Evaluation of Phosphate Fertilizer Type on Plugging of Drip Irrigation Tape

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Phosphate fertilizers have a widely held reputation for reacting with other materials including the dissolved salts in irrigation water to form solids that can plug drip emitters and tapes. Phosphates can combine with many common cations in water to form precipitates with very low solubility. The propensity for phosphates to precipitate with Calcium, Magnesium and other metallic ions that occur in irrigation water is the basis for the commonly issued warning to avoid the use of phosphate fertilizers in chemigation programs. The undeniable advantages of drip systems for applying fertilizers with the same precision as the water applications have not been extended to fertilizer programs where phosphates are needed by the crop. Phosphate nutrition, unlike many other essential plant nutrients, is a matter of constant need throughout the growing season and is proportional to the size and vigor of the plant. Ideally, they should be available to the crop in steadily increasing amounts for the whole the growing season. Typically, phosphates are applied as a dry material, in one large dose, often prior to planting. Uptake of phosphate by the plant from the root zone competes with a variety of chemical and mineralogical reactions that can significantly reduce the availability of the nutrients over time. Frequent small applications of phosphate as in chemigation through a drip system would allow for a much more efficient application program and better utilization by the crop. Unfortunately fears of permanent plugging of the drip system by chemical precipitates prevents the use of this potentially effective method of phosphate fertilizer application.

A contributing factor to the problem of chemigation with phosphate is the fact that there are only a few common forms of the fertilizer and each has the potential to react with Calcium in the irrigation water. Nitrogen, Potassium and most micro-nutrient fertilizers are available in a variety of formulations many of which have high solubility. That is not the case for the phosphates. Liquid forms of phosphate fertilizers are limited to Phosphoric acid (0-54-0) and Ammonium Phosphate solution (10-34-0). Phosphoric acid is usually very expensive and 10-34-0 is commonly assumed to form precipitates with even a small amount of Calcium in the irrigation water. Recently, the CSU Fresno – Center for Irrigation Technology was approached by the manufacturer of an organic based liquid phosphate fertilizer. The possibility that an organic complex containing the phosphate might be less likely to react with Calcium in the water suggested this new form of phosphate fertilizer might be more successful in a chemigation program.

A testing program was devised to compare the organic-phosphate material along with the two common inorganic forms in drip tape using poor quality, high Calcium irrigation water. The testing program was designed to evaluate the plugging potential of the fertilizers under conditions at least as extreme as those encountered in the field. A very high application rate of phosphate was used in both new and used tapes and with water sources selected for high salinity and Calcium content. A combination with other fertilizers containing Calcium was also part of the test. The results were somewhat surprising and, while the organic phosphate material did appear to be less of a plugging problem, the most interesting conclusion from this evaluation was the fact that each of the drip tapes tested maintained a normal delivery under conditions that were initially expected to cause serious plugging. While this simple series of tests should not be construed as conclusive proof that phosphates can be applied through drip tapes without any danger of plugging, it does indicate the fact that the ability of modern drip tapes to handle poor quality water and solids has been considerably underestimated.

Methodology

The effects of adding three fertilizer materials, (10-34-0 liquid ammonium phosphate, 0-54-0 phosphoric acid, and a organic based phosphorus fertilizer) on drip tape flows were evaluated with various water sources. A system traditionally used to test plugging of drip tape by sand particles from media filters was used for the tests. The system entails a pump, pressure regulation system, heat exchanger, and two 25 ft. runs of drip tape used to test plugging or reduced flow rates (Fig. 1). Once water and fertilizer was emitted from the drip tape it was re-circulated through the system continually. Flow rates were recorded periodically during the test.

