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Treating Drip Irrigation Systems with Chlorine

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Groundwater containing high concentrations of iron (greater than 1 ppm) and ponds and streams containing algae and bacteria cause many of the drip irrigation clogging problems New Jersey growers encounter. Iron in groundwater is often dissolved and remains dissolved as long as the water is held at groundwater temperature, pH, and pressure. After being pumped to the surface and distributed through irrigation laterals, the water temperature, pH, and pressure may change, often causing the dissolved iron to precipitate from the water into a solid form which appears as "rust." is this precipitated (ferric) form of iron that can physically clog emitters.

Iron in groundwater can also result in clogging problems due to a type of bacteria which "feeds" on dissolved (ferrous) iron. The bacteria secrete a slime called ochre which may combine with other solid particles in the drip tubing and plug emitters. Chlorination is an effective treatment for these two types of clogging.

Clogging problems also arise where water is being pumped from a surface source (pond or stream). These waters almost always contain algae and bacteria which can live inside of and clog filters and drip emitters. Chlorine is used under these conditions to kill these organisms.

Chlorine treatment of water containing dissolved iron will cause the iron to precipitate so that it can be filtered and removed from the system. Chlorine will also kill the iron bacteria and any other algae or bacteria present in the irrigation water. In either case, chlorine treatment **should take place upstream of filters** in order to remove the precipitated iron and microorganisms from the system before the water enters the distribution system.

Chlorine is available in gas, liquid, and solid forms. Chlorine gas is extremely dangerous and not recommended for agricultural purposes. Calcium hypochlorite is a solid form of chlorine available as granules or tablets containing 65-70% calcium hypochlorite. Sodium hypochlorite is a liquid form of chlorine marketed in a variety of forms, including laundry bleach (5.25% sodium hypochlorite) and postharvest wash material (10-15% sodium hypochlorite). It is important to note that both liquid and solid forms of chlorine will cause water pH to rise. This is critical because chlorine is most effective in acidic water. If water pH is above 7.5, it must be acidified for chlorine injection to be effective.

The required chlorine injection rate is dependent on the amount of microorganisms present in the water source, the amount of iron in the irrigation water, and the method of treatment being used. To remove iron from irrigation water, 1 ppm of chlorine (as chlorine gas, sodium hypochlorite, or calcium hypochlorite) is required for each 1 ppm of iron present in the water. For iron removal, **chlorine should be injected continuously into the irrigation water**. Adequate mixing of the water with chlorine is essential. For this reason, the chlorine injector should be mounted 50-100 ft. upstream of filters. An elbow between the injector and the filter will also help insure adequate mixing.

Chlorine can be injected continuously or intermittently for treatment of algae and bacteria. Continuous chlorine injection at a rate which results in the presence of 1-2 ppm of "free" chlorine at the end of the furthest

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lateral will assure that the proper amount of chlorine is being injected. Free, or residual, chlorine can be tested using an inexpensive D.P.D. (di-ethyl-phenylene-diamine) test kit. A swimming pool test kit can be used but it must measure free chlorine. Many pool test kits measure only total chlorine.

If a chlorine test kit is not available, one of the following schemes is suggested as a starting point:

For Iron Treatment

- Inject liquid sodium hypochlorite continuously at a rate of 1 ppm for each 1 ppm of iron in irrigation water.

For Bacteria and Algae Treatment

- Inject liquid sodium hypochlorite continuously at a rate of 5-10 ppm where the biological load is high.

- Inject 10-20 ppm liquid sodium hypochlorite at the end of each irrigation cycle for the length of time required to fill the entire system with this solution. For most systems, this period will be 20-30 minutes. Injecting chlorine during the final portion of an irrigation cycle is especially effective in killing the bacteria which grow and multiply when the system is not running.

- Inject 50 ppm liquid sodium hypochlorite for the length of time required to fill the entire system with this solution 1-2 times each month.

- Superchlorinate (inject liquid sodium hypochlorite at a rate of 200-500 ppm) once per month for the length of time required to fill the entire system with this solution and shut down the system. After 24 hours, open the laterals and flush the lines.

EQUATION 1. Required Injection Rate for Positive Displacement Injection Pumps.

$$\text{Required stock solution injection rate in ounce/hour} = \frac{(0.77) \times (\text{desired treatment level in ppm}) \times (\text{irrigation system flow rate in gallon/minute})}{\%\ \text{chlorine in stock solution}}$$

Chlorine can be injected using many types of fertilizer/pesticide injectors, including positive displacement injection pumps. A key feature of positive displacement injection pumps is that their injection rate is constant and is not affected by the irrigation system flow rate or pressure. Most positive displacement injection pumps can be set to operate at a specific injection rate. These types of pumps are powered by gasoline, diesel, or electric motors and include piston, diaphragm, gear or lobe, and roller (or peristaltic) types. The required chlorine stock solution injection rate for positive displacement injectors can be calculated using Equation 1.

