Abstract

There are many external influences that are forcing the agricultural industry to investigate and change to more advanced technology. There is a need to implement more efficient management strategies, and yet, at the same time to keep on striving to survive in a highly competitive marketing environment. The use of subsurface drip irrigation systems brings more opportunities to irrigate more efficiently and the possibility to automate the irrigation process. The fact that the whole irrigation scheme is underground opens up new possibilities to total mechanization of the production process. There are a couple of differences between the design of a surface and a subsurface drip system. The subsurface system allows the use of sewerage water for irrigation purposes. This paper will be dealing with issues such as different crops, design requirements, scheduling, fertigation and maintenance of the subsurface drip system.

Introduction

Many places in the world there are people that have been using sub-surface drip irrigation (SSD) for as long as 15-20 years now. The first successful SDI system in Hawaii was installed in March 1970. In South Africa, Swaziland and Zimbabwe there are sub-surface systems that have been running for 9-10 years. Subsurface drip systems are installed to last between 5-10 years. The normal cultivation practices for this period are done as usual, while the drip system is still underground.

Some of the biggest motivational factors that are forcing changes in the industry are availability and affordability of irrigation water and labour related problems. Under the current economical climate the battle for survival is becoming more and more intense every day. The need to use every drop of available water becomes a fine art. Water is the most limiting factor in South Africa and we’re heading for a water shortage in the near future. Local experts and experts from abroad claim that irrigation efficiency can be increased by about 30% (Koegelenberg). Normally this results in an increase in yield and quality of produce. The increasing cost of fertilizer is also forcing farmers to change to more efficient ways in feeding the crop to produce maximum yield and the best quality.

There is a tendency to mechanize as far as possible, as the pressure is increasing from the labour side. This is possible with an irrigation system that can be installed underground. It is easier to automate the whole operation on the irrigation scheduling.

Subsurface drip irrigation systems open up a possibility to use sewerage water to irrigate parks, sport fields, golf courses and gardens. This the only accepted way to use sewerage water without a health risk for irrigation. Crops can be irrigated successfully by using water quality too bad for furrow or overhead irrigation systems. This possible by keeping the salt outside the active root zone. Effluent water from mills and factories can be dealt with in this way too.

Crops

There are three different positions of placing the subsurface drip irrigation system.

- Shallow - 0.5- 10cm deep
- Medium – 10- 25cm deep
- Deep – deeper than 25 cm

The most important crop under subsurface drip irrigation is sugar cane with an approximate amount of 8900ha in Southern Africa alone. Other crops that are cultivated successfully under SSD systems are Strawberries, peppers, chillies, lettuce, broccoli, beans, peanuts, onions, tomato’s, water melons, cotton, maize, sorghum, coffee, vine yards, tea trees, grazing, lucern, nuts, hobs and hohova.

When irrigating with saline water, it is advisable to place the dripper lines shallower. This will prevent built-up of salts in the active root zone.
Surface vs. Subsurface drip irrigation

Normally a thinner wall thickness (0.15 - 0.6mm) dripper lines are used in SSD than on surface drip irrigation (0.6 – 1.2mm) system.

Advantages of SSD above a surface drip system:
- More efficient water consumption.
- Longer life span of the system.
- Bigger wetted volume of soil in root zone.
- Soil surface remains dry – less weed control.
- Shorter time between two crop cycles.
- Mechanical harvesting is easier.
- Better water infiltration – no surface crust to prevent infiltration.
- Sewerage water can be used for irrigation.
- Labour savings in the coiling and rolling out of the dripper lines.
- Efficient irrigation of awkwardly shaped and problematically sited lawns and landscape areas.

Disadvantages of SSD systems:
- No deep ploughing for pest control.
- Damage to SSD systems under wet soil moisture conditions during harvesting processes.
- Crop cultivation is restricted to specific row spacing.
- Limited information about implements and cultivation practices.
- Thin wall products are subject to rodent and insect damages.
- Danger of potential root intrusion into the drippers.
- Danger of mud sucked into the drippers.
- Salinity accumulation on the top of soil.
- Improper maintenance – will result in clogging build-up.
- “Back Pressure”
- Roots “choking” the laterals.