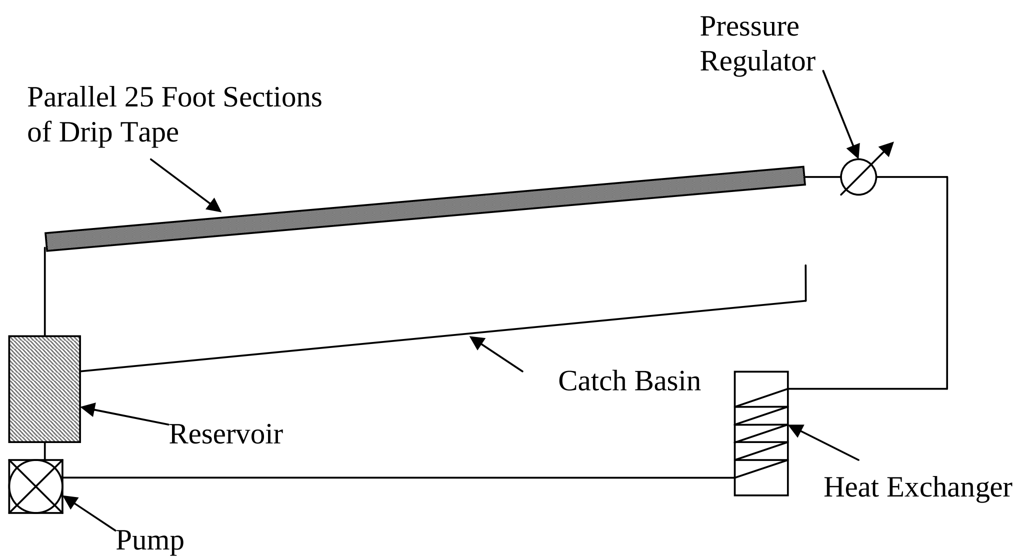

Fig. 1 Schematic of drip testing apparatus

Flow rates of individual emitters were recorded with volumetric cylinders over a two minute period and converted to gallons per hour. Initials tests of the study were run for a time period of four hours but latter tests were extended in time to induce more plugging. The initial tests included five readings for each test. Reading #1 before addition of fertilizer, reading #2 thirty minutes after addition of fertilizer, reading #3 two hours after the addition of fertilizer, reading #5 four hours after addition of fertilizer, and reading #6 after flush of system with test water. Fertilizers were added to the system by pouring a stock solution into the reservoir. The extended tests were similar to the shorter test but additional readings were made every two hours until late in the day approximately fifteen hours after the start of the test they system was shut-down for the night. The testing system was restarted the next morning, allowed to run for thirty minutes, after which flow rates were recorded. Depending on severity of plugging a flush with clean test water or phosphoric acid (0-54-0) was done after which additional flow rates were recorded. Table 1. is an example the type of data created with the extended test.

Table 1. Table of data produced from extended test

Drip Tape Plugging Test Results - Drip Tape Flow Rates									
	Fertilizer		Test Water		Drip Tape				
	Organic		Coastal		Salinas Valley				
Sample Time	745	910	1040	1240	1530	1830	2130	1245	1400
Sample Description	Test Water	Fert + 0.5 h	Fert + 2 h	Fert + 4 h	Fert + 7 h	Fert + 10 h	Fert + 13 h	Fert + 28 h	Post Flush
Reading #	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5	Reading 6	Reading 7	Reading 8	Reading 9
GPH/Emitter	0.22	0.23	0.23	0.23	0.22	0.22	0.21	0.22	0.23
% of Initial Flow Rate	100%	101%	101%	101%	100%	97%	94%	100%	104%

The testing conditions were a simulation of two extreme situations in California where phosphate fertilizer could be used in vegetable production irrigated with drip tape. In each case, a typical drip tape and a poor quality water from each simulated location was used. Testing with a high quality water was also done for calibration of the testing equipment and procedures. Three types of water were used as test water for evaluation. Fresno State campus water was used to represent high quality water, tile drain water from southern Kings County with high levels of calcium and magnesium was used to represent low quality, Central Valley water, and well water from northern Monterey County with high levels of calcium was used to represent low quality Salinas Valley water.

Two types of drip tape were chosen to match the different test waters. A 6" spacing tape (Toro Aqua-Traxx EAXxx0667) typical of those used in the coastal vegetable growing regions was used for the Salinas Valley simulation and a 12'' tape (T-Tape TSX 7XX-12-220) typical for vegetable and field crop production in the southern San Joaquin Valley was used with the tile drain water source. Both tapes were obtained from the growers who supplied the water samples. The tape was new in each case but some of the Central Valley testing was duplicated with similar tape recovered from the field after three seasons and no differences in results were apparent. The fertilizers were all applied at a rate of 150 lbs./A of P_2O_5 which is a very high rate but one that could be required for a high value vegetable crop in either location.

