NETAFIM™

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MAINTENANCE GUIDE - DRIP

NETAFIM SA PRODUCT GUIDE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DOCUMENT INFORMATION

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1. GENERAL

1.1 The Irrigation System

The system is a powerful tool to control and manipulate the crop. In today's world, producing crops is a very competitive market and it is always important to have a reliable irrigation system to ensure constant production of the highest quality.

Figure 1 - Drip irrigation systems

1.2 Design

A well-designed system that allows for safety margins and maintenance procedures must be one of the considerations when choosing a system.

NB	**Never do a chemical treatment while plants are actively growing in an artificial growing medium or limited root zone**

1.3 Prevention is better than cure

One of the most pressing issues that we face during our visits to drip irrigation installations is the lack of proper preventative maintenance. People do not have any doubt that they should service their tractors, cars, packing machinery etc. However, when it comes to the irrigation system it is different; it is simply not done properly.

NB	**A wise man once said, "You only need to brush the teeth you want to keep."**

1.4 Prevent Blocking

List of precautions:

- Oxidation of iron and manganese. See NSA Design Guide – Filtration.
- Prevent calcium and magnesium precipitation by correcting pH level.
- Rinse fertiliser enriched water out of the system.
- Chlorinate or use Hydrogen Peroxide to prevent slime formation.
- Maintain water source and use according to specifications.
- Top float suction.
- Design for maintenance.
- Flush main, sub-main and Dripline.
- Maintenance training program for irrigation staff.
- Follow maintenance programme.
- Install vacuum valves.
- Protect mainline hydraulics.
- Mark all valves and air valve setups to protect damage from machinery.
- Protect installation from vandalism.
- Follow correct installation procedures.
- Position Dripline (ground level or on wires) according to use and surrounding conditions.
- Suitable filtration, primary and secondary.

1.5 Injection Guidelines

Where to inject chemicals?

- Try to minimise handling chemicals, the best is injecting direct from the 20-25 litre containers.
- It is best to inject chemicals just after the block valve to avoid dirt in the mainline. FIGURE 2.
- If you are injecting chemicals at a central point, you must first ensure that the mainline is clean.
- If the mainline is not clean, the dirt will separate from the mainline while treating the Dripline and this dirt will follow the route to the Dripline and create more blocking problems than before the treatment.
- If you want to inject chemicals for maintenance at a central point, then you must design and operate the irrigation for this option from day one.

Figure 2 - Chemical injection at block level

1.6 Secondary Filters

This is the second protection of the system and is normally installed at block valves or groups of block valves. These filters are of great value in the event of a mainline break or where dirt that is small enough to pass through the primary filter and then build up to form larger particles that can cause a potential blockage. In systems where fertigation or asbestos mainlines are still being used, it is a good idea to use these filters. We would recommend a filter with the same micron as the primary filter. This is the life insurance of a system.

2. SAND IN DRIP SYSTEMS

2.1 General

Sand is the most harmful element for drippers. Sand does not decompose. After infiltrating any kind of dripper, it cannot be removed or dissolved, even with the use of chemicals. This applies for all types of drippers.

- The water source can be causing the sand problem and can be avoided with settling dams, filters or a combination of these.
- Sand can also be a result of mainline breakages in the system and can be avoided with secondary filters at block valves.
- Sand can also block the dripper externally with fine sand that can get blown in or with water (puddles or rain). In this last case it would be advisable to put the dripperline on a wire.
- Sand can also be sucked in when a vacuum condition prevails. Design and provide for vacuum valves on the highest point of the sub-main.

2.2 During Installation

As sand is such a huge problem, it is very important to follow certain procedures during installation:

- Ensure that main and sub-mains stay clean at all times.
- Never leave inlets and outlets open, not even for a short period of time.
- In the digging of holes, remove all debris and immediately install the start connector with the blank pipe until above the ground and bend the end over until the dripperline is installed.
- Install the dripperline and bend ends over.
- Flush mainline.
- Flush sub-mainline.
- Flush Dripline.
- Make sure that the installation team understands the above.

3. MAINLINE

3.1 Mainline Failure

Steps to follow in the event of mainline failure:

- System irrigation.
- Break in mainline.
- Close all valves downstream of the break.
- Switch off the pump.
- Fix break.
- Open the flush valve of the mainline.
- Turn on pump and slowly fill the mainline.
- Flush mainline.
- Open the sub-main and the block valves.
- Close the flush valve of the mainline.
- Flush sub-mainline.
- Close the flush valve of the sub-main line.
- Flush Dripline (1 to 3 times).

NB	**Velocity during flushing of Dripline must be ≥ 0.5 m/s at the ends of the Dripline. If too many lines are flushed at the same time, the flush is ineffective.** **See *6. FLUSHING PROCEDURE* on page 14.** **Dripperline ends can be opened and closed a few times to create a pressure differential. In this way, Netafim PC drippers enter into a self-cleaning cycle, which will flush dirt out of the drippers.**

3.2 Cleaning of the Mainline

Pipelines are developed to deliver a certain quantity of water at a specified pressure to the end point (user). Inner diameter of pipe is decreased with deposits and if these deposits are not cleaned, the system will not operate according to specifications.

3.3 Maintain Pipelines

It prevents the replacement of pipelines.
Decrease pump wear and reduces electricity usage.
Pipelines can do what they are developed to do.

3.4 Chemical

To clean pipelines chemically is an option, but we do not have the experience and knowledge to do this and one can cause greater damage if mainlines are only partially cleaned and then during irrigation more dirt is loosened and it blocks the drip system. It is prohibited to do an acid treatment in AC (asbestos-cement) pipes. The treatment will damage the AC pipe and will dump dirt into the drip system.

3.5 Physical

This option is more work the first time, especially with older systems where the producer does not even know what his pipe network looks like. This means that the pipe must be opened (in PVC, cut the line) A "pig" is installed in the line. Seal the line (use long repair connector piece) and pump the "pig" to the planned position of the network. At T-pieces or reducers the "pig" must be removed and re- inserted after this obstacle. In the case where inner diameter is drastically different, the "pig" must be replaced with the suitable size. The results are obvious and the process must be repeated till the line is clean. (See Protea Pigs at www.proteapig.co.za).

Figure 3 - Physically cleaning a mainline

NB	**New pipelines can be designed to make allowances for the above-mentioned maintenance. Capital cost will be higher, but it can be saved again with long-tern operational cost.**

4. GENERAL CAUSES OF BLOCKAGES

Dripper blockages can be due to microbiological and/or chemical causes.

Figure 4 - Biological clogging in a dripper

- Organic sedimentation
- Bacteria, slime and algae
- Oxidising treatment:
  - Chlorine or Hydrogen Peroxide

Figure 5 - Pipe internal diameter narrowing

- Silt build-up
- Carbonates, hydroxides and phosphates
- Acid treatment

NB	**In exceptional cases where iron > 0.3 ppm or manganese >0.1 ppm in the irrigation water, special procedures are necessary, example oxidation.**

Figure 6 - Dripper blockage - iron

Figure 7 - Dripper blockage - Manganese

With iron and manganese blockages there is no guarantee that chemical treatments will open drippers again. The problem must be dealt with before the water is used. If it is in the form of bacteria you can try a double treatment of acid and hydrogen peroxide, see *11. TWO-STEP TREATMENT* on page 27.

Drippers can also become blocked due to physical causes (solid materials) e.g. clay, silt, sand and organic material. Systems also get blocked with the use of unsuitable fertilizer and/or a fertilizer program that is not followed correctly.

NB	**Mechanical treatment of drippers by hitting, pinching and bending actions is not recommended and will only damage the drippers.**

5. WATER ANALYSIS

5.1 Purpose of chemical water analysis

Water analysis is necessary to determine whether the water is suitable for crop production, any impact on the soil and if there is any potential for blockages of the planned irrigation system.

5.2 Procedures taking samples

5.2.1 General

- Rinse sample bottle and cap using water from the source to be sampled.
- Fill bottle till top to avoid air in the sample. Store avoiding direct sunlight or heat.
- Sample 0.5 ℓ – 5.0 ℓ depending on profile selected, see table below.
- **MARK THE CONTAINER PROPERLY WITH RELEVANT INFORMATION:**
  - Grower's name, type of crop, water source, location, and date sample.
  - NSA contact person and who is responsible for payment (Netafim or client).
  - Email detail who must receive a copy of the laboratory report.
- No time limit to reach laboratory. Microbiological analyses within 24 hours keep <10°C.