Soil preparation

Subsurface drip irrigation is usually buried for a period of 10 years and more. Therefore it is very important to do proper soil preparation beforehand. Do thorough ripping, ploughing and the necessary fertilizer applications in the initial stages of the soil preparations. If proper soil preparation is done, there should be no difficulty to insert the laterals in the soil. It will also help to install the laterals at a uniform depth.
Avoid installing during the high rainfall period when the soil is too wet.

Design requirements

A typical SSD system lay-out can be find in Figure 1 in the appendix. The design requirements for a SSD are the same as a SDI system. The only difference is that the laterals are installed at a certain depth under the soil and more strategically placed anti-vacuum valves are necessary within the system. The system can be designed with or without a collection manifold to flush the system. A SSD system should be designed to have a discharge uniformity (EU) of 85%.
Practically a SSD system requires more attention on the maintenance and more frequent flushing than a surface drip system.

Drippers – type and spacing
- Dripper types. The selection of drippers is of crucial importance. It makes no sense to select drippers designed only for one or two of seasons to be installed in SSD systems and expect it to be functional for 5-10 years. Drippers with turbulent flow paths are much more resistant to
clogging than drippers with a laminar flow path. The wider, deeper and shorter the flow path in the dripper, the less the chances of clogging. Pressure compensating drippers and lower discharge rates of drippers; allow longer runs of laterals, while staying within the design norms. The danger of high discharge rate drippers is the possibility of deep percolation and water passing the root zone. There are claims being made those drippers with a split or flap opening, provide more resistance against root intrusion into the drippers. It is recommended to use drippers where the filter/intake of the dripper itself, is located in the area of cleaner water – away from the sidewall of the lateral. Claims are made that drippers with a flap or split opening are prone to lesser suck-back for sand and mud into a SSD system.

- Dripper spacing. It is advisable to lay out dripper test lines to determine the lateral water movement in the soil. According to Jorgenson et al is the wetted soil volume with the same dripper bigger subsurface than on surface. This implicates that there is more water available per total volume of soil, than with the surface dripper. This research case showed that the wetted radius of the subsurface drip was only 80%, compared to the surface drip. In other words, the results of a surface drip test line should be multiplied by 80% to ensure a total wetted strip.

Wall thickness of laterals

Under normal circumstances thin wall dripper lines (0.1-0.6mm) are installed subsurface. This is possible because the dripper lines are protected underground. This reduces the cost of the dripper lines. According to Koeglenberg it is possible that deeper installation of drippers (> 200mm) can cause a reduction of 10-20% in the flow. This is the result of the soil pressure on top of the drippers. This might be possible where very thin wall thickness (0.1-0.2mm) products are being used at operating pressures of 0.5 – 0.8 Bar.

However our experience has showed us that a wall thickness < 0.3mm is very susceptible to insect damage.

Pumps

The pump must be able to supply sufficient water at all times to prevent formation of a vacuum, even during flushing of laterals and collecting pipes. A SSD system designed with a collection manifold requires an increased flow of 10 – 20% during the flushing operation. Check if back flushing pressure requirements of your filter can be achieved with the pump. Back flushing requirements for filters are (Hewson):

- Spin Klin disc filters 35 m (50 psi)
- Gravel 15-20 m (20-25 psi)
- Screen 20-25 m (26-30 psi)

Places where water contains a very high silt load, is it advisable to construct settling dams to allow the silt to settle out of the water.

Filters

The filter system is the heart of any drip irrigation system. Proper design should be done when designing a filter system. Water quality and dripper type should be considered when designing a filter system. All the design criteria for surface drip are applicable for SSD systems. Disc or gravel filter systems can be used.