The original testing procedure did not result in any plugging with any tape, water source or fertilizer combination. The four hour period with the fertilizer in the tape was apparently insufficient time to allow the chemical precipitation to form. The test procedure was modified to increase the time and add a second cycle to simulate a second irrigation with the fertilizer remaining in the tape between irrigations. Plugging was observed with this longer test procedure. Figure 2 and Table 2 show the Salinas Valley test with 10-34-0 and the tape was almost completely plugged by the end of the first run and did not recover at the beginning of the second irrigation cycle. The test equipment failed during the second cycle so the flushing with acid to test the recovery from the plugging could not be completed. Table 3 and Figure 3 show the same fertilizer with good water and the Central Valley tape. The results were similar to those in Table 2 in that complete plugging occurred at the end of the first irrigation and the interval before the second. In this case, flushing with acid was able to restore about 40% of the emitters to nearly their original flow rate. The organic based phosphate fertilizer caused some reduction in flow rate under the same conditions but the loss was about 10% compared to nearly 100%

plugging with the 10-34-0. Recovery after flushing with water in the second irrigation restored the original flow rate of the tape for both the Salinas Valley simulation, Table 4 and Figure 4 and the Central Valley simulation, Table 5 and Figure 5.

These simulations, while intentionally extreme, are not intended to be proof that phosphate fertilizers can be safely applied through drip tape. The chemical precipitates can still form and plug the tape under field conditions similar to these. The interesting results found in the tests were these:

1. The chemical precipitation may require several hours to form and cause plugging. Short irrigation periods and short chemical applications within those short irrigations may be safer than long runs.
2. Phosphate fertilizer remaining in the tape because of insufficient post-application flushing can be responsible for additional plugging problems.
3. Some forms of phosphate fertilizers may produce significantly less chemical precipitate than other forms.
4. Tapes in current use are capable of being flushed after partial plugging with phosphate fertilizers to restore some, and perhaps all of the original performance.

It would appear that the "fatal plugging" by fertilizers of drip tape and emitters that was observed in the first years of the use of drip irrigation is not as big a problem as it once was. The use of phosphate and other low solubility fertilizers may be considered for chemigation programs with appropriate testing and careful monitoring, flushing and maintenance of the system.

Table 2 Table summarizing data evaluating 10-34-0, coastal water, and Salinas Valley drip tape

Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
10-34-0	Coastal	Salinas Valley	
Sample Time	715	2200	800
Sample Description	Test Water	Fert + 14 h	Fert + 24 h
Reading #	Reading 1	Reading 8	Reading 9
GPH/Emitter	0.23	0.02	0.01
% of Initial Flow Rate	100%	9%	6%