5.2.2 Boreholes

- Allow the water to run for 15 minutes before filling the container.
- Where iron and manganese can be a problem: (look for precipitation at the source) a separate sample should be taken. Half fill the container with water, add 3 - 5 drops acid and then fill the rest of the container. This container must be marked separately for the analysis of iron and manganese only. COMMUNICATE THIS PROCEDURE TO THE LABORATORY STAFF.

5.2.3 Dams / Rivers

- In a new development it is recommended that the sample be taken at the same place as the planned suction point (dam surface or bottom).
- Existing system, take sample directly after the pump (pump for a minute before sampling).

5.2.4 Dripline end

- Wait until the system pressure has stabilized.
- Open end of the dripline and let water flow for 2-3 minutes before taking the sample.

NETAFIM CODE LABSERVE CODE ANALYSIS →	**NET01** C1111 IRRIGATION	**NET02** C1112 NET01 + TSS	**NET03** C1113 GREENHOUSE	**NET04** C1114 NET03 + TSS	**NET05** C1120 EFFLUENT[1]
Sample size required	0.5 ℓ	1.0 ℓ	0.5 ℓ	1.0 ℓ	1 ℓ + 5 ℓ
EC, pH	•	•	•	•	•
[2] Irrigation class	•	•	•	•	•
[2] TDS Total Dissolved Solids	•	•	•	•	•
TSS Total Suspended Solids	-	•	-	•	•
Ca, Mg, K, SO_4^{-2}, Na, Cl	•	•	•	•	•
Fe, Mn, B	•	•	•	•	•
CO_3^{-2}, HCO_3^-	•	•	•	•	•
Total Alkalinity as $CaCO_3$	•	•	•	•	•
[2] Alkalinity Hazard	•	•	•	•	•
[2] Hardness (Ca, Mg, Total as $CaCO_3$)	•	•	•	•	•
[2] SAR Sodium Absorption Ratio	•	•	•	•	•
[2] Langelier Index	•	•	•	•	•
NH_4^+ [water with high NH_4^+ concentration, sample must be kept cool (<10°C)]			•	•	•
NO_3^-	-	-	•	•	•
P	-	-	•	•	•
Cu, Zn, Mo, Si	-	-	•	•	•
COD Chemical Oxygen Demand	-	-	-	-	•
NO_2^-	-	-	-	-	•
SOG Soap, Oil and Grease	-	-	-	-	•
VSS Volatile, Suspended Solids (take second water sample of 5 ℓ and mark "VSS" , this test required ≥ 1 gram of solids for a result)					•
NOTE [1] Effluent water where no chlorine or heavy metals are added to the process and without faecal contamination. NOTE [2] Determined by calculations or reference tables.					

Table 1. Water analysis profiles as per agreed between Netafim and Labserve

6. FLUSHING PROCEDURE

6.1 Flushing of Drip Systems

Flushing of drip systems is the most important procedure that can be performed to maintain the system. Sub-main lines are easy to flush if correctly designed and fitted with a flush valve. A fixed program to flush sub-mainlines will reduce the dirt that can accumulate and therefore reduce flushing of Dripline.

Figure 8 - Sub-main flushing

Water moves from the beginning to the end of Dripline and the flow within the dripperline decreases towards the end. This also means that the flow velocity is drastically reduced towards the end. All dirt in suspension will collect at the end of the dripper lines. Regular flushing of the system, even without any chemicals will address this problem. Dripline can be opened and closed a few times to bring about a pressure fluctuation; in this manner Netafim PC dripper will enter a self-cleaning mode that will flush dirt out of the drippers.

Figure 9 - Dripperline flushing

6.2 Dripline

For effective flushing, a velocity of 0.5 m/s or more is recommended. The best is to only flush one or two Dripline at a time. The most practical way to determine if you have the correct velocity in the field during flushing is to measure how many seconds it takes to fill a one litre container.

Product	Time to fill one litre
UniRam 17, DripNet PC 16, Aries 16	12 Seconds
Super Typhoon125 or 150 and Streamline Plus 60 or 80	10 Seconds
UniRam and DripNet PC 20, Aries 20	8 Seconds

Table 2. Flushing of Dripline – achieving 0.5 m/s velocity

Where pressure regulated valves are used, the pressure regulating function should be disengaged and set manually to increase the pressure. Be careful not to exceed the maximum pressure where low- density polyethylene (LDPE) pipes and PVC start connectors with grommets are used.

6.3 The flushing of the system

- Fill the system with water and obtain the correct working pressure.
- Flush mainlines then flush the sub-mains and then the Dripline.

6.4 Rain and flushing

During heavy rain, silt and sand can enter the drippers from the outlet side (drawn back into the dripper) and when it dries, the sediment will remain in the flow path. To prevent blockages one must irrigate after the run-off water has drained, usually one or two days after the rain. This is a technical irrigation to flush the drippers, although the crop does not require water. This technical irrigation continues until the system has reached the planned operating pressure plus 5 minutes and then is turned-off. Repeat every second day, until the soil is no longer over saturated.

7. REDUCING pH WITH ACID

7.1 Purpose

The purpose of pH adjustment is to ensure favourable conditions for chlorination. The pH levels influence the effectiveness of chlorination.

pH	% HOCl - Strong form of free chlorine - Active ingredient	% OCl^- - Weak form of free chlorine - Less active ingredient
< 4	100	0
5	100	0
6	100	0
7	75	25
8	25	75
9	2.5	97.5
10	0	100
11	0	100

Table 3 - The relative proportion of hypochlorous acid (HOCl) and hypochlorite anion (OCl-) in water at different pH values

NB	
	HOCl is the active agent as seen in the table. The efficiency drops dramatically at pH higher than pH 7.

7.2 Safety

- Read the manufacturer's instructions carefully.
- Always add the acid to the water. Do not add water to acid.
- Acids are dangerous to handle.
- Wear protective clothing, gloves and glasses.
- It can lead to blindness and burns.
- Drinking or inhalation of the acid gasses can be fatal.
- Acidification and chlorination must be done at two separate injection points.
- A mixture of acid and chlorine in the same tank can lead to a highly poisonous chlorine gas.
- Never store acid and chlorine together

7.3 Step by Step – Practical guide for acid adjustment:

1. Connect the fertiliser injection pump and get the system up to working pressure.
2. Set the injection pump to full capacity.
3. Switch the injection pump on, use clean water and determine the injection rate.
4. Fill a 50 litre container with clean irrigation water and measure the pH.
5. Add 1 mℓ acid (use syringe), mix and measure pH. Remember SAFETY first.
6. Repeat steps 4 and 5 till the pH value drops to 6. Record total amount (mℓ) of acid.
   - Note: pH of system will increase again as soon as chlorine is injected.
7. Fill the dosing container "D" with water and add calculated quantity of acid.
8. Begin injecting with acid solution.
9. Measure pH downstream of the injector; if the pH is not 6 then redo the calculations.
10. Now you can begin with the chlorination downstream of pH adjustment.

NB	**Use a 50 litre container "C" for the calibration.** **A larger container can be used for the Dosing "D" solution that must be injected.** **The pH must not drop below 6.** **Maximum injection time is the time for container "D" to empty at the set injection rate. More than one block can be chlorinated during this time.**

TABLE OF CONTENTS

7.4 Example: Reducing pH

Flow rate for treated block	=	30	m^3/h
Injection rate (dosing pump)	=	100	ℓ/h
Calibration volume "C"	=	50	ℓ (container = 60 ℓ)
Dosing volume "D"	=	150	ℓ (container = 200 ℓ)
Acid for pH = 6.0	=	6	ml (answer of step #6)

Formula 1

Acid per 1000 ℓ of water = $\dfrac{\text{6 mℓ x 1 000 ℓ of water}}{\text{50 ℓ (volume "C")}}$ = 120 mℓ of acid

Formula 2

Volume acid per hour = $\dfrac{\text{30 m}^3\text{/h x 120 mℓ acid}}{\text{1 000}}$ = 3.6 ℓ of acid

Formula 3:

Volume acid for "D" = $\dfrac{\text{3.6 ℓ acid x 150 ℓ (volume "D")}}{\text{100 ℓ/h (injection rate)}}$ = 5.4 ℓ of acid

Formula 4:

Volume water for "D" = 150 ℓ ("D") minus 5.4 ℓ of acid = 144.6 ℓ of water

Formula 5:

Maximum Injection Time for volume "D" solution = $\dfrac{\text{150 ℓ (volume "D")}}{\text{100 ℓ/h (injection rate)}}$ = 1.5 hours

NB

See *8. ACID TREATMENT* that follows below for different types of acids. Always add acid to water not vice versa.

