Proc. Fla. State Hort. Soc. 89:21-23. 1976.

A METHOD FOR ESTIMATING CHLORINE REQUIREMENTS AND AN APPARATUS FOR CONTROLLED CHLORINE INJECTIONS IN DRIP IRRIGATION SYSTEMS[1]

HARRY W. FORD
University of Florida,
Institute of Food and Agricultural Sciences,
Agricultural Research and Education Center,
P. O. Box 1088, Lake Alfred, FL 33850

Additional index words. chlorinator.

Abstract. **Chlorine, whether as a gas or liquid bleach formulation, has been used successfully in controlling certain slime problems and to precipitate low concns of iron in drip irrigation systems. The method described for estimating chlorine requirements is simple and requires only 1 min to perform the test in the field.**

The chlorinator described utilizes sodium hypochlorite and operates by suction inside the well casing or on the vacuum side of surface mounted pumps. The chlorine solution is filtered with a fritted glass disc mounted in polyvinylchloride (PVC) tubing. The apparatus can be calibrated to inject as low as (3 ml/min) 21 hr for each gal of chlorine solution or as high as (24.6*l*) 6.5 gal of chlorine solution per hr of injection. The total cost for materials is approx $15.

The general nature and types of clogging problems in drip systems in Florida have been widely reported (1, 2, 3, 4). Sodium hypochlorite, calcium hypochlorite, chlorinated cyanurate compounds, and chlorine gas can be used effectively to control certain slimes and minimize clogging. The principal uses for chlorine are: as an inhibitor of sulfur slime for waters containing hydrogen sulfide; to control general slime growths that are not specifically associated with iron or sulfur; to precipitate < 1.0 ppm (parts per million) iron for removal in sand filters; for slime control where low concns of both iron and hydrogen sulfide are present; and to reduce algal slime in emitters utilizing surface water.

Chlorine, as a liquid or gas, has maintenance, injection, and monitoring problems (1, 5). This paper describes a procedure for estimating chlorine requirements together with an apparatus for injecting hypochlorite and cyanurate solutions into the suction side of centrifugal pumps or down into the well.

Procedure

Estimating chlorine requirements. Chlorine requirements must be known in order to utilize the injection apparatus described in this paper. In the majority of wells and water sources tested, 65 to 81% of the chlorine reacted with certain inorganic compounds or was sorbed by organic substances in the water. The hypochlorous acid required to satisfy such requirements is of no value as a slimicide because it combines with organic matter. The free residual chlorine (the excess hypochlorous acid) is the active slimicide and should be established before injection. In 6 sites under evaluation with the new chlorine injector, a min of 2 to 3 ppm of free residual chlorine had to be available at the injection point (with pH < 7.5), in order to yield 0.5 to 1.0 ppm free residual at the last emitter. Chlorine requirements can be estimated in 4 steps.

1. Prepare a standard sodium hypochlorite solution (NaOCl). Mix 16 ml of fresh 5.25% NaOCl with 50 ml deionized water. Place in 60 ml amber glass dropping bottle containing a straight pipette medicine dropper and store at < 75°F. Determine the exact chlorine concn in the standard by adding 1 drop (with the medicine dropper) to a 300 to 500 ml calibrated bottle of deionized water. The exact vol of the bottle selected must then be used throughout the procedure. Shake for 10 sec and read for *total* chlorine with an N,N-diethyl-p-phenylenediamine (DPD) chlorine test kit (1, 5). Total chlorine should be between 1.0 and 3.0 ppm and should be recorded. Concn of the standard should be rechecked each time the test procedure is used. A new standard should be prepared when the concn (as tested in deionized water) drops below 1.0 ppm.

2. Collect a water sample in the calibrated bottle from the irrigation system that is to be treated with chlorine. If the water contains sulfides, then it will require 9 ppm of chlorine for each ppm of sulfides. If the water contains iron, it will require about 1 ppm of chlorine for each 1 ppm of iron. Usually 0.5 to 1.0 ppm NaOCl is required for organic matter. Take this into consideration when running this test.

3. Add enough drops of NaOCl standard solution to obtain 0.2 to 3 ppm of *free* chlorine. Mix the sample for about 15 sec, read for *free* chlorine. If there is no red color in the test vial, add more drops of chlorine—retest and also rerun. If more than 3 ppm of free chlorine (that is the upper limit of the test kit) is present, start over by using fewer drops of standard chlorine solution. If free residual chlorine can be read on the test kit color disc (even a very low value of 0.2 ppm), then run the test for total chlorine. Dilute an aliquot if the total chlorine reading is above 3 ppm—the highest value on the test kit scale.

