

Subsurface Drip Irrigation (SDI)



Getting Started with Subsurface Drip Irrigation

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As the name suggests, subsurface drip irrigation, or SDI for short, is drip irrigation applied underground.

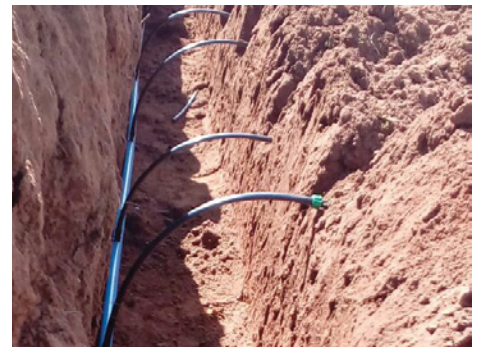
There are two forms of SDI: Shallow and Deep.

Shallow Burial: Refers to the burial of the drip line/tape a few centimeters below the surface. This allows growers to achieve many of the benefits of subsurface irrigation while preventing the thin tube from being blown by the wind. The drip line/tape is intended to be removed and disposed of after the season. Each season, new drip line/tape is installed so growers use the thinnest drip line/tape possible for the environmental conditions to reduce costs. Often the drip line/tape is installed under plastic mulch and installed at the same time as the mulch. This SDI method is often used with single season vegetables, strawberries, and melons.



Shallow Burial SDI

Deep Burial: Refers to the burial of the drip line/tape at least 10 cm (4") below the surface. The goal of deep burial is multi-season use with the same drip line/tape being used from a few years to over 20 years. The burial is generally 10 – 30 cm (4 – 12") with thicker drip line/tape (minimum 12 mil and up to 45 mil) used to ensure that the product will properly function for many years. Additionally, pressure compensated (PC) drip lines may be used to achieve extra-long run lengths, or to irrigate on sloping ground. This SDI method has a wide range of crop applications including cane, corn, cotton, vineyards, tomatoes, orchards and alfalfa. Additionally, deep burial can provide an excellent solution for crop rotation.



Deep Burial SDI

Many of the benefits of SDI apply to both shallow and deep burial; however, the focus of this brochure is deep burial applications due to the unique requirements when designing a multi-year irrigation system.

Irrigate up to, and beyond 10 years...

Rivulis has a rich history as pioneers of micro irrigation technology. Our Rivulis SDI projects continue to perform decades after original installation:

- Cotton, Phoenix, USA – 17 years
- Asparagus, Germany – 12 years
- Sugarcane, Australia – 21 years
- Vineyards, Australia – 17 years
- Sugarcane, Mexico – 13 years

Why Switch to SDI?

We are going to say it upfront. SDI will cost more and be more complicated to install than most other drip irrigation systems to start. However, there is a clear reason why more and more growers are switching to SDI: **they realize the benefits quickly outweigh any of the initial challenges.**

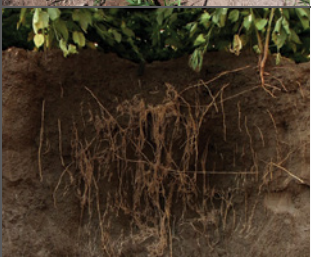
Upfront cost is higher, but long term savings, combined with greater yields, make SDI an excellent long-term financial decision.



"I can't afford not to use subsurface drip irrigation."

Chuck Dees
Irrigation Consultant for
Stamoules Product
Company, growing over
6500 hectares of crops.
USA

Below are some of the long term benefits you will experience using SDI:

Save Water: No Evaporation	Irrigation applied underground eliminates surface water evaporation. Compared to evaporation as high as 45% with sprinkler irrigation (<i>Measurements of evaporation during sprinkler irrigation, University of Southern Queensland, 2012</i>)	
Minimize Weeds	By applying water directly to the plants no water is being applied to the interrow. Less water in the interrows or on the surface means fewer weeds, and less costs (herbicides) to eradicate the weeds.	
Stronger Root Structure	When a drip lateral is buried 30 cm, roots need to 'chase' the water. This leads to a very healthy root structure that penetrates deep into the ground as opposed to concentrating on the surface.	