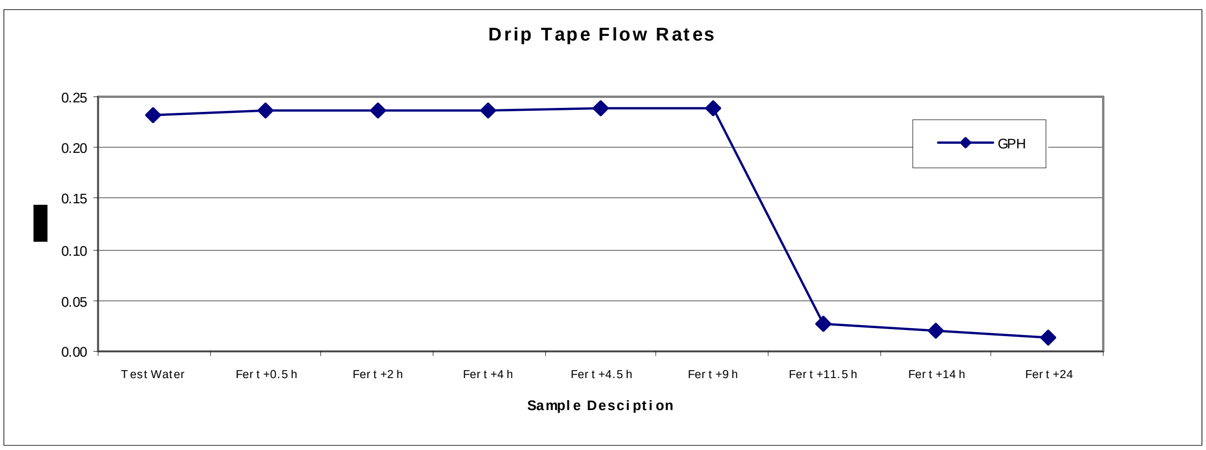

Fig. 2 Graph illustrating reduction of drip tape flow rates when running 10-34-0 and coastal water through Salinas Valley drip tape

Table 3 Table summarizing data evaluating 10-34-0, campus water, and Central Valley drip tape

Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
10-34-0	Campus	Central Valley	
Sample Time	640	2200	850
Sample Description	Test Water	Fert + 15 h	Post Acid + Flush
Reading #	Reading 1	Reading 8	Reading 11
GPH/Emitter	0.17	0.00	0.07
% of Initial Flow Rate	100%	0%	40%

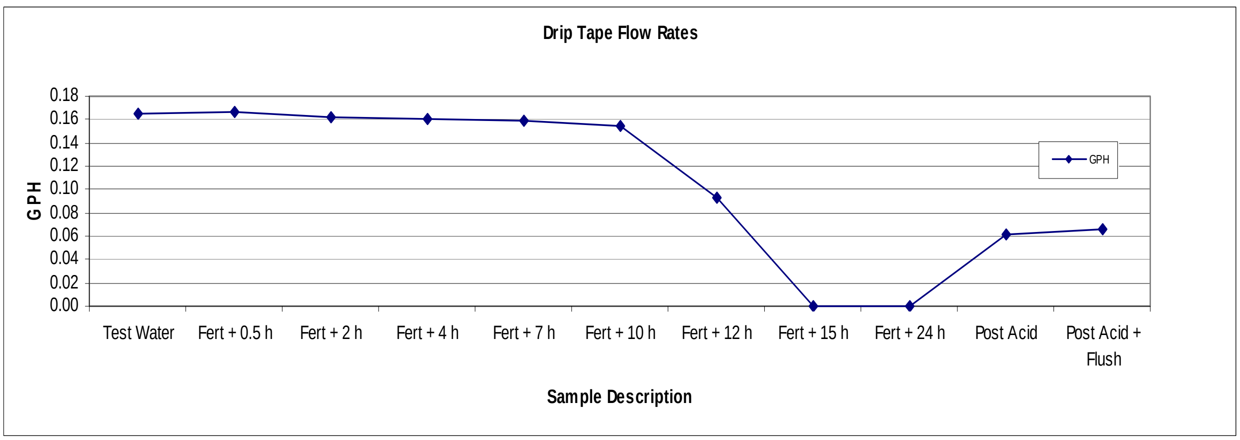

Fig. 3 Reduction in flow rates of drip tape after several hours or running 10-34-0 and campus water in Central Valley drip tape

Table 4 Table summarizing data evaluating an organic fertilizer, coastal water, and Salinas Valley drip tape.

Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
Organic	Coastal	Salinas Valley	
Sample Time	745	2130	1400
Sample Description	Test Water	Fert + 13 h	Post Flush
Reading #	Reading 1	Reading 7	Reading 9
GPH/Emitter	0.22	0.21	0.23
% of Initial Flow Rate	100%	94%	104%