4. The difference between ppm total chlorine standard used in the sample (drops of chlorine standard required times ppm of standard) and the total chlorine residual in the sample represents the chlorine that will be lost to chemical reactions such as hydrogen sulfide, iron, or other inorganic metals. The difference between the total chlorine residual in the sample and the free chlorine in the sample represents the chlorine that will be reacting with organic matter and nitrogenous substances such as ammonia. Example: assume 1 drop of NaOCl standard equals 3 ppm. Three drops of NaOCl standard when added to the sample yielded 2.5 ppm free chlorine. In this example, the free chlorine residual is in the desired range of 2 to 3 ppm. Thus, the initial rate for injection of NaOCl into the drip irrigation system would be 9 ppm (3 drops x 3 ppm standard). In the example, if the free chlorine residual reading had been only 1 ppm then it would be necessary to inject 22 ppm of NaOCl to obtain a 2.5 ppm free chlorine residual (3 drops x 3 ppm standard x 2.5). The concn of chlorine can be adjusted up or down during actual injection depending on chlorine test readings taken from emitters along the line and at the end of the system.

Formulas can be used to calculate the gal per hr (gph) of NaOCl solution that must be injected to obtain a desired ppm of chlorine in the irrigation water. The gal per min (gpm) pumping rate must be known.

Formula for gph of 10% NaOCl: 0.0006 x (ppm of desired chlorine) x (gpm pumping rate)

Formula for gph of 5.25% NaOCl: 0.00114 x (ppm of desired chlorine) x (gpm pumping rate)

[1]Florida Agricultural Experiment Stations Journal Series No. 179.

Constructing the chlorine injector. A diagram of the apparatus is shown in Fig. 1. The unit can be used on systems with surface mounted centrifugal pumps or submerged pumps where the chlorine injection line can be positioned directly below the pump inlet. The apparatus is unsuitable for submerged turbine pumps. The equipment consists of a fritted glass disc filtering unit, a plastic valve, and a calibrated orifice to regulate flow of the NaOCl (Fig. 1 and Tables 1, 2). The injection line, insofar as possible, should extend at least 20 ft down inside the drop pipe or cased well. Do not extend below the casing into the cavity of the well. The chlorine injection rate is controlled by the diam and length of the orifice inserted in the injection line. Changes in flow rates can be made by modifying the length of the microtubing in the orifice or by simply substituting orifices. The orifices are constructed from the tethered exit plugs of Spot Systems vortex emitters. Exit plug orifices, with 0.015 inch and 0.023 inch inside diam (I.D.) polyethylene tubing inserts, are hand drilled with appropriate drill sizes and the polyethylene tubing inserted and cut to the specified length (Table 1). In order to use Table 1, measure the pumping vacuum at the point where the orifice is to be mounted. An automotive vacuum gauge can be used. One must also know the gph of NaOCl to be injected.

The size of the glass or plastic jug for hypochlorite solutions is a matter of personal preference. A 5-gal glass water