As an example, assume household bleach (5.25% sodium hypochlorite) is being used as a stock solution, that a treatment level of 3 ppm of chlorine is desired, and that the drip system has a 200 gallon per minute (gpm) flow rate. The required injection rate is calculated in Example 1.

EXAMPLE 1.

$$\text{Stock solution injection rate} = \frac{0.77 \times 3 \times 200}{5.25} = 88 \text{ ounce/hour household bleach}$$

Table 1 was created using Equation 1 and can also be used to determine stock solution injection rates. Values in Table 1 are based on desired treatment level, stock solution chlorine concentration, and an **irrigation system flow rate of 100 gpm**. **Stock solution injection rates from Table 1 must be adjusted proportionally for other irrigation flow rates**. Using the example from above, assume household bleach (5.25% sodium hypochlorite) is being used as a stock solution, that a treatment level of 3 ppm of chlorine is desired, and that the drip system has a 200 gallon per

EQUATION 2. Required Injection Rate for Proportional Injection Pumps.

$$\text{Required stock solution injection rate in ppm} = \frac{(100) \times (\text{desired treatment level in ppm})}{\%\ \text{chlorine in stock solution}}$$

minute flow rate. From Table 1, a stock solution injection rate of 44 ounce/hour is multiplied by two to account for the irrigation system flow rate. As a result, the required injection rate is 88 ounce/hour.

EXAMPLE 2.

$$\text{Stock solution injection rate} = \frac{100 \times 10}{12.5} = 80\ \text{ppm}$$

Proportional injection pumps are also commonly used to inject chlorine. Proportional injection pumps are powered by the water pressure of the irrigation system and inject materials at a rate which is proportional to the irrigation system flow rate. Injection rates are often adjustable and are usually specified as ratios, percentages, or ppm. Table 2 lists equivalent values of these injection rate units.

EQUATION 3. Required Dilution Rate for Injection Pumps.

$$\text{Required dilution rate in parts water:parts chlorine stock solution} = \left[\frac{\text{injection pump setting}}{\text{required stock solution injection rate}}\right] - 1$$

For proportional injectors, Equation 2 can be used to calculate the required stock solution injection rate.

As an example, assume postharvest wash material (12.5% sodium hypochlorite) is being used as a stock solution and that a treatment level of 10 ppm of chlorine is desired. The required injection rate is calculated in Example 2.

Table 3 was created using Equation 2 and can also be used to determine stock solution injection rates for proportional injection pumps.

Injection pumps used to add fertilizer to irrigation water often have higher injection rates than those required for chlorine treatment. In these cases, stock solutions must be diluted to account for injector limitations. Dilution rates can be calculated using Equation 3.

In Equation 3, the injection pump setting and the required stock solution injection rate must both have the same measurement units (ppm, percent, or ratio).

As an example, assume that a stock solution injection rate of 80 ppm is required but that the proportional injector being used has a minimum injection rate 5000 ppm. Equation 3 is used to determine the required dilution rate. The required dilution rate calculation is shown in Example 3.

EXAMPLE 3.

$$\text{Required dilution rate in parts water:parts chlorine stock solution} = \left[\frac{5000\ \text{ppm}}{80\ \text{ppm}}\right] - 1 = 61.5$$

In this case, 61.5 units of water must be mixed with every unit of postharvest wash material. With this mixture, an injector delivering 5000 ppm will be supplying 80 ppm of stock solution.

Chemical treatment of irrigation water with chlorine will prevent many of the clogging problems that can seriously disable drip irrigation systems. The injection of chlorine requires that labeled products be used and that the operator possess a New Jersey Private Applicators License. New Jersey legislative code also requires that a functioning backflow prevention device be used where chemicals are injected into an irrigation system.

TABLE 1. Required chlorine stock solution injection rate (ounce/hour) for positive displacement injection pumps.

Concentration of injected stock solution (% chlorine)	Desired irrigation water treatment level (ppm)					
	1	2	3	4	5	10
	(ounce/hour of injection per 100 gallon/min of irrigation flow rate)					
5.25	15	29	44	59	73	146
10	8	15	23	31	39	77
12.5	6	12	18	25	31	61
15	5	10	15	20	26	51
20	4	8	12	15	19	38

TABLE 2. Equivalent injection proportions.

Ratio	PPM	Percent
1:10,000	100	0.01
1:5,000	200	0.02
1:2,000	500	0.05
1:1,000	1000	0.1
1:500	2000	0.2
1:200	5000	0.5
1:100	10000	1
1:50	20000	2
1:20	50000	5
1:10	100000	10

TABLE 3. Required chlorine stock solution injection rate (ppm) for proportional injection pumps.

Concentration of injected stock solution (% chlorine)	Desired irrigation water treatment level (ppm)					
	1	2	3	4	5	10
	(required injection rate in ppm)					
5.25	19	38	57	76	95	190
10	10	20	30	40	50	100
12.5	8	16	24	32	40	80
15	7	13	20	27	33	67
20	5	10	15	20	25	50

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