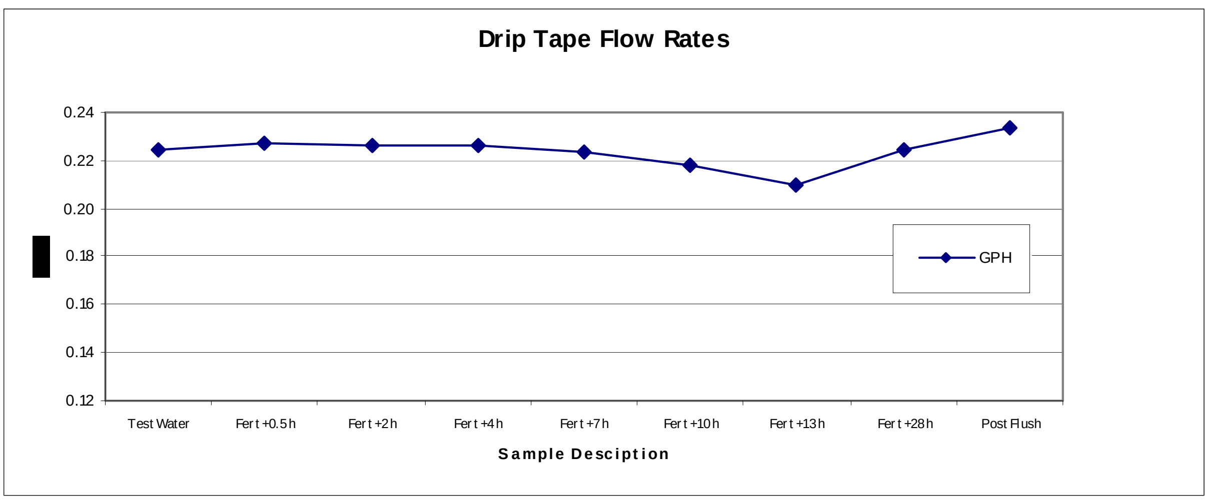

Fig. 4 Drip tape flow rates slightly decreased when running an organic fertilizer and coastal water through a Salinas Valley drip tape.

Table 5 Table summarizing data evaluating an organic fertilizer and drainage water ran through Central Valley drip tape.

Drip Tape Plugging Test Results - Drip Tape Flow Rates			
Fertilizer	Test Water	Drip Tape	
Organic	Drainage	Central Valley	
Sample Time	640	2200	900
Sample Description	Test Water	Fert + 15 h	Post Flush
Reading #	Reading 1	Reading 8	Reading 10
GPH/Emitter	0.16	0.15	0.16
% of Initial Flow Rate	100%	92%	99%

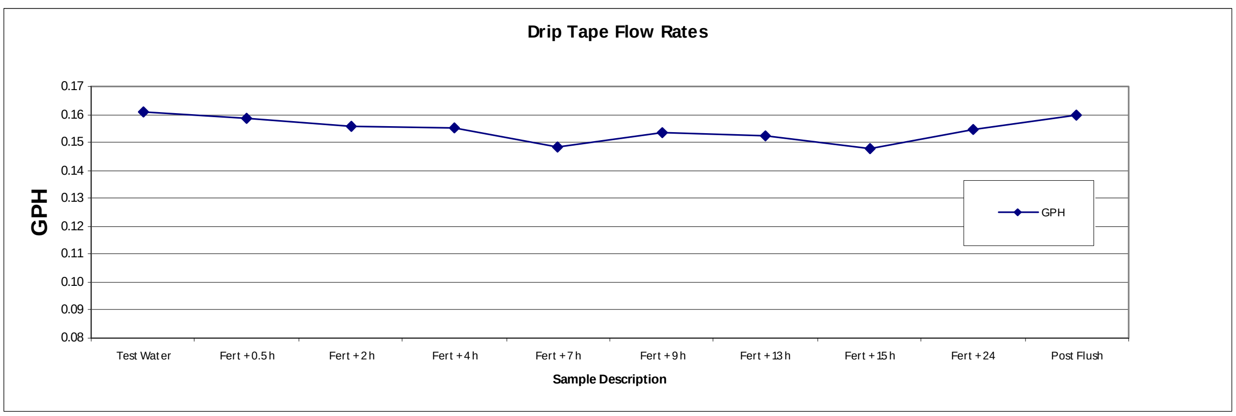

Fig. 5 Drip tape flow rates decreasing slightly when running an organic fertilizer and drainage water through Central Valley drip tape