It is important to get expert advice when you’re dealing with high Iron, bicarbonate or poor water quality.

Fertigation units

Fertigation and drip irrigation cannot be separated. To utilize the SSD system to the fullest is it essential to design and install a properly designed fertigation unit.
Injection units can operate on the suction side of the pumps, centrifugal pumps, positive replacements pumps, pressure differences and proportional dividing injection units. Fertigation can be injected before or after the filter system. If the injection point is after the filter system, an additional filter should be installed between the fertigation unit and the injection point.

Fertigation can be done on a central point or at different injection points or at blocks. Use only liquid or water-soluble fertilizers of high quality. Consult with the fertilizer agronomists regarding products that can be used for fertigation.

**Flow meters**

Flow meters are essential in monitoring the performance of a drip system. It is even more important for a SSD system, because you cannot see the emitters. It is advisable to log down the flow and the time to get that specific flow per block. This will indicate quite early if there is a problem developing in the system.

**Pressure regulating valves**

The dripper lines cannot withstand very high pressure (0.5-4.0 Bar), depending on the product to be used. It is important to use pressure regulators that are reliable. It is essential to set the pressure at the recommended pressure for that specific product. The pressure should be adjustable/or be able to override the regulation, to increase the pressure during the flushing of the laterals operation.

**Air valves/Anti vacuum valves**

The biggest danger on a SSD is the suck-back of mud into a system after an irrigation cycle. The water drains to the lowest point in the entire system, causing a vacuum that sucks the mud into the system. A slope of only 0.5% is enough to create a suck-back problem. Install a vacuum breaker on the highest point in the system. Ensure they are correctly sized for the pipe diameter they're relieving. There should be an anti-vacuum valve on the supply line and the flushing manifold.

**Flushing manifolds**

Proper flushing is important to ensure that the systems don't clog. The flushing can be done on individual laterals or combined into a flushing manifold. On big systems the flushing end of the laterals can be connected together in a flushing manifold. The design of a flushing manifold is difficult and complicated. The friction loss and flow are not a linear function. It is recommended to use a reliable computerized design program to design the flushing manifolds. The lateral length and design pressure should also be correct to ensure proper flushing of the laterals. The design of the flushing manifold depends on the minimum flow velocity of the laterals. The following flushing velocities are recommended in Table 1 according to Koeglenberg.

<table>
<thead>
<tr>
<th>Nominal pipe diameter (mm)</th>
<th>Design flushing velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>0.35</td>
</tr>
<tr>
<td>22</td>
<td>0.4</td>
</tr>
<tr>
<td>35</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Provision of an extra 2 m pressure should be made to compensate for the friction loss through the flushing valve. The flushing valve should be the same diameter of the flushing collection pipe. The collection pipe should be one diameter size larger than all the combined flow from the laterals connected to it.

**Installation recommendations**
There are two options of installation of a SSD system. The first is before seeding or planting (recommended option), and the other is after germination or alongside existing growth. The difference between the first and second option is that you need a sharp disc wheel to cut through the roots during the installation process. It is also then impossible to install the lateral directly underneath the plant row if it is already established.

The crop, seedbed preparations, other traffic, cultivation practices, rooting depth and germination would determine the depth of installation. On potatoes the depth of installation is about 25mm deep. In sugar cane the depth of installation is 100-300 mm deep. For row crops such as cotton and maize the installation depth is 300-400 mm deep. Normally where a crop rotation is followed and seedbed preparation is needed the depth of the laterals should be at least 300 mm deep.

Under saline soil and water conditions the installation depth should be a bit shallower to keep salts out of the root zone.

Pay attention to the following aspects during the installation process:

- The drippers should be facing up. This ensures that the silt in the system would settle at the bottom of the lateral and would not have any influence on the dripper itself.
- Adjust the speed of the injection to the field condition.
- Lay the laterals according to instructions to prevent sand and silt penetration during installation.
- Use the depth wheel on the injection feeder to control and maintain the depth of injection rather than the load control of the tractor.
- Make sure that the dripper pipe doesn’t twist around during the installation process.
- Use the Netafim connectors to connect the laterals.