NETAFIM™ SOUTH AFRICA

8. ACID TREATMENT

8.1 Purpose

The purpose of acid treatment is to loosen the scale deposits (carbonates, hydroxides, phosphates) that occur in the Dripline. Treatment is not effective where organic deposits occur. In certain cases the injection of acid can be sufficient to destroy slimy bacteria. See *9. CHLORINATION* and *10. HYDROGEN PEROXIDE*

8.2 Safety

- Read the manufacturer's instructions carefully.
- Always add acid to water. Do not add water to acid.
- Acids are dangerous to handle.
- Wear protective clothing, gloves and glasses.
- Acid can lead to blindness or burns.
- Drinking and inhalation of the acid gasses can be fatal.
- Store separate from other chemicals.
- Use clean water (not fertiliser rich water) during **ACID TREATMENT**.

8.3 Flush the system

Flush the mainline and sub-main and the Dripline before chemical treatment.

8.4 Products

Recommended concentrations (specific acid in treated water)	Type of acid	Standard concentration (of a specific acid)
0.6%	Hydrochloric acid (HCl)	33%
0.6%	Sulphuric acid (H_2SO_4)*	65%
0.6%	Nitric acid (HNO_3)	60%
0.6%	Phosphoric acid (H_3PO_4)*	85%

Table 4 - Recommended concentrations for different acids for water treatment:

In the event that the acid available is a different concentration to what is shown in the table above, please adjust as per the example below:

$$\text{Recommended concentration if using Sulphuric acid of 98\%} = \frac{65\%\ \text{acid} \times 0.6\%}{98\%\ \text{acid}} = 0.4\ \%$$

NB	**In other words, you must use 0.4 % concentration when you are using 98 % sulphuric acid and not the 0.6% concentration as shown in table above.** *** Avoid using sulphuric or phosphoric acids if the irrigation water is high in bicarbonates**

8.5 Warning

- Acid treatment should reduce the pH of the water to between 2 and 3.
- Never do this treatment while plants are actively growing in an artificial growing medium.
- Never do this treatment if the Dripline are installed on steel wires.
- Do not use nylon fittings on the injector pump when connecting to the system. These fittings are not resistant to high concentrations of acid.
- Acid is very corrosive when it comes in contact with steel, asbestos-cement and aluminium pipes. Polyethylene and PVC pipes are tolerant to acid. Low pH can damage the irrigation system. In general corrosion is hastened when the pH is lower than 5.6 in the water.
- Localised corrosion can occur at the injection point, but can be reduced if the injection opening is installed in the middle of the pipe. For this one can use a 316 stainless steel elbow.
- The ideal pH for most crops is between 5.8 and 6.2. With a pH higher than 6.5 calcium and phosphates can react and precipitate within the system. Do not use phosphoric acid in high pH water with high calcium and bicarbonate content.

8.6 Step by Step – Practical guide for acid treatment:

- Get the system to working pressure and flush all lines.
- Irrigate for one hour with clean water to wet root area and to protect roots.
- Connect the fertiliser injection pump to the block that needs to be treated.
- Turn on the injection pump at full capacity with clean water and determine the volume water that it delivers in 10 minutes. This is the application volume. Test it again by placing the same volume in a container and ensure that it injects the correct volume in 10 minutes.
- Do calculations and prepare the solution that must be injected.
- Inject the acid so that the concentration in the irrigation water equals 0.6%.
- After acid treatment, flush injection equipment with clean water.
- Irrigate for a further hour after the acid has been injected. This will ensure that the pH of the root area returns to the value before treatment.
- Flush system. Only one or two Dripline at a time see *6. FLUSHING PROCEDURE* on page 14.

NB	**If dilution is required, fill an acid proof container (plastic) with calculated amount of water and mix the acid carefully in the water.**

8.7 Example: Acid Treatment

Acid type	=	Hydrochloric Acid (HCl)	
Acid standard concentration	=	33	%
Flow rate for treated block	=	30	m^3/h
Injection time	=	10	minutes
Required acid (%) in treated water	=	0.6	%

Formula 1

System volume for 10 minutes $= \dfrac{30\,000 \text{ ℓ/h} \times 10 \text{ minutes}}{60 \text{ minutes}} = 5\,000$ ℓ

Formula 2

Required volume of acid $= \dfrac{5\,000 \text{ ℓ} \times 0.6\%}{100} = 30$ ℓ

Formula 3

Minimum injection rate $= \dfrac{30 \text{ ℓ} \times 60 \text{ minutes}}{10 \text{ minutes}} = 180$ ℓ/h

8.8 Summary

- The required injection rate is 180 litres per hour, injecting 30 litres of acid within 10 minutes if acid can be injected undiluted.
- If the injection pump can inject undiluted acid, it is the best to inject the acid direct from the acid container.
- If dilution is required, the injection rate will increase by the dilution factor.
- The quantity of acid required can be ascertained by laboratory tests (titration). It is advisable to continuously test to get a pH vs. acid (titration) curve established. With titration the required volume of acid can be determined as the water quality changes at various times of the year and will ensure the most economical use of acid.

9. CHLORINATION

9.1 Purpose

The purpose of chlorination is to solve problems that are caused by organic sedimentation in the system such as bacteria, slime and algae.

9.2 Safety

Active chlorine solutions are very dangerous for humans and animals.

- Read the manufacturer's instructions carefully.
- Avoid eye and skin contact.
- Prevent drinking of the solution or inhalation of the gases.
- Direct contact between chlorine and fertiliser can cause a thermal reaction that can lead to an explosion. It can be life threatening.
- Acid treatment and chlorination must be done at two different injection channels. A mixture of acid and chlorine in the same tank can lead to a highly toxic poisonous gas.
- Store apart from other chemicals.
- Chlorination together with herbicides, pesticides and fertilisers, lowers the efficiency of the chlorine (use clean water during chlorination).
- Always add chlorine products to water and not vice versa.

9.3 Influence of the pH of irrigation water

The affectivity of chlorine is influenced by the pH of the irrigation water. At a pH of 6 to 7 the effectiveness of chlorine is optimal. When the pH of the water is higher than 8 the efficiency of chlorine is reduced to below 25% and the pH of the water has to be adjusted. See 7. REDUCING pH WITH ACID on page 15.

9.4 Flush the system

Flush the mainline and sub-main and the Dripline before chemical treatment.

9.5 Point of injection

Do the injection at the block valves. In the case where injection must be done at a central point, the mainline must be cleaned before any block valves are opened. If this is not done all the dirt from the mainline will move to the Dripline and worsen the existing problem.

9.6 Duration of injection

Keep on with the injection for 20 minutes after 0.5 – 3.0 ppm active (measured with a swimming pool test kit that can test for "free available chlorine") chlorine is measured at the last dripper. Measure while dripper is dripping, do not open the end of dripperline. The higher the biological activity in the water, the longer it will take to measure active chlorine at the last dripper.

9.7 Chlorination Options

9.7.1 Continuous Chlorination

This is only recommended where it is legally required or for the contesting of cases like in nurseries. In the case of very high algae/bacteria counts or high iron or manganese in the water it can be applied in consultation with an expert.

9.7.2 Periodic Chlorination

It can be done monthly or weekly depending on the quality of water. Where the purpose of the chlorination is to improve the filtration ability, the injection must be done near the filters. Ensure that there is complete dispersal of the chlorine in the filters. The chlorine concentration must be 2-3 ppm.

9.7.3 Seasonal Chlorination*

This can be done 1-2 times a season. Perform the treatment directly after the season to leave the system clean in the off-season.

9.7.4 Super Chlorination*

These are dangerous words. The recommendation is **not to exceed 30 ppm** because chlorine is an oxidation agent. Oxidation influences rubber that is used in most systems at start connectors as well as diaphragms of valves and drippers.

NB	***Do not apply this treatment while plants are actively growing in an artificial growing medium.**

Chlorination treatment options		Desired concentration (ppm)	
		Start of System	End of System
Prevention	Continuous	3 – 5	0.5
	Periodic	5 – 10	1 - 2
Corrective	Seasonal	10 - 15	2 - 3

Table 5 - Recommended chlorination treatments.