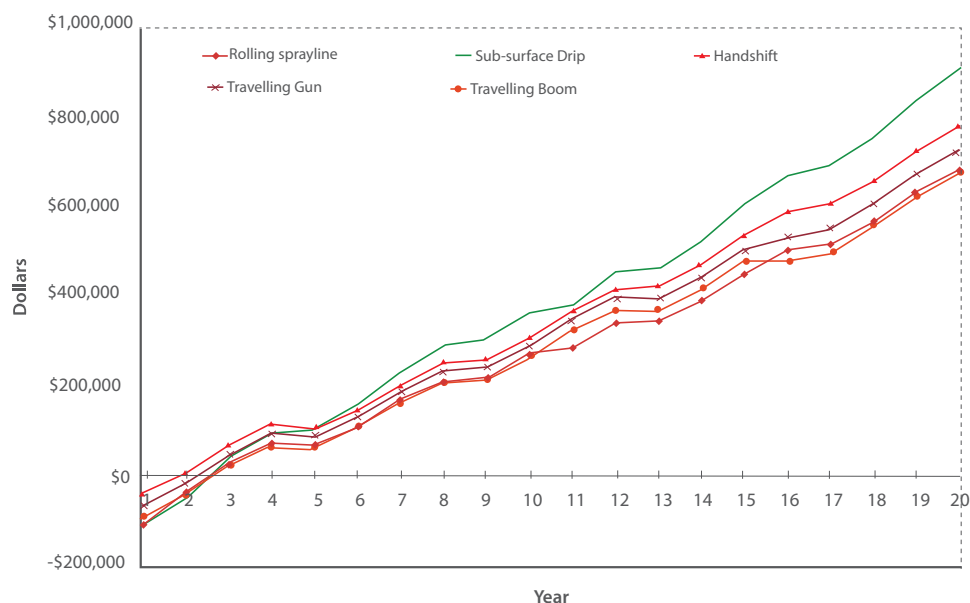
Apply chemigation direct to the root zone – fertilizers, herbicides, insecticides, fungicides	Fertilizers, insecticides and fungicides are a critical (and expensive) part of growing a successful crop. SDI improves the application of chemigation and reduces total costs. Using SDI, chemigation is injected into the drip irrigation system and is applied directly to the root zone. Application is extremely efficient and targeted with 90% efficiency and in some cases, even up to 97% efficiency can be achieved (<i>Economic Feasibility of Converting Center Pivot Irrigation to Subsurface Drip Irrigation, American Society of Farm Managers & Rural Appraisers, 2016</i>). What method of spray chemigation can reach uniformity of >90% consistency? Also, unlike spray irrigation, you do not need to worry about wind restrictions. With increased and targeted uniformity, there is a clear cost benefit as less chemigation is required for application. Additionally, when you apply directly via your drip system, you do not need to use a tractor and avoid all of the associated costs of fuel, labor and machinery.	
Reduce Plant Disease	A noticeable difference of SDI is that while the plants are irrigated, the top soil remains relatively dry. Compared to sprinkler irrigation, or even surface drip irrigation, SDI enables you to irrigate right up to harvest. Furthermore, a drier surface results in less humidity and therefore less risk of fungal disease.	
Easy Field Access and Harvest	When drip laterals are buried, field access is easy as SDI eliminates the need for irrigation pipes on the surface. For harvesting of nuts where mechanical sweepers are used, any irrigation on surface can be a problem. This problem is eliminated with SDI. Furthermore, you can irrigate right up to harvest without the normal risk of bogging in crops such as sugarcane and alfalfa.	
Irrigate odd shaped fields & corners of pivots	Unlike most mechanized irrigation, SDI can be installed in odd-shaped blocks – maximizing every hectare. Additionally, when pivot irrigation is already installed, SDI can be installed in the corners so this area of production is not lost.	
High Frequency Irrigation	A fundamental difference of SDI compared to traditional irrigation systems is that SDI utilizes high frequency irrigation. Small doses of water help prevent water logging, help keep oxygenation to crop, and provide a better environment for root growth.	

Cost Benefit Analysis

A key benefit of SDI is once the system is installed, it will deliver water and nutrients efficiently to your crops for many years to come. The one-time up-front cost for the system will cover you for many years and the on-going maintenance is far lower than most irrigation systems. For example, compare a drip connector that costs a few cents verse a pivot gearbox that can cost thousands of dollars.