The dimensions for the installation machines are shown in figures 4, 5, 6 in the appendix.

**Installation procedures**

It is important to complete a thorough seedbed preparation before marking out the area. There should be no clots or stones and a relatively flat, smooth seedbed present.

- Mark out the field and the positions of the main and sub main lines and laterals. Place markers about 50 m apart on the lateral position. These markers would help to install the laterals correctly.
- Insert the dripper laterals into the marked seedbed. Extend the injection point past the proposed sub-mains and collection manifolds to ensure a uniform insertion depth.
- Make sure the main line has practical isolation points installed.
- Use a trenched to dig the trenches for the sub mains and collector pipes. The width of the trenches should be 100-300 mm wider than the pipes for more convenient installation.
- The trenches should be deeper than the laterals. Clean out the trenches and make sure there are no rocks present. The floor of the trench should be flat to avoid damaging pressure to the PVC pipes. The trench floor should be hard to prevent the pipe from sinking down due to the pressure of the trench filling up and the weight of the water, pulling out the start connectors from the distribution line.
- Install and connect the sub main lines and drill the holes in the PVC for the start connectors. Before drilling the holes, test the drill on a different piece of pipe before hand and recheck the drill bit several times throughout the day, since it may need some readjustment or cleaning. Use the recommended size drill bit to drill the holes. The holes should be clean, precisely round with no burns. Cover the trenches with finely crumbled soil up to the height of the PVC pipe before filling the trenches mechanically. The soil will protect the PVC pipes from rocks or hard soil clots damaging the pipes.
- See figures 2 (PVC) and 3 (PE) in the appendix for the connection instructions.
- Install the start connector and connect a piece of blanco pipe onto the start connector. The end openings of the blanco risers can now are closed and the sub main be flushed thoroughly. Inspect for any leaks that may occur and fix it. Cover the trenches again. Place the blanco riser pipe inside a metal or hard PVC pipe during the filling process. This prevents the riser pipe to be pinched or closed by stones or hard soil clots. The alternative is to check the whole system for leaks after the laterals are connected. Close the trenches while the system is operating. This will also prevent the risers to collapse during the covering process.
Start-up of the system

- For the system start-up, fill the system gradually, one sub-main at a time. Open the ends of the mains and sub-mains and flush thoroughly before connecting the laterals.
- Connect the laterals with the far end of the laterals open. Flush before connecting the connector pipe or the flushing valves.
- Check, clean and back flush the filter. If you’re using media filters back flush those filters as well to get rid of the dust in the sand.
- If you are using an automatic back flushing system, make sure there is enough pressure and the duration of the flushing is sufficient to clean the filters thoroughly.
- Initial back flushing should be done manually before running the system on automatically.
- Check the pressure at the reducing valves and adjust it to suit your laterals recommended working pressure.
- Once the system is in full operation, check all pressures and flow rates, paying attention to the farthest points in the system. Make sure operating specifications are met.
- Set the controllers, fertigation pumps and test their operation.

DRIP IRRIGATION SYSTEM MAINTENANCE.

Experience has shown that about 80% of dripper plugging is caused by either micro biological or chemical reactions. Injecting chlorine into the system can solve it. Except where there is more than 1ppm iron or manganese present in the irrigation water. If there are more than 1ppm Iron or manganese present in the water, consult an expert on water treatment.

Prior to and after injection, the system should be thoroughly flushed. It is recommended that the irrigated area be divided into small plots and each plot treated individually.

CHLORINATION

The aim of chlorination is to treat plugging problems caused by organic sedimentation like bacteria, slimes and algae.

Table 1. Recommendations on Chlorination.