9.8 Products

- Calcium Hypochlorite (HTH swimming pool chlorine).
  - This is a dry granular product with active concentrations of between 65% and 70%.
  - Rule of thumb: 15g HTH (67%) per m^3 water equals 10 ppm.
- Sodium Hypochlorite
  - This is a liquid product with active concentrations of between 12% and 15%.

9.9 Example: Chlorination Treatment

Product 1	=	Calcium hypochlorite (67% active)	
Product 2	=	Sodium hypochlorite (12% active)	
Require Cl^- concentration at injection	=	15	ppm
Flow rate for treated block	=	30	m^3/h
Injection rate (dosing pump)	=	100	ℓ/h
Dosing volume "D"	=	150	ℓ (container = 200 ℓ)

Formula 1

Concentration HTH solution $= \dfrac{15 \text{ ppm} \times 30 \text{ m}^3/\text{h}}{100 \text{ ℓ/h} \times 10} = 0.45$ % Cl^-

NB	**Maximum concentration of 4 % is advised to avoid flocculation.**

Formula 2 – Product 1

kg of HTH product $= \dfrac{0.45\% \text{ (solution)} \times 150 \text{ ℓ (dosing volume "D")}}{67\% \text{ (CL}^- \text{ in HTH product)}} = 1.0$ kg

Formula 2 – Product 2

Sodium hypochlorite (ℓ) $= \dfrac{0.45\% \text{ (solution)} \times 150 \text{ ℓ (dosing volume "D")}}{12\% \text{ (CL}^- \text{ in product)}} = 5.6$ ℓ

9.10 Summary

- Product 1: Calcium hypochlorite (67% active)
  - Dissolve 1.0 kg HTH in 150 litres of water to give us a chlorine solution of 0.45%. If we then inject this 0.45% chlorine solution at a rate of 100 ℓ/h we will get the required 15 ppm chlorine at the injection point if the system flow rate is 30 m3/h.
- Product 2: Sodium hypochlorite (12% active)
  - Add 5.6 litres of sodium hypochlorite (12% active) to 150 litres of water to give us a chlorine solution of 0.45%. If we inject this 0.45% chlorine solution at a rate of 100 ℓ/h we will get the required 15 ppm chlorine at the injection point if the system flow rate is 30 m^3/h.

10. HYDROGEN PEROXIDE (H_2O_2)

10.1 Purpose

The purpose of chlorination is to solve problems that are caused by organic sedimentation in the system such as bacteria, slime and algae. Hydrogen peroxide is more aggressive than chlorine in loosening residues in pipes and is not sensitive to high pH like chlorine.

Hydrogen peroxide always decomposes exothermically into water and oxygen gas.

$$2\ H_2O_2 \longrightarrow 2\ H_2O + O_2$$

10.2 Safety

- Read the manufacturer's instructions carefully.
- Hydrogen peroxide solutions are very dangerous to humans and animals.
- Avoid eye and skin contact. Wear protective clothes, gloves and glasses.
- Avoid drinking or inhalation of gases.
- Store separately from other chemicals.
- Always add hydrogen peroxide to water and not vice versa.
- Use clean water, not fertiliser enriched water during hydrogen peroxide treatment.

10.3 Flush the system

Flush the mainline and sub-main and the Dripline before chemical treatment.

10.4 Point of injection

Other than with continuous treatment, do the injection at the block valves. In the case where injection must be done at a central point, the mainline must be cleaned before any block valves are opened, if this is not done all the dirt from the mainline will move to the Dripline and worsen the existing problem.

10.5 Duration of injection

Keep on with the injection for one hour or time of travel (time it takes for a drop to travel from injection point to last dripper). Use the method that takes the longest. The higher the biological activity in the water, the longer it will take. Use hydrogen peroxide kit (paper strips) to measure concentration (ppm).

NB	**If value is higher than the ability of the measuring strip, the sample should be diluted with water. To calculate results multiply the value received by the dilution factor. See recommendation for the concentration of hydrogen peroxide at the end of the system.**

10.6 Standing time

The system must stand for 12 to 36 hours after injection so that the chemicals that have not drained out of the system can work. The lifespan of hydrogen peroxide is a few days and not as short as chlorine. Flush the system after this time.

10.7 Product

Hydrogen peroxide reduces the incidence of *Fusarium* and *Verticillium* fungi in soils and growth mediums. It reduces the growth of algae and slime in volcanic rock medium, greenhouse containers as well as irrigation systems. Hydrogen peroxide is used in water at 30 to 50 ppm in vegetable and flower crops to reduce the above mentioned pathogens. The advantages of using hydrogen peroxide are rapid reaction, environmentally friendly and do not cause dangerous residues.

Concentration	Product pH	Specific Gravity	Oxygen
H_2O_2 (35%)	< 5	1.13	16%
H_2O_2 (50%)	< 4	1.20	23%

Table 6 - Hydrogen Peroxide products

Hydrogen Peroxide is a strong oxidiser which:

- Prevents the accumulation of bacterial slime in pipes and dripperline extensions.
- Cleans the Dripline in which organic sedimentation and bacterial slime have accumulated.
- Oxidises micro elements to prevent the development and reproduction of bacteria (iron, manganese and sulphur).
- Improves the efficiency of initial filtering under high organic stress conditions.
- Disinfects irrigation water, sewage and wastewater.
- Prevents and removes odours in the water, impairing biological activity.
- Lowers BOD / COD values by oxidising the polluting substance: both organic and inorganic.
- Is not effective for the prevention or dissolution of scale sediments, sand and silt.

Hydrogen peroxide treatment options	Point of injection	Frequency	Duration (h)	Desired concentration (ppm)	
				Start of System	End of System *
Continuous	Upstream of filters	Continuous		5 - 15	1 - 2
Preventative **	Downstream of filters	2 week cycle	1	25 - 75	2 - 4
Corrective	At irrigation block	1 – 4 time per year	1	250	8 - 10
Shock treatment	At irrigation block	1 – 2 times per year	1	500	8 - 10

Table 7 - Recommended hydrogen peroxide treatments

- *The H_2O_2 concentration at the end of the system is the target. Use hydrogen peroxide strips to monitor the H_2O_2 at the end of the system and adjust the concentration at the start to achieve this target.
- ** The preventative treatment 2-week cycle comprises:
  - Week 1: Pressurise the system and inject H_2O_2 for 1 hour.
  - Week 2: Flush the Dripline.

NB

Do not apply treatments while plants are actively growing in an artificial growing medium. Never exceed 500 ppm concentration of Hydrogen Peroxide.

10.8 Step by Step – Practical guide for hydrogen peroxide treatment:

- Get the system to working pressure and flush all lines.
- Irrigate for one hour with clean water to protect roots.
- Connect the fertiliser injection pump to the block that needs to be treated.
- Turn on the injection pump with clean water and calibrate required injection rate.
- Do calculations and prepare the solution for injection.
- Inject the hydrogen peroxide to required concentration in the water.
- After treatment, flush injection equipment with clean water.
- System can stand for 12 to 36 hours.
- Flush system.

10.9 Warning

- Contact with the hydrogen peroxide preparation may cause burns.
- Contact with the eyes may cause blindness.
- Swallowing may cause death.
- All operations related to hydrogen peroxide preparation (filling the storage tank)
  - Before filling the tank with the substance, verify that it was thoroughly rinsed and clean of fertiliser. Direct contact between Hydrogen Peroxide and some of the fertilisers containing ammonia causes rapid heating and may sometimes cause the tanks to explode. This is a lethal hazard for anyone in the vicinity.
- Hydrogen peroxide is a corrosive agent for steel, aluminium, cement coating and asbestos cement.
- Tanks made of polyethylene and PVC are not sensitive to hydrogen peroxide.
- It is vital to take these factors into consideration when planning treatment.