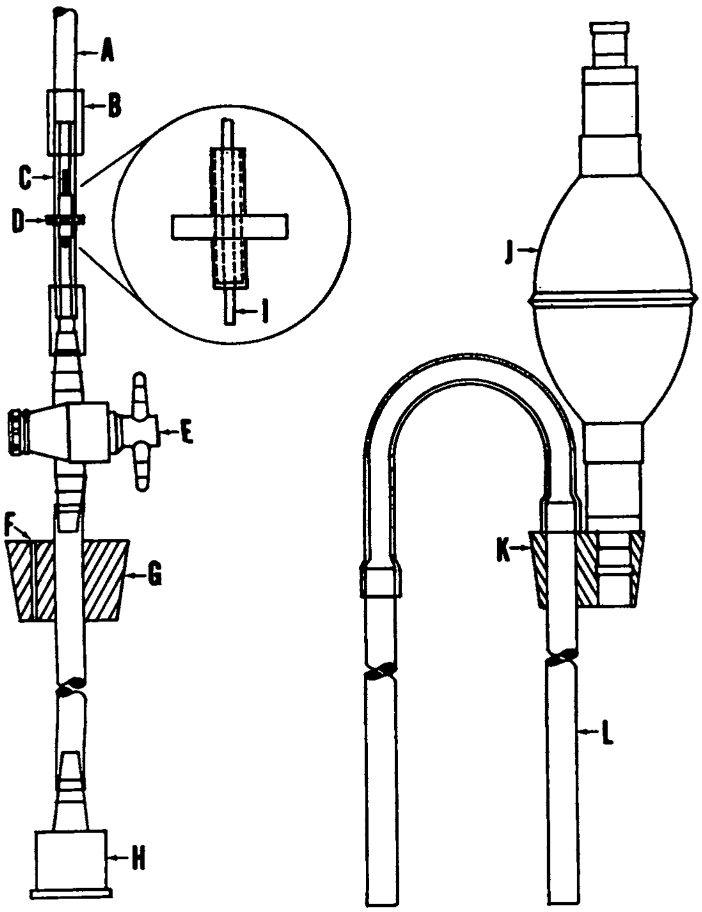

Fig. 1. Vacuum type chlorinator (left) and hypochlorite syphon tube (right): (A) 1/4 inch O.D. plastic injection line, (B) 3/16 inch I.D. flexible plastic tubing, (C) 1/4 inch I.D. flexible plastic tubing, (D) tethered Spot emitter exit plug, (E) plastic valve, (F) air vent, (G) neoprene stopper inserted in chlorine container, (H) fritted glass gas dispersion tube (the filter), (I) orifice constructed from microtubing, (J) one-way rubber bulb, (K) neoprene stopper inserted in chlorine container, and (L) stiff plastic tubing.

Table 2. Parts required for construction of the injection apparatus.

Item	Source[z]
Tygon type tubing 1/8 inch I.D. 1/4 inch O.D. 3/16 inch I.D. 7/16 inch O.D.	Chemical-laboratory Supply Co.
1/4 inch O.D. PVC white flexible tubing	Laboratory supply and hardware stores
Polyethylene microtubing 0.015 inch and 0.023 inch I.D.	Fisher Sci. Co., Pittsburg
Stopcock PP/TFE 2 or 4 mm	'Nalgene' brand; Laboratory Supply Co.
Gas dispersion tube, 25 micron porosity; a plastic tube with bell housing containing a fritted glass disc	Cole-Palmer Instrument Co., Chicago
Spot vortex emitters	Spot Systems, Div. Wisdom Industries

[z]Specific named sources are listed because of limited sources of supply. It does not constitute an endorsement of the source.

Table 1. Polyethylene orifice[z] for pump suction (or psi differential) and gph NaOCl to be injected.

Drill size	Diam of orifice (inch)	Length of orifice (inch)	gph of NaOCl at specified Hg vacuum (or psi differential)			
			5 inches (2.5 psi)	10 inches (5.1 psi)	15 inches (7.6 psi)	20 inches (10.1 psi)
58	0.015[v]	2.0	0.05	0.10	0.19	0.38
58	0.015[v]	1.0	0.09	0.19	0.32	0.45
58	0.015[v, w]	0.5	0.11	0.25	0.35	0.48
63	0.023[u, w]	4.0	0.15	0.34	0.90	1.10
63	0.023[u]	2.0	0.35	0.70	1.50	1.50
63	0.023[u]	1.0	0.40	0.90	1.30	1.70
63	0.023[u, w]	0.5	0.60	1.10	1.40	1.70
—	0.022[x]	0.25	1.00	2.10	2.90	3.30
68	0.031	0.25	1.50	2.30	3.10	4.30
58	0.042	0.25	2.00	4.00	5.40	6.50[y]
53	0.070	0.25	3.30	6.20	—	—
43	0.089	0.25	3.70	—	—	—

[z]Orifices constructed from the tethered exit plug sections of Spot Systems vortex emitters—some with the addition of 0.015 inch and 0.023 inch tubing.
[y]The max flow rate with fritted filter and other resistance to flow factors.
[x]Standard Spot emitter orifice without drilling.
[w]No orifice sizes available between 0.015 inch and 0.023 inch. The 0.015 inch and 0.023 inch I.D. insert cannot be made shorter than 0.5 inch.
[v]Polyethylene tubing: 0.015 inch I.D./0.043 inch O.D.
[u]Polyethylene tubing: 0.023 inch I.D./0.038 inch O.D.

jug has proven satisfactory. Chlorine solutions must be protected from heat, air, and sunlight. Do not have more than a 3-day supply of chlorine solution in the jug. Wrapping the jug with aluminum foil or a cloth cover and having a roof cover will often suffice.

One can usually tell whether the injector is working by observing bubbles moving in the injector tubing and by testing the chlorine concn in the irrigation water. It is essential that the free residual chlorine level in the drip irrigation system be monitored several times a week. A DPD type chlorine test kit must be used (1, 5).

The entire injection system must be air tight. The 1/4 inch PVC tubing from orifice to injection point down in the well, must not be spliced (which cause air locks). The injection line should never be permitted to run dry. An aerated filter or orifice will collect salt (NaCl) and other deposits from oxidized hypochlorite. The salt will clog filter and orifice. The filter can be cleaned with water and a toothbrush. The orifice can be cleaned in water. The filter and orifice should routinely be cleaned after 30 to 50 hr of irrigation.