<table>
<thead>
<tr>
<th>Chlorination objective</th>
<th>Application method</th>
<th>System head</th>
<th>System end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventing sedimentation</td>
<td>Continuous chlorination</td>
<td>3.0 - 5.0</td>
<td>&gt; 1.0</td>
</tr>
<tr>
<td></td>
<td>Intermittent chlorination</td>
<td>10.0</td>
<td>&gt; 3.0</td>
</tr>
<tr>
<td>System cleaning</td>
<td>Continuous chlorination</td>
<td>5.0 - 10.0</td>
<td>&gt; 3.0</td>
</tr>
<tr>
<td></td>
<td>Intermittent chlorination</td>
<td>15.0</td>
<td>&gt; 5.0</td>
</tr>
</tbody>
</table>

When the chlorination is aimed at improving the filtration performance (sand filters) it is recommended to inject it close to the filtration plant, to ensure even distribution among the filters. Chlorine concentration after the filter battery should be no less than 1 - 2ppm in continuous chlorination and 3* more in intermittent chlorination.

When using HTH dry granular (Swimming pool chlorine)
It is a granular dry product with a concentration of 75%.

Preparing a solution with HTH.

Use a CLEAN fertiliser tank or a plastic drum to prepare a +/- 10% solution.

Concentration of HTH solution = HTH (kg) * concentration of HTH (%) / Amount of water (L)

Example: 3kg HTH * 75% 
          20 L water
When using liquid chlorine solution, use the following formula:

\[
\text{Chem. solution injection rate (L/h)} = \frac{\text{desired ppm of chlorine} \times \text{System Flow (m}^3/\text{h)}}{\% \text{ Cl of solution} \times 10}
\]

**Example:**

\[
\text{Require 10 ppm chlorine} \times 50 \text{m}^3/\text{h}
\]

\[
11.25% \times 10
\]

\[
= \text{4.4 L solution /h}
\]

If you do have a fixed injection rate from your injection pump, you can use the following calculations.

**Determine the % of solution for a fixed injection rate from the dosage pump**

\[
\text{Concentration of HTH solution (x%) = } \frac{\text{Required Cl- (ppm)} \times \text{System flow (m}^3/\text{h)}}{\text{Dosage rate of pump (L/h)} \times 10}
\]

**Determine the amount of HTH required for a given container:**

\[
\text{Concentration of HTH solution (x%) } \times \text{ capacity of container (lt)}
\]

\[
\frac{\text{kg HTH required}}{\% \text{ Cl- in HTH}}
\]

**EXAMPLE:**

- Require 10 ppm Cl- for injection
- System flow is 30 m$^3$/h
- Injection pump dosage rate is 100 Lt/h
- Container tank is 500 Lt

\[
\text{Concentration of HTH solution (x%)} = \frac{\text{Required 10 ppm Cl-} \times 30 \text{m}^3/\text{h}}{100 \text{Lt/h dosage rate}}
\]

\[
= 0.3% 
\]

\[
\text{kg HTH required} = \frac{0.3% \times 500 \text{Lt of container}}{75(\% \text{Cl-)} \text{ in HTH}}
\]

\[
= 2 \text{ kg}
\]

To summarize the above calculations: We need to dissolve 2kg HTH in the 500Lt water. That will give us a 0.3% Cl- solution. If we inject at a fixed rate (100Lt/h) of the injection pump of a 0.3% Cl- solution we will get a Cl- concentration at injection point of 10 ppm of Cl-.

When using chlorine gas, use the following formula:

\[
\text{Chlorine gas inj. rate} = \text{desired ppm of free chlorine} \times \text{System Flow (m}^3/\text{h)}
\]

**Length of injection**

Keep on injecting the chlorine solution until 1-3ppm of FREE chlorine can be measured at the furthest dripper. The higher the microbiological activities in the system, the longer the time of injection will be.