10.10 Example: Hydrogen Peroxide Treatment

Product concentration	=	50	%
Require H_2O_2 concentration at injection	=	250	ppm
Flow rate for treated block	=	30	m^3/h
Injection rate (dosing pump)	=	100	ℓ/h
Dosing volume "D"	=	150	ℓ (container = 200 ℓ)

Formula 1

$$\text{Concentration } H_2O_2 \text{ solution} = \frac{250 \text{ ppm} \times 30 \text{ m}^3/\text{h}}{100 \text{ ℓ/h} \times 10} = 7.5 \ \% \ H_2O_2$$

Formula 2

$$\text{Litres of } H_2O_2 \text{ required} = \frac{7.5\% \times 150 \text{ ℓ of water}}{50\% \ H_2O_2} = 22.5 \text{ ℓ of } H_2O_2$$

10.11 Summary

We must add 22.5 litres hydrogen peroxide (50%) to 150 litres water. This gives us a 7.5% hydrogen peroxide solution. If we then inject this 7.5% solution at a rate of 100 ℓ/h into a system with a flow of 30 m^3/h we will get the required concentration of 250 ppm hydrogen peroxide at the injection point.

11. TWO-STEP TREATMENT

11.1 Purpose

Where normal chemical treatments do not give satisfactory results, you could try a two-step treatment. Practical experience shows good results by doing an acid treatment followed by a hydrogen peroxide treatment: not done together.

Before treatment | After one treatment | After two treatments

Figure 10 - Combination treatment – before and after

11.2 Safety

Follow all safety instructions for acid and peroxide treatments.

11.3 Step by Step Instructions

- ONLY do the two-step treatment at the block level.
- Open the block valve and pressurise the system.
- Flush sub-mainline.
- Determine the maximum number of Dripline to be open for a velocity of 0.5 m/s.
- UniRam 17 must fill a one litre container ≤ 12 seconds.
- Flush Dripline and ensure that all lines are free from any obstructions due to bending or end stop fittings.
- Use your thumb to open and close the end of the dripper lines to develop a pressure differential in the dripper to initiate the self-flushing action of the Netafim PC drippers.
- Do an ACID TREATMENT (0.6%) for ten minutes.
- Flush injection equipment with clean water for one minute.
- Do a HYDROGEN PEROXIDE TREATMENT for one hour or the duration of system flow time if it exceeds one hour.
- Standing time of 24 to 36 hours.
- Flush system.
- Wait for a week.
- Flush the system
- Repeat the steps above.

11.4 Notes:

- Never try to open blocked drippers by means of physical efforts, (folding, hitting) because this will only worsen the problem.
- Hydrogen peroxide has a lifespan of ± two days and we must use this to our advantage. It is worthless to treat the same block more than once on the same day.
- Hydrogen peroxide treatment can be started with 500 ppm for the first two treatments and then be reduced to 250 ppm if more treatments are required.
- Monitor the process by cutting drippers (at the same place in the block) and to compare it with the control drippers that were cut before the first treatment.
- Pull the remaining dripperline and join with connector. When all treatments are complete add Dripline (same as existing) at the end to fill the complete crop row with drippers.
- Monitor the flow, pressure and kW of the system.
- The condition of the system will determine the amount of treatments required to clean the system.
- Verify on site if you should stop the acid treatment after a few combination treatments by the amount of dirt flushed from the system. If the answer is yes then only do hydrogen peroxide treatments and reduce the concentration (ppm) over time.
- Always use clean water (not fertiliser enriched water) to do any chemical treatments.

NB	**Do not undertake these treatments together: first acid treatment, then hydrogen peroxide treatment.**

12. SUMMARY OF CHEMICAL TREATMENTS

12.1 Remember Safety First

Always follow all safety instructions.

WARNING: Never do a chemical treatment while plants are actively growing in an artificial growing medium or limited root zone.

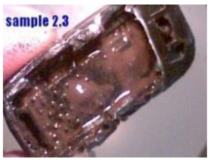
12.2 Products

From our experience we use one of the options below for treating drippers:

- Acid
  - Salt or carbonate deposits
- Hydrogen Peroxide
  - Bacteria, slime and algae
- Combination: (Acid then Hydrogen Peroxide)
  - Iron and/or Manganese bacteria

12.3 Field Test

Cut drippers from field and do an onsite test for best results. See case study below:

			
Filter	Diaphragm	Flow Path	Chamber

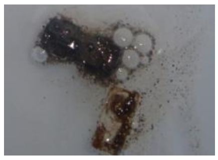
			
	Acid (HCl)	Hydrogen Peroxide (H_2O_2)	

Figure 11 - Combination treatment case study

NB	**Above example from field showed that Hydrogen Peroxide gave best reaction. Drippers were treated at 250 ppm H_2O_2 and required four treatments.**

12.4 Number of treatments

- Normally one treatment per year is required.
- If no treatments were done for seven years, it would most properly require seven treatments to restore the system to a good operating condition.

12.5 Simplified chemical treatment without calculations

Before chemical treatment pressurise the system, flush sub-mainline(s) and then the Dripline of the irrigation block(s) that must be treated. Inspect for any maintenance problems e.g. damaged fittings, start connectors or Dripline.

See Table 5 on page 14 for flushing velocity in Dripline.

12.6 Safety

Always follow safety instructions. All treatments injected at block level. Minimise chemical handling.

12.7 Step by Step

Steps	Acid Treatment	Hydrogen Peroxide Treatment	
Chemical and concentration (%)	HCl (33%)	H_2O_2 (50%)	H_2O_2 (50%)
Required concentration (start of system)	0.6%	500 ppm	250 ppm
Required concentration (end of system)	n/a	8 – 10 ppm	4 – 5 ppm
System flow rate (treated block)	30 m^3/h	30 m^3/h	30 m^3/h
Amount of chemical required	1.0 ℓ/m^3	* 1.0 ℓ/m^3	* 0.5 ℓ/m^3
	30 ℓ	30 ℓ	15 ℓ
Injection time	10 minutes	60 minutes	60 minutes
Injection factor	6	1	1
Injection rate (undiluted chemicals)	180 ℓ/h	30 ℓ/h	15 ℓ/h
Calibrate injection pump (use water)	Yes	Yes	Yes
Pre-Injection time	60 minutes	60 minutes	60 minutes
Flush injection equipment (use water)	Yes	Yes	Yes
Post-Injection time	60 minutes	No	No
Waiting period	No	12 – 36 hours	12 – 36 hours
Flush Dripline	Yes	Yes	Yes

Table 8 - Step by step

NB	***Example above. The hydrogen peroxide treatment is calculated using 50% concentration and for 60 minutes injection time.**

12.8 Two-step Treatment

Pressurise and flush system. Irrigate for one hour, inject the acid for 10 minutes, then flush injection equipment with clean water and do the hydrogen peroxide treatment for one hour. Wait for 12 – 36 hours and flush Dripline. Only do one combination treatment per week.

13. PREVENTING ROOTINTRUSION

13.1 Purpose

Prevent root intrusion into sub-surface drippers. The chemical should only be accumulated on the soil particles surrounding the drippers and not to a greater volume of soil.

Root intrusion occurs more on the permanent sub-surface drip systems where roots are growing into the buried emitters. For seasonal vegetable crops, root intrusion is commonly minimised by avoiding water stress during the growing season and at the end of the season the roots and plants are killed by acid injection.

Root intrusion is most likely to occur during times of induced water stress. Chemical treatments must be applied well in advance of induced water stress. Water stress can be:

- Planned according to the grower's discretion.
- Due to a fault or failure in the water supply.
- Due to an unexpected increase in the water consumption of the crop.

13.2 Where to inject?

Inject chemicals for this treatment only at block level.

13.3 Warning

Treatment is not recommended under the following conditions:

- When plants are very young, close to planting and seedlings.
- In all cases in which the volume of roots is very small.
- In soilless media.
- When the soil is wet above field capacity due to rain or irrigation.
- When Dripline are not evenly buried.
- Surface drip or covered under plastic.
  - Surface puddles that appear during treatment can damage the crop.
- When relevant authorities do not authorise specific chemical products.

NB	**The use of some herbicides is prohibited depending on country regulations. Please check all local regulations before use.**

13.4 Number and frequency of treatments per season (year)

The number of treatments per season should be 1 or 2, depending on the type of soil, unplanned or induced irrigation interruptions, and duration of the irrigation and the Nutrigation™ seasons.

Crop	When to apply chemical treatment
Orchards / perennial fruit trees	Up to two treatments per season, starting from the second year of age. • The first treatment should be implemented in the first third of the irrigation season. • The second treatment should be implemented when beginning reduction of water applications to the crop towards the end of the irrigation season. Young trees are vulnerable to these treatments. In the case of new plantations and plantations of up to one year of age, consult Netafim's Agronomy Division.
Open field crops (seasonal or perennial)	Treat once a year. The time for this mandatory treatment is when beginning the reduction of water applications to the crop towards the end of the irrigation season. Certain crops will require one additional treatment during the irrigation season, because previous interruptions or reductions of water volume that were carried out increase the potential for root penetration into drippers.
Lawns	4 weeks after planting seeds. 2 to 3 weeks after laying the grass carpets (instant lawn).