Commercial swimming pool 10% hypochlorite solutions often contain precipitates that will clog the filter. The supernatant of "dirty" chlorine solutions must be syphoned into the glass jug in order to keep out precipitates. A simple syphoning system is shown in Fig. 1.

Literature Cited

1. Ford, H. W. 1975. The use of *chlorine in drip irrigation* systems. *Proc. Fla. State Hort. Soc.* 88:1-5.
2. ———. 1976. Controlling slimes of sulfur bacteria in drip irrigation systems. *HortScience* 11:133-135.
3. ———, and D. P. H. Tucker. 1974. Water quality measurements for drip irrigation systems. *Proc. Fla. State Hort. Soc.* 87:58-61.
4. ———, and ———. 1975. Blockage of drip irrigation filters and emitters by iron-sulfur-bacterial products. *HortScience* 10:62-64.
5. White, G. C. 1972. Handbook of chlorination. Van Nostrand Reinhold Co. 744 pp.

Proc. Fla. State Hort. Soc. 89:23-26. 1976.

SOIL MOISTURE DISTRIBUTION IN A SPRINKLER IRRIGATED ORANGE GROVE[1]

J. MOSTELLA MYERS AND D. S. HARRISON
IFAS, Agricultural Engineering Department, University of Florida, Gainesville, FL 32611

W. J. PHILLIPS, JR.
IFAS, Cooperative Extension Service, Ocala, FL 32670

Additional index words. citrus, tensiometer.

Abstract. **Soil moisture pressures were measured in soil under irrigated orange trees to determine soil moisture extraction patterns. Measuring points extended in depth from 6 to 48 inches and horizontally from the base of the tree to midpoint between trees.**

Initially, after wetting soil to field capacity, moisture is extracted primarily from soil near the center of the tree and at shallow depths. As moisture depletion progresses, the soil zone supporting major moisture extraction is transitive, both laterally away from the center and downward.

The soil moisture status with respect to time and position is presented graphically for several soil moisture depletion cycles during different segments of the growing season.

The prime function of an irrigation system is to apply water in the soil to replenish moisture extracted by the action of plants. Irrigation equipment developers and system designers have concentrated much effort over the years in producing a system to apply water as uniformly as possible over the entire soil surface. For closely spaced crops, this is unquestionably of great importance. For that matter, it is equally important for widely spaced crops if the irrigation system in use is of the type that applies water to all the land area of the field. In recent years the irrigation industry has made available to users several different irrigation systems with capabilities for uniformly applying water to selected parts of the field only. Drip emitters and under-the-tree spray heads are among the more popular limited area irrigation types in use in Florida.

This paper presents the results of a study conducted to determine patterns of soil moisture extraction for mature orange trees. The information presented identifies soil moisture extraction patterns and provides a basis for locating selective area application devices so that moisture will be replenished where the deficit occurs first.

Materials and Methods

This study was conducted in 1975 and 1976 in an 11 year old orange grove located about 20 miles southeast of Ocala in Marion County. The grove is planted to "Parson Brown" orange trees on sour orange rootstock. The soil type is Astatula fine sand with a sandy clay substratum beginning approximately 4 feet below the surface. Cultural practices used are normal for a commercial planting of the age and production level. The test area is irrigated by a "solid-set" overhead irrigation system.

The basic data for the study were obtained from 20 soil moisture tensiometers placed in the soil in a spatial arrangement as indicated by Fig. 1. Tensiometers located horizontally 26, 56 and 86 inches from the center of the tree were under the foliage canopy of the tree, while those 116 inches away were at the midpoint between trees and out from under the canopy. The tensiometers were of the indicating type with a capacity for measuring soil moisture pressure (suction) between 0 and 85 centibars. Tensiometer measurements were generally made at weekly intervals.

Results and Discussion

An analysis of the soil moisture pressures for a one year period indicate consistent patterns of soil moisture depletion. With the soil moisture at field capacity, the moisture extraction rate was greatest from soil nearest the main trunk of the tree. Without adding moisture the extraction pattern expands both horizontally and vertically. This paper will include a presentation and discussion of extraction for two time periods with minimum rainfall interference; one in the fall and the other in the spring. These time periods represent the significant findings from the experiment.

[1]The authors gratefully express appreciation to Mr. Horace Holmes, Lake Florinda Grove, Route 1, Oklawaha, Florida, for providing grove site for the experiments.
Florida Agricultural Experiment Stations Journal Series No. 202.