**Notes of caution for chlorine injection include:**

- **Active chlorine solutions are dangerous to human beings and animals. Follow manufacturer’s instructions very carefully. Avoid contact with eye or skin, avoid swallowing the solution or inhaling the vapours.**
- **Direct contact between chlorine and fertiliser might create a thermo-reaction that can be explosive. This can be extremely dangerous.**
• Water acidification and chlorine injection should be done at two different injection ports; mixing acid and chlorine liquid in the same tank will produce highly toxic chlorine gas. **Never store acids and chlorine together.**
• Chlorine injection combined with herbicides or pesticides may reduce the effectiveness of these herbicides or pesticides because the chlorine attacks the organic composition of these chemicals.
• **Always add chlorine supplies (liquid or dry) to water,** not vice versa.

**ACIDS**

Purpose of treatment is redissolving of scale deposits (carbonates, hydroxides, phosphates etc.) in the drip system. Treatment is not effective in cases of organic sediments. As noted above, acid treatments enhance the effectiveness of chlorine. In many cases acids by themselves are sufficient to eliminate small slimy bacteria. Typical acids are:
• Sulphuric acid
• Phosphoric acid
• Urea-sulphuric - nitrogen fertilizer that provide both acid and fertilizer
• Citric acid
• Hydrochloric acid

Table 2. Recommended concentration of acid for water treatment.

<table>
<thead>
<tr>
<th>Recommended concentration of a specific acid in treated water</th>
<th>Type of acid</th>
<th>Marketed % of each acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6 %</td>
<td>Hydrochloric acid (HCl)</td>
<td>33 - 35%</td>
</tr>
<tr>
<td>0.6 %</td>
<td>Sulphuric acid (H₂SO₄)</td>
<td>65%</td>
</tr>
<tr>
<td>0.6%</td>
<td>Nitric acid (HNO₃)</td>
<td>60%</td>
</tr>
<tr>
<td>0.6%</td>
<td>Phosphoric acid (H₃PO₄)</td>
<td>85%</td>
</tr>
</tbody>
</table>

If your acid has a different percentage you should correct the recommended concentration of your specific acid in the treated water.

Example : Your acid is Sulphuric acid 98%

The correction is 65/98 * 0.6 = 0.4%

In other words your Sulphuric acid 98% in the water should be a 0.4% concentration.

The acid treatment will acidify the water to an approximate pH of 2-3. Therefore this treatment should be done without watering the cultivated crop, especially when using artificial medium. Use non-fertigated water. Treatment time should be 10 - 12 minutes. **After termination of acid injection, irrigation should be continued for an extra hour.**

**Practical acid treatment - Step by step**
1. Connect your fertilizer injector to the block that is being treated, and pressurize the system.
2. Start your fertilizer injector on full injection capacity (with **clean water**) and check the injected volume of water in exactly 10 minutes. We will refer to it as the “injected volume”. Fill the container with water and check your calibration (If calibrated correctly the exact amount of water should be injected into the system in 10 minutes and the acid concentration in the water will be 0.6%.
3. After the acid has been injected, inject clean water to clean the injector of any acid residue.
4. **Continue to irrigate for a further hour after termination of the acid injection.**

**Determine the amount of acid needed for a 0.6% concentration for a treatment time of 10 minutes?**

Example:

The treated system flow is 20 m³/H
Fertilizer injector discharge is 180 litres/H
Treatment time is **10 minutes**, at a **0.6% acid concentration.**
- System flow for 10 minutes = 20 000l/h * 10/60minutes = 3333.3 Lt
- Determine amount of acid for a 0.6% concentration: 3333.3 * 0.6/100 = 20Lt
- Determine the injection rate for 10 minutes: 180Lt/h * 10/60minutes = 30Lt
- Amount of water needed to add to the acid for required injection rate: 30Lt - 20Lt of acid = 10Lt of water to mix with the acid.

To summarize the calculations:
- "injected volume" is 30 litres
- block flow rate is 3.33m³/10 minutes
- require 20 litres of acid to get a 0.6% concentration.
- add 10 litres of water in an acid proof container and mix the 20 litres of acid with extreme caution into the water while mixing the water and acid well. Inject the solution into the irrigation system.