Table 9 - Timing of chemical treatments

13.5 Prior to treatment:

The following procedures must be performed several days before planned treatment:

- Turn on the system and wait for 20 minutes after the system has reached working pressure. Make sure that no puddles form above ground level. If there are puddles of significant size, the soil is not suitable for treatment or the soil is still too wet.
- Inspect system, including Dripline for leaks and bad connections and repair all faults before treatment.
- For the treatment of lawns and sports fields make sure that the Dripline are buried deep enough and are not located between the soil surface and the grass carpet. If not, avoid treatment.
- Verify the quantity of drippers in the block that is planned for treatment.
- Check that the injection pump and connections are in working order. Calibrate the injection pump for 20 minutes and record the quantity of water that is pumped in the 20 minutes.
- Disconnect the above ground system if it is connected to the sub-surface system.
- Test the ground moisture by hand. Do not continue with the treatment if the soil is too wet or after rain or irrigation. Prior to the treatment the plot must be partially dried by reducing normal irrigations or skipping irrigation.

NB	**Puddles that appear above ground during treatment can damage crops and lawn**

13.6 Products

Treflan, Stomp and Alligator are commercial brands of chemical products for use to prevent root intrusion. These products prevent roots from penetrating into the Dripline. The active material is Trifluraline (Treflan) and Pendimethaline (Stomp and Alligator) and different manufacturers exist in the market with a variation of names and active material percentages.

- Treflan (Trifluraline 48%)
- Alligator (Pendimethaline 40%).
- Stomp (Pendimethaline 33% or 55%)

Chemical	Concentration	Calculation	mℓ perdripper	# Drippers per 1ℓ product
Trifluraline	48%	6/48 =	0.125	8 000 drippers
Pendimethaline	40%	6/40 =	0.150	6 667 drippers
	33%	6/33 =	0.182	5 500 drippers
	55%	6/55 =	0.109	9 167 drippers

Table 10 - Number of drippers treated per 1ℓ product

If the dripper spacing is less than 0.33m, call it 0.33m. In other words, if there are more than 3 drippers per metre of dripperline, calculate as though there were only 3 drippers per metre.

13.7 Example: Product required: all soils

Dripper lines – centre to centre = 1.9 m
Dripper spacing = 0.6 m [> 0.3m, thus OK]
Drippers per linear mete = 1 ÷ 0.6 = 1.67 [< 3 drippers/m, thus OK]
Dripper lines per ha = 10 000 m² ÷ 1.9 m = 5 63 m/ha
Number of drippers per ha = 5 263 m x 1.67 drippers/m
= 8 789 drippers/ha
Area to be treated = 9.11 ha
Drippers per treatment area = 80 068 drippers/block
Product and concentration = Treflan [48%]
Product per dripper = 0.125 mℓ [6/48]
Product per treatment area = 10 008 mℓ ≈ 10 ℓ

13.8 Example: Product required: loam or clay soils

Product per block = 10 008 mℓ ≈ 10 ℓ

Minimum injection rate = 30 ℓ/h for 20 minutes [(60/20) * 10ℓ]

Product can be diluted with water to adapt for injector capacity e.g. 300 ℓ/h injection rate, add 10 ℓ product to 90 ℓ water = 100 ℓ solution, that will take 20 minutes to inject at 300 ℓ/h.

13.9 Product required: sandy soils

Sandy soils (more than 70% sand and less than 8% clay), regardless of the type of crop, it is recommended to execute the herbicide treatment, dividing the application into two injections, each of which should be half of the dose calculated for a single application.

The interval between these two injections should be two (2) weeks.

Example

Product per block	=	10 008 mℓ ≈ 10 ℓ
Product/block/application	=	10 ℓ ÷ 2 = 5 ℓ
Minimum injection rate	=	15 ℓ/h for 20 minutes [(60/20) * 5 ℓ]

Product can be diluted with water to adapt for injector capacity e.g. 300 ℓ/h injection rate, add 5 ℓ product to 95 ℓ water = 100 ℓ solution, that will take 20 minutes to inject at 300 ℓ/h.

Repeat second application after two weeks.

13.10 Stages: Step by Step Instructions

STAGE A

Chemical injection: Quantity and time as per calculation.
Inject chemicals for this treatment at block level or at central point if system is designed for central treatments.

STAGE B

Chemical distribution: travel time per graph below and design

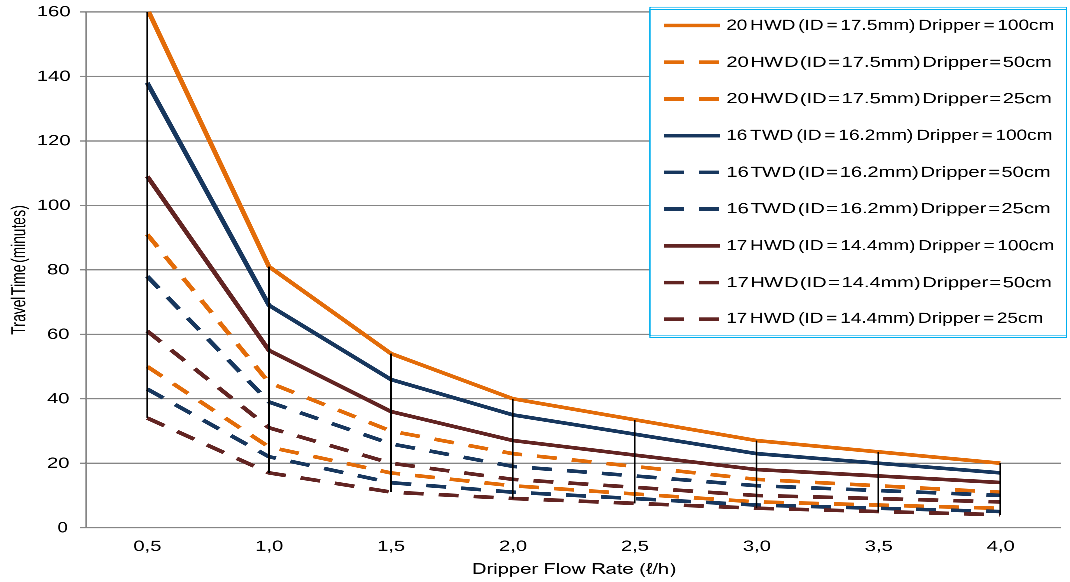


Figure 12 - Graph: Dripper Travel Time

NB	**Above graph shows the distribution (travel time in minutes) for STAGE B, calculated for 150m lateral length. For lateral length of 75m decrease travel time (-10%) and for 300m increase travel time (+10%). This data shows that dripper flow rate is the biggest influence for travel time and second will be dripper spacing, then internal diameter and last lateral length.** **The velocity is very low at the end of the Dripline and travel time can be halved if you ignore the last ± 12 drippers.**

STAGE C

Wait 24 hours after treatment before resuming regular irrigation

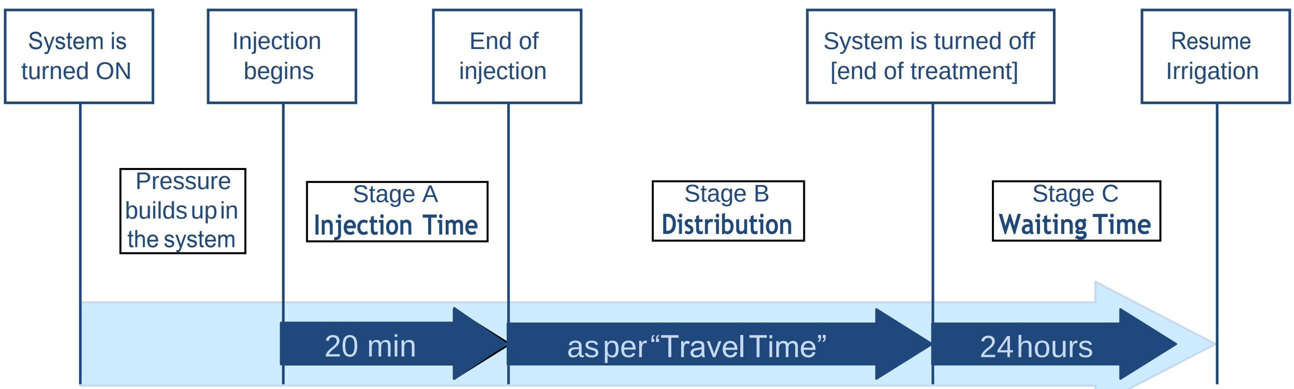


Figure 13 - Root intrusion treatment stage summary

13.11 Alternative travel time calculation

Travel time in a dripperline can be calculated as follows.

