05 gm/liter) and over 100,000 gallons of water would be needed to dissolve one ton of pure gypsum.

Common sources

The most common fluid calcium fertilizers found in the market are calcium ammonium nitrate, calcium nitrate and calcium thiosulfate. Their properties are presented below in Table 2. Calcium chloride and calcium polysulfide are commercially available products but are used less frequently due to the addition of chloride and handling issues, respectively.

The most commonly used acid fertilizers today are sulfuric acid, phosphoric acid, and urea sulfuric acid products. All are highly effective for water treatment but due to the handling risk that phosphoric and sulfuric acid present, only the much safer urea sulfuric acid products will be presented here.

USA

Urea-sulfuric acid (USA) fertilizers are a unique class of products with a variety of useful applications, from cleaning of drip irrigation systems to wheat stubble burn-down. USA chemistry was developed to provide acidifying benefits of sulfuric acid without the personnel hazard that is associated with the transportation and handling of concentrated sulfuric acid. The heat of reaction and the extremely corrosive nature of sulfuric acid have been removed during the manufacturing process of USA products. Never attempt to mix sulfuric acid with urea as this is a very violent reaction that requires specialized equipment and procedures! USA products are available from two basic suppliers: Agrium and Verdegaal Brothers, and are available in three grades having the properties (Table 3}.

USA products are ideally suited for treating irrigation water that is high in bicarbonate, particularly in low volume irrigation systems such as drip or micro-sprinklers. The general chemical equation when injecting USA into irrigation water containing bicarbonates is: $H_2SO_4 + 2HCO_3 \underline{S}O_4^{2-} + 2CO_2 + 2H_2O$. The bicarbonate is digested, releasing carbon dioxide gas and water. At a pH of 6.5, about 50 to 60 percent of the bicarbonate ions carried in the irrigation water is consumed by this reaction. So, the benefits of reduced bicarbonate content are:

- Reduced plugging pressure on drip system
- Reduced formation of excess lime (calcium carbonate) in the soil
- Higher levels of soluble and exchangeable calcium in the soil
- Reduced soil pH in some situations
- Reduced opportunity to form sodic soils
- Maintain or improve soil porosity and structure.

Techniques

Techniques for using USA in low volume irrigation systems are important in the following ways:

Clean out. Periodic clean out is required to remove calcium carbonate deposits, loosen suspended solids that may have passed through the filter and consume biological matter. This is commonly referred to as "shock treatment" because it requires injection of USA at rates that cause a drastic drop in water pH. Target pH for shock treatments is in the 3.0 to 3.5 range. Shock treatments should be used only in systems that are composed of 100% acid tolerant materials. Always verify with manufacturers or dealers before acidifying irrigation systems. Most systems should receive a shock treatment at least annually. Injection may be made upstream or downstream from the filter station, depending on materials used in the filtration system. Contact your drip system dealer for specifics. Run injection for two hours, flush system with clean water, and open ends of 8 to 10 lines at a time to slush dislodged solids until clear water flows. Repeat treatment if needed but always flush with clean water after acid injection.

Maintenance. Continuous, or near continuous, maintenance applications are needed to achieve a water pH of 6.0 to 6.5. This improves water quality and lessens the opportunity for drip system plugging by mineral deposits. Maintenance applications may not eliminate the need for periodic shock treatments, but will lengthen the time required between such treatments. Maintenance applications are particularly beneficial with water having high bicarbonate and calcium levels (high plugging potential). Shock treatments should be performed during dormancy on perennial crops or post-harvest on annual crops to prevent accidental root injury. Use of USA may provide partial to moderate relief from root intrusion, depending on the degree of intrusion and the size of intruded roots. Larger roots are far more difficult to dissolve than are finer roots. Follow instructions above for shock treatment but turn the system off and allow the system to stand 4 to 6 hours before turning the system back on and flushing with clean water. Open 8 to 10 lines at a time to flush dislodged solid matter until clear water flows.

Rate

What rate of USA should be used to adjust pH to the maintenance range or for a shock treatment? The dominant ions found in irrigation water that determine the rate of USA needed to

achieve a target pH are bicarbonate (HCO_{3-}) and carbonate (CO_{3-}). Since all waters vary in the amount and identity of dissolved ions they contain, including bicarbonate and carbonate, there is no one single recommended rate needed to achieve a desired pH range that will be correct for all water sources.

Several methods are available to make this determination:

- pH titration or "buffer" curve performed by a commercial laboratory
- Installation of an injection controller that monitors irrigation water pH and adjusts USA injection rates to achieve the programmed target pH reached.
- Use of pH paper or portable pH meter in the field is a crude but acceptable method as well. The user checks water pH at the end of the run and adjusts injection rate either up or down until the desired final pH is reached.

Injecting USA

Procedure for injecting USA into irrigation systems includes:

1. Turn on irrigation system and wait until system is fully charged before injecting USA.
2. Inject USA to achieve desired pH. Periodic use of pH paper or portable pH meter to verify that target pH is being achieved is a good practice. Take samples from emitters farthest away from the injector.
3. For shock treatments, inject for a period of 2 to 3 hours, turn off and completely flush system of clean water. Open ends of 8 to 10 drip lines at a time and flush until clear water flows.
4. For continuous injection at maintenance rate, follow steps 1 and 2 above. Inject for entirety of irrigation set, but allow the last hour to flush the system of remaining acid.

Iron Chlorosis

Because iron solubility and subsequent plant availability are so profoundly influenced by soil pH, most all iron deficiencies in alkaline soils are a factor of pH and not actual iron levels in the soil. A 1.0 unit change in soil pH can alter iron availability by 100 to 1,000 fold. USA products can be a very effective tool in combating this malady. Banding is the most effective and practical means of addressing lime induced iron chlorosis as broadcast applications would require astronomically high rates in many situations to achieve the desired results. So to correct:

1. Apply 15 to 20 gallons as a surface spray band, dribble or subsurface injection on alkaline, calcareous soils. Dilution with water may be required to reduce viscosity. Do not exceed 1:1 dilution with water.
2. Repeat treatments may be needed, based on limestone content of the soil and degree of iron deficiency.

Sodic Soils

USA products are very effective at providing near immediate remediation of sodic (high sodium) soils but require the presence of free limestone (calcium carbonate) to achieve the desired results. Presence of free time can be readily determined in the field by simply pouring USA or any other acid, such as vinegar, on moist soil and observing bubbling off of carbon dioxide gas. If any bubbling is observed, then there is an abundance of free lime contained in the soil. The reactions that take place are:

- Acid digestion of limestone to release calcium ions. Sulfuric acid-----gypsum + carbon dioxide + water.
- Displacement of sodium from the soil exchange complex by calcium, which has a higher affinity for exchange sites than sodium. Sodium sulfate is then leached from the root zone, providing there are no hardpans or other restrictions to leaching.

Gypsum + sodic soil------Calcium soil + sodium sulfate. Due to economic considerations, USA should only be used for immediate response as a band application and only comprise a small portion of the total amendment needed. More economical sources, such as elemental sulfur and/or gypsum, should be selected for broadcast applications to provide the majority of sodium remediation activity.

True fluids calcium and acid-containing fertilizers offer use flexibility, convenience, and near immediate results when used properly. Contact a local Certified Crop Adviser (CCA) or product manufacturer for more information on the products discussed in this article and their value in solving your soil or water issue.

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