Acids are very corrosive to steel, cement and aluminium. Polyethylene and PVC are tolerant. Low pH solutions can damage irrigation system hardware. In general, corrosion accelerates rapidly as the pH drops below 5.5. The ideal pH is between 5.8 - 6.2. Above pH 6.5, Ca and P would react and precipitate. There can also be localized corrosion around the injection point in a pipeline system if the acid is not located properly. Injection points should protrude into the centre of the pipeline to assure adequate mixing of acids with the water.

The amount of acid required to drop the pH can only be determined through tests of water samples. A titration curve is unique for each water source and type of acid. Titration tests should be run occasionally due to the fluctuation in water quality during the seasons.

CAUTION Always add acid to water. Do not add water to acid. All acids can be dangerous to handle, and appropriate eye protection and clothing should be worn.

ROOT INTRUSION

This problem occurs more on the permanent subsurface drip systems where roots growing into the buried emitters. For annual crops such as lettuce, 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.

For some trees and vines, an active program of chemigation with TRIFLURALIN 5 (TREFLAN) is the only way of control. This herbicide only kills the root tips of the plants without killing the plants, themselves. Some emitters have the chemical TREFLAN impregnated into them.

Purpose of treatment
To prevent root intrusion into subsurface drippers. The chemical should be accumulated only on the soil particles surrounding the drippers.

Tests and checks before treatment
The following tests should be carried out several days before the treatment.
1. Turn on the system and wait for 15 minutes. Check if puddles were created on the soil surface. If the puddle is of substantial size, the soil is not suitable for Treflan treatment.
2. Check leaks, bad connections and every part of the irrigation system and repair where necessary.
3. For the treatment of Lawns, ensure that the dripper lines are buried and not lying between the grass and the ground. If not avoid Treflan treatment.
4. Verify the amount of drippers in the treated block.
5. Make sure that the injection pump and relevant connectors are in working condition. Calibrate the injection pump to 10 minutes and write down the amount of water pumped in this 10 minutes period.
6. If the treated system is connected to a surface system, disconnect the surface system.
7. Check the soil moisture by hand, avoid treatment where soil is too wet after a rain or irrigation. Wait for a reasonable dryness of the soil.

REMEMBER: Puddles on the soil surface during treatment might cause damage, especially lawn and field crops.
Table 3 indicates the number of treatments necessary to be done in a year. The number of treatments per year is a function between crop, climate and soil type.

Table 3. Number of treatments per year.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Effective irrigation period *</th>
<th>Med. - Heavy Soil</th>
<th>Light Soil **</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Crops</td>
<td>&lt; 2 months</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&lt; 4 months</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&lt; 8 months</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Over the year</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Notes:
* Effective irrigation is where the plot is continually irrigated. Example: Cotton is seeded in October, the irrigation starts from the beginning of December up to the end of February. In this case the “Effective irrigation Period” is 3 months.
** Light soils defined here are soils with about 70% of sand and above 8% clay.

When to start the First Treatment?
Perennial crops: 3 weeks after the beginning of irrigation period.
Seasonal crops: 3 weeks after regular irrigation, it does not contain germination and encourage irrigation.
Grass/Lawns: 4 weeks after planting.

Treflan quantity per treatment: 0.125g Treflan product/dripper
Example: In treated plot are 8000 drippers
8000 * 0.125g = 1000g for plot

The Treatment
• The treatment is divided into two stages:
  Stage 1- is “Treflan injection” of 5 - 15 minutes
  Stage 2- is the “Treflan distribution in the system”.
• The first stage (Treflan injection) should be short, 5-15 minutes maximum.
• The second stage varied according to the dripper flow, dripper spacing and lateral length.
• The second stage starts after injection has been terminated, and ended in a known time.
• At the end of this stage turn off the system and wait 24 hours for next irrigation.