EQUATION 1. Travel time in one dripperline

$$T = 0.04656 \, x \, M \, x \, [5.253 + \log_e(L) - \log_e(M x 100)] \, x \, d^2/Q$$

T	=	Travel time (minutes)
M	=	Dripper spacing (m)
L	=	Length of dripperline (m)
d	=	Internal diameter of dripperline (mm)
Q	=	Dripper flow rate (ℓ/h)

EQUATION 2. Travel time in one dripperline less 'n' drippers at the end

$$T_1 = (0.04656 \text{ x } M \text{ x } [5.253 + \log_e(L) - \log_e(M\text{x}100)] \text{ x } d^2) - (0.04658 \text{ x } M \text{ x } [5.253 + \log_e(M \text{ x } n) - \log_e(M \text{ x } 100)] \text{ x } d^2) / Q$$

T_1	=	Travel time excluding the last 'n' drippers
n	=	Number of drippers at the end of the dripperline to be excluded

These two equations can be entered into MS Excel as follows.

	A	B	C	D	E	F	G	H	I	J
1	**Calculation - Travel time in dripperline**									
2										
3	**Data**									
4										
5	d	16	mm	Dripperline ID						
6	Q	1	ℓ/h	Dripper discharge						
7	M	0.5	m	Dripper spacing						
8	L	400	m	Dripperline length						
9										
10	**Results**									
11										
12	T	43.7	minutes	Complete time of flow		n				
13	T1	23.7	minutes	Partial time of flow excluding		15	last drippers			
14	T2	20.0	minutes	Extra time of flow through		15	last drippers			
15										
16	T	43.7	formula as follows							
17										
18	T	=0.046558*B$7*(5.253+LN(B$8)-LN(B$7*100))*B$5^2/B$6								
19										
20	T1	23.7	formula as follows							
21										
22	T1	=(0.046558*B$7*(5.253+LN(B$8)-LN(B$7*100))*B$5^2)-(0.04658*B$7*(5.253+LN(B$7*F13)-LN(B$7*100))*B$5^2)/B$6								
23										

Figure 14 - Travel time equations in MS Excel

14. METHODS IN SAMPLE COLLECTION OF DRIPPERS

14.1 General

- Purpose of sample is for routine investigation or blockage problems.
- Type of system and age of system.
- Water source.

14.2 Instructions

- Cut 30 cm pipe with the dripper in the middle.
- In case it is a large area with many blocks, choose just one block for testing.
- If the block has Dripline left and right of the sub-mainline, mark as follows:
- - mark left hand side A, B, C and D.
- - mark right hand side A, B, C and D.
- Sample collection uses the 4th and 5th bases.
- Dripline 4 and 5 from the beginning and end of the sub-mainline.
- Drippers 4 and 5 from the beginning and end of the Dripline.

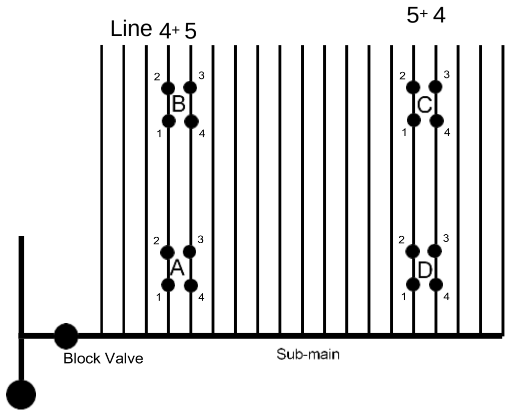


Figure 15 - Dripper sampling

14.3 Notes

- All samples must be wrapped in wet paper and put in a plastic bag.
- These guidelines are also for button drippers. Make sure that the dripper is cut out with poly pipe. Again, 30 cm with dripper in the middle.
- If you cut the drippers for samples as above then use the next set of drippers towards the inside from the cut drippers for flow and pressure test.

15. PEST CONTROL

15.1 Rodent Control

Unmanaged populations of rodents in agricultural fields can cause significant damage and loss of productivity in a wide range of crops.

A wide variety of rodents may inhabit agricultural lands, including:
• Voles • Mice • Ground squirrels • Gophers

Small rodents such as mice and voles damage young and older trees alike in nurseries and orchards by girdling the tender saplings and branches. Studies in New York have shown up to a 66% reduction in apple yields because of girdling by an overpopulation of voles.
In field crops, these small mammals love to unearth and devour newly planted seeds and snack on the young seedlings that survive.

Larger rodents such as pocket gophers damage field crops by eating the root system out from under the plant.

Rodents can also cause damage to farm equipment and infrastructure. They may gnaw on small-diameter cables and irrigation pipes.
The mounds created by larger rodents can damage or disrupt harvesting equipment, while the tunnels can cause leaks in irrigation channels and even small earthen dams.

In general, rodents responsible for most of the damage to agricultural crops and systems live underground for at least part of their lives. A physiological feature of rodents is that their teeth grow continuously. As a result, these animals must chew to wear down their teeth so that they fit in their mouth; otherwise the animal will starve. Both the feeding and the need to gnaw cause damage to crops and equipment.

There is no single, simple method for managing rodent overpopulation on agricultural lands. Control of these potential pests requires a well-designed plan that is executed on a consistent basis.

The formation of a systematic plan for managing rodents in subsurface drip irrigated fields requires research into the predominant species in the region and formulation of rules regulating how these populations may be managed. The aim of this chapter is to outline the components of a well-designed rodent control plan, and to help growers formulate such a plan.

15.2 Rodent management plan

Management of rodent populations on agricultural land generally falls into the following categories:

- Habitat modification and exclusion to reduce population pressure.
- Trapping and removal.
- Use of repellents to deter invasion.
- Use of repellents to deter gnawing.
- Extermination.

Each category is discussed with respect to protecting crops and equipment.

15.3 Habitat modification to reduce rodent pressure

Existing rodent pressures either from surrounding fields or within a newly planted field are the first source o f conflict between rodents, crop, and equipment.

A cultivated zone surrounded by unkempt ground or by open fields infested with rodents represents a continuous battle. Thus, the first step in an integrated rodent management program is to reduce the pressure of high rodent populations in the entire area.

First take a visual count of rodent presence in the surrounding fields. Large rodents such as pocket gophers will leave tell-tale mounds. Smaller animals such as mice and voles will not be as obvious. The presence of "runways" in grassy areas is one sign of small rodent activity.

Assessing the rodent population in the general area will provide an indication of the intensity of the management required to protect the crop and the irrigation system.

After assessing the situation, establish a buffer zone around the field. Elimination of weeds, ground cover and litter around the field will reduce habitat suitability. Cultivating this area is a good deterrent for small rodents as it destroys runways and may eliminate them outright.
Larger animals such as pocket gophers can burrow under this area, but the lack of food may slow them down.

If cultivation is not an option, weed control is still imperative especially for pocket gopher management. Weeds often have large tap roots which are the preferred food for gophers, while fibrous rooted grasses are less appealing. The opposite is true for smaller rodents, which enjoy the cover that grasses provide. Thus, in fields of corn, which has a fibrous root structure, the main rodent pressure may be mice and other small rodents.

15.4 Trapping and removal

Trapping can be an effective method to reduce the population of large rodents such as pocket gophers in small to medium-sized fields (< 50 acres).

Trapping is also effective to clean up remaining animals after a poison control program. In the case of smaller rodents such as mice, trapping is not usually cost effective because these animals have such rapid reproduction rates.

Body-gripping traps work exceptionally well for capturing pocket gophers.
Traps can be set in the main tunnel or in a dripperline, preferably near the freshest mound. Consult a specific pocket gopher control guide for details on how and where to set these traps.

Gophers usually visit traps within a few hours of setting, so newly placed traps should be checked twice daily. If a trap has not been visited within 48 hours, move it to a new location.