Injection - Technical points
• The present fertilizer pump is usually suitable.
• Before turning the system on, check the pump and the connectors.
• Fill a clean water tank to the volume equal to 5-15 minutes of pumping time and mix the calculated quantity of Treflan into it.
• Only after every thing is ready, turn on the system.
Remember, injection time should be short, there for you should be fully organized and do not waste time.
### Table 4. Treflan treatment Table (minutes)
The following table represents “distributing time” (Stage 2) only

<table>
<thead>
<tr>
<th></th>
<th>Lateral length: Distributing time:</th>
<th>200 - 400 m Distributing time:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RAM</strong></td>
<td>&lt; 200 m 30 min</td>
<td>200 - 400 m 40 min</td>
</tr>
<tr>
<td><strong>TYPHOOON</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dripper spacing: Distributing time:</td>
<td>0.3 m 45 min</td>
<td>0.6 m 50 min</td>
</tr>
<tr>
<td><strong>PYTHON</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral length: Distributing time:</td>
<td>&lt; 300 m 45 min</td>
<td>300 - 400 m 55 min</td>
</tr>
<tr>
<td><strong>OZ LINE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral length: Distributing time:</td>
<td>&lt; 300 m 45 min</td>
<td>300 - 400 m 80 min</td>
</tr>
</tbody>
</table>

### FERTILIZER: DO’S & DON’TS

Injected fertilizers into the system can also contribute to clogging. Field surveys indicate considerable variation in fertilizer solubility in different water sources. For example sulphide-laden waters can react with dissolved iron and manganese to form a precipitation in the water. This reaction can also occur with phosphorous and calcium and magnesium.

It should be noted that compatibility problems may occur only when liquid fertilizers are combined. When preparing fertilizer solutions from various ingredient sources, one must consider the following:
1. The safety involved in making the solutions.
2. Fertilizer solubility and purity must be considered when using solid fertilizers to prepare fertilizer solutions.
3. The effects of the liquid fertilizer solution upon one another when added to the same tank.
4. The reactions of the liquid fertilizers in the irrigation system and the irrigation water.
5. Certain solid fertilizers will cool the water, or fertilizer solution when added to the solution, this will retard or delay their solubility.
6. Special consideration must be given to the product used and irrigation water quality when injecting phosphorus materials.
7. The type of irrigation system and its susceptibility to plugging or other problems.

Most dry solid fertilizers are manufactured by coating them with a special conditioner to keep the moisture from being absorbed by the fertilizer pellets. The most common conditioners applied to commercial fertilizers are: attapulgite clay, diatomaceous earth and hydrated silica. Normally these conditioners settle at the bottom of the mixing tank, while making a solution. Care must be taken to draw the clear fertilizer solution without disturbing the sediment that settled at the bottom of the tank. This sediment can pose a serious plugging hazard when injected into an irrigation system.

*If there are any questions about the safety of making a mix or compatibilities of the ingredients/or fertilizers, it would be advisable to consult a fertilizer expert or advisor for advice. A good rule of thumb is: WHEN IN DOUBT, LEAVE IT OUT!*

A simple test (THE JAR TEST) can be done to determine the compatibility of different fertilizer’s in a specific water source:
1. Add sufficient drops of liquid fertilizer to a sample of the water source so that the final concentration of the diluted fertilizer mixture that would be flowing through the irrigation system.
2. Cover and hold the mixture in the dark for 12 hours.
3. Determine whether any precipitate is formed in the bottle, by directing a light beam at the bottom of the glass container. If there is no apparent precipitation, the fertilizer should be safe to use in that specific water.
Incompatible fertilizers:

- Phosphoric acid/Ammonium phosphate & Aqua Ammonia
- Urea ammonia
- Calcium nitrate
- Iron containing fertilizers
- Calcium ammonium nitrate
- Magnesium containing fertilizers

Sulphate containing fertilizers & Calcium or Magnesium containing fertilizers can also be a great risk under certain circumstances.

References

9. Mare’. P.I. Netafim SA. Personal information