Trapping is usually most effective in the spring and fall when the gophers are actively building mounds.

15.5 Repellents

Rodent repellents can be divided into two large categories, those that affect the population at large and those that repel the rodent from gnawing on cables or small-diameter tubing such as a dripperline.

Two repellents that have proven effective in reducing rodent populations over a large area are owl boxes and wet soil.

Owl boxes are being employed in greater numbers as part of rodent management programs. The principle is simple: the higher the owl population, the fewer the rodents. The application of owl boxes to deter rodents is becoming more prevalent. This technique works especially well for small-bodied rodents such as mice but also affects larger rodents because owls prey on the young. Consult the local extermination service for the design and placement of owl boxes appropriate for the area.

Wet soil, but not flooded, can be an effective deterrent for rodents that spend much of their time in tunnels. The repellent effect of wet soil seems to be the result of poor oxygen transfer through it. Rodents that live-in tunnels depend upon the air traveling through the soil for oxygen. In wet soils, the rate of oxygen diffusion is greatly reduced and produces an environment that is inhospitable to the rodents.

Flooding the soil to drown the rodents is not as effective. The rodents are mobile enough to avoid drowning, and most have tunnels designed to avoid the wettest areas in the field in the case of heavy rains. The soil need not be saturated to affect the population. In practice, the use of soil wetness to repel rodents is limited because many crops require soil drying before harvest and because the irrigation system is turned off for a period.

Other general repellents are less effective in rodent management over a large area. Sound or ultrasound generators have not been proven effective in driving out rodents. Taste repellents such as capsicum may affect some rodents such as voles but have less effect on pocket gophers.

Targeted repellents applied on or around the object to be protected, such as a sapling, cable or dripperline, may be effective when combined with a plan to reduce overall populations.

Proper dripperline installation practices can reduce rodent damage, particularly by mice. When inserting thin-walled Dripline in deep installations, the insertion shank can leave cracks in the soil and a path down to the dripperline that mice love to follow, chewing as they go. Best installation practices dictate that these installation cracks in the soil be sealed by running a tractor tire over cracks created by the plow. This will close the opening in the soil and cut off easy access by mice or voles to the loose soil around the dripperline.

15.6 Preventive installation procedures

The following installation procedures can significantly reduce potential rodent damage to subsurface Dripline. It is highly recommended that all these procedures be followed:

- Prepare a buffer zone around the field and apply rodenticides according to a plan drawn up with the local extension agent if rodent pressures are high.
- Have the field as free of crop residue as possible. Field mice are especially fond of plant residues.
- Insert Dripline as deep as practical for the crop being grown. Dripline inserted at depths greater than 30 cm (12") exhibit less rodent damage.
- Apply a repellant or toxicant when inserting the dripperline.
- Seal the slit made by the shank by using front tractor tires to reduce ready-made paths for small rodents. The front tires should be narrow, single-ribbed, cultivating tires and the front of the tractor must be weighted.
  This operation must be completed on the same day as the dripperline insertion.
- Operate the irrigation system for 12 hours per zone within two weeks of completing the installation.Do not reach a situation where the Dripline are inserted in the fall and the first irrigation is performed in the spring.

Rodents, especially pocket gophers, are often most active in the fall and early spring. It is often at these times, when the irrigation system is not being used, that the most damage occurs. Experience has shown that rodent damage when the system is shut down can be reduced by properly applying an acid treatment. As acidification of the dripperline is standard practice for end-of-season cleaning, a slight modification of this process may also help to protect Dripline from rodent damage.

Follow these guidelines:

- Flush each zone at the recommended pressure.
- If the field is dry, pre-irrigate each zone for 6 hours.
- Inject N-pHuric* at 200 ppm for 1 hour before shutting down each zone.
  Shut down zones leaving N-pHuric in the lines.

*N-pHURIC combines the benefits of both urea and sulfuric acid while virtually eliminating the undesirable characteristics of using sulfuric acid alone.

Chemigating with a properly labeled pesticide that has a strong odor or fumigation effect will cause many rodents to keep away from subsurface Dripline.
This may be an effective technique for early season deterrence.
Make sure the pesticide is properly labeled for use in the area.

Extermination

Several rodenticides, including toxicants and anticoagulants, are in current use for managing rodent populations.

CAUTION

Consult the local authority for approved rodenticides - toxicants and anticoagulants - in the country/ area and always follow the application directions.
In general, placing approved baits around the perimeter of the field prior to irrigation system installation will reduce rodent pressures on a new field.

For pocket gophers, a mechanical "burrow builder" that releases bait is effective in perimeter applications. Hand baiting tunnels is time consuming but effective if done by a trained applicator.
The usual treatment for gophers is bait plowed in every other furrow and around the perimeter of the field. Fumigants applied in the tunnels are usually not as effective as toxicants and trapping because they tend to diffuse, giving the gopher enough time to escape.

15.7 Rodent management action plan

An integrated approach must be taken to reduce rodent damage to crops and equipment. This plan must involve reducing acceptable habitats for rodents close to the field and may involve trapping or poisoning to control active populations. In addition, the dripperline itself can be protected by using the repellent effect of some pesticides and slightly acidifying the soil around the Dripline.

Fall and spring are the seasons when rodents are most active and may cause the most damage. Therefore, any management program must focus on these seasons. Do not underestimate the wealth of reference materials and the help of local extension agents and pest control specialists. Many growers have implemented successful plans for rodent management on their fields, protecting the investment in their irrigation system and improving yields.

To be effective, any rodent control plan must be diligent and consistent in a timeframe determined by the extent of the rodent pressure in the surrounding area.

15.8 Ant control

WARNING
Always observe the pesticide manufacturer's instructions and the regulations issued by the relevant local authority.

Most pesticides are comprised of an active substance and an emulsifier. They are usually marketed in the form of powder, grains, or liquid.

Pesticides in the form of powder or grains are banned for use through drip irrigation systems because they do not dissolve efficiently in the irrigation water. Their use does not allow determination of the exact concentration of active substance in the solution, and in addition, the active substance may damage the drippers' diaphragm and even clog the drippers.

Ant treatment products are to be applied externally, by scattering or spattering them on the ground and ants' nests.

These products are to be applied in the concentration indicated by the manufacturer (Machteshim, Luxemburg, Bayer, Syngenta, etc.).
There are several products and active substances that can be used for ant treatment:

Disictol, Diazinon, Chlorpiryfos, Fipronil, Clap (pyperonyl butoxide), Pirinex, Basudin, Ecogan, Imidacloprid 35% (against termites), etc.

If products in emulsion liquid form, such as the Dorsan - Chlorpiryfos 48% and Clap, are to be used through a drip irrigation system, the product must be injected at a maximum concentration of 0.1% to prevent damage to PC dripper diaphragms and other accessories of the system.

The manner of application and the product quantity will be as recommended by the manufacturer, but the mother-solution should be applied as to allow a concentration of no more than 0.1% of the active substance in the irrigation water.

It is necessary to continue irrigating with plain irrigation water for the time necessary to flush the entire quantity of the injected product out of the irrigation system and ensure its total transfer to the soil (this depends on the system size) (see Advancement time, page 49).

In CNL systems, open the end of the Dripline while flushing the system.

16. MAINTENANCE SCHEDULE – GENERAL

MONITOR	EACH CYCLE	WEEKLY	MONTHLY	QUARTERLY	YEARLY *
Check the system for leaks		•			
Monitor system flow (flow meter)		•			
Monitor pressure differential over the filters		•			
Set backwash cycle of filters (if no pressure differential meter)		•			
Monitor all hydraulic and electrical connections of valves			•		
Open filters for inspection				•	
Service air valves, block valves and pressure control valves					•
Service pump and motor					•
Service fertilizer injector pump					•
Flush fertilizer system with water	•				
Flush mainline			•		
Flush sub-mainline (water quality) **			•		
Flush laterals (water quality) **			•		
Monitor working pressure at end point			•		
Take water sample of system and analyse for change in water quality				•	
Acid treatment	See "Drip - NSA Maintenance Guide"				
Hydrogen peroxide treatment					
Treatment for root intrusion					

Table 11 – Maintenance schedule - General

* At the end of the irrigation season, the system must be clean and drained when it is not in use. In cash crops the systems must be treated after each harvest, if the Dripline are removed prior to harvest, they can be treated before the planting of the next crop, if this is done within two months.

** With poor quality water, the laterals must be rinsed weekly.

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