Long Term Cash Flow Analysis of Different Irrigation Methods. SDI is the clear winner



Cash flow analysis of different irrigation methods for alfalfa, maize, soybean, wheat and other row crops. Within a very short period, SDI has paid back the investment and is providing greater cashflows to the farms compared to all other irrigation methods measured.

The Economics of Sub-Surface Drip Irrigation, published by the Department of Primary Industries, QLD, Australia, 1999

Producing *more* Milk with SDI in Brazil

Location: Araçatuba, São Paulo state, Brazil.

Objectives: Decrease cost of production while maintaining 12 cows producing 140 liters milk per hectare per day

Study: Irrigate pasture using SDI to improve pasture growth, therefore reducing silage requirement and costs of conventional production.

The Results:

As the table below shows, milk production increased with SDI irrigation while the cost per liter of milk produced halved.

This is in addition to other benefits such as the animals being able to return to pasture in less time and less tick problems as the soil was not wet.

Cost of Milk Production Analysis								
	SDI Drip Irrigation*				Conventional Production**			
	Liters of milk / animal	Feed Consumption kg / day	Cost of feed R\$/kg	Total R\$/l of milk produced	Liters of milk / animal	Feed Consumption kg / day	Cost of feed R\$/kg	Total R\$/l of milk produced
Average Production	12	2.5	\$0.65	\$1.63	9	3	\$0.73	\$2.19
Silage Consumption		8	\$0.13	\$1.04		20	\$0.13	\$2.60
Total				\$2.67				\$4.79

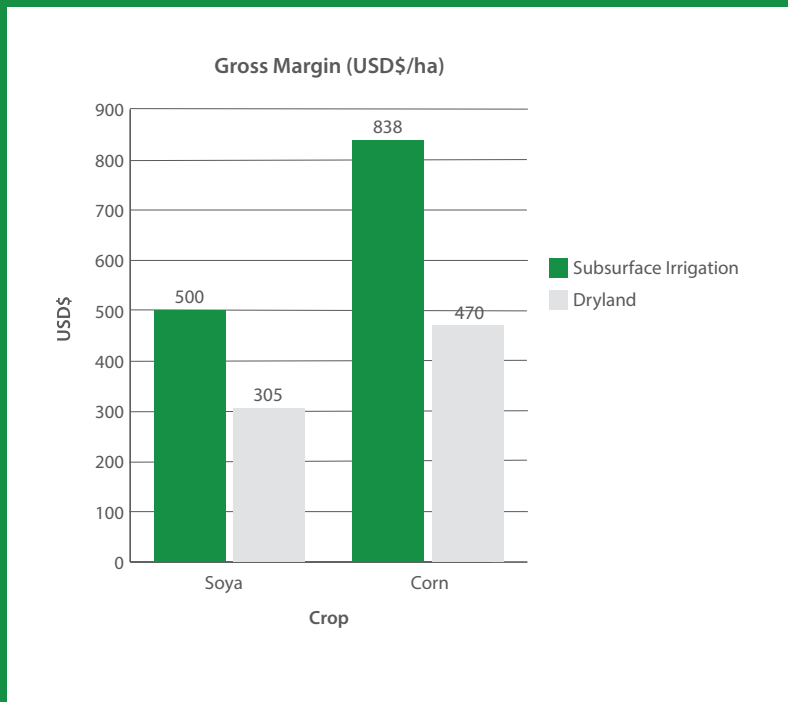
* SDI Drip Irrigation System uses Concentrated Grazing where animals graze a different restricted size area each day

** Conventional Production is where all cattle are grazing the total area



Real economic results. 5 year study: Gross margin/ha of SDI vs dry land of soya and maize

INTA Manfredi, a national institution for agriculture technology in Argentina conducted a 5 year trial to determine the gross margin per hectare of SDI versus dry land production in various crops. The results are clear – SDI delivers significantly more profit per hectare than dry land in both Soya and Corn.



Extensive Crops Economic Results in an Underground Drip Irrigation System. INTA Manfredi, Argentina

"Having control allows you to make the most of every day. Generally you have 365 days between ratoon and harvest. Every day counts and the traditional approach of laying out loads of fertilizer and hoping for rain is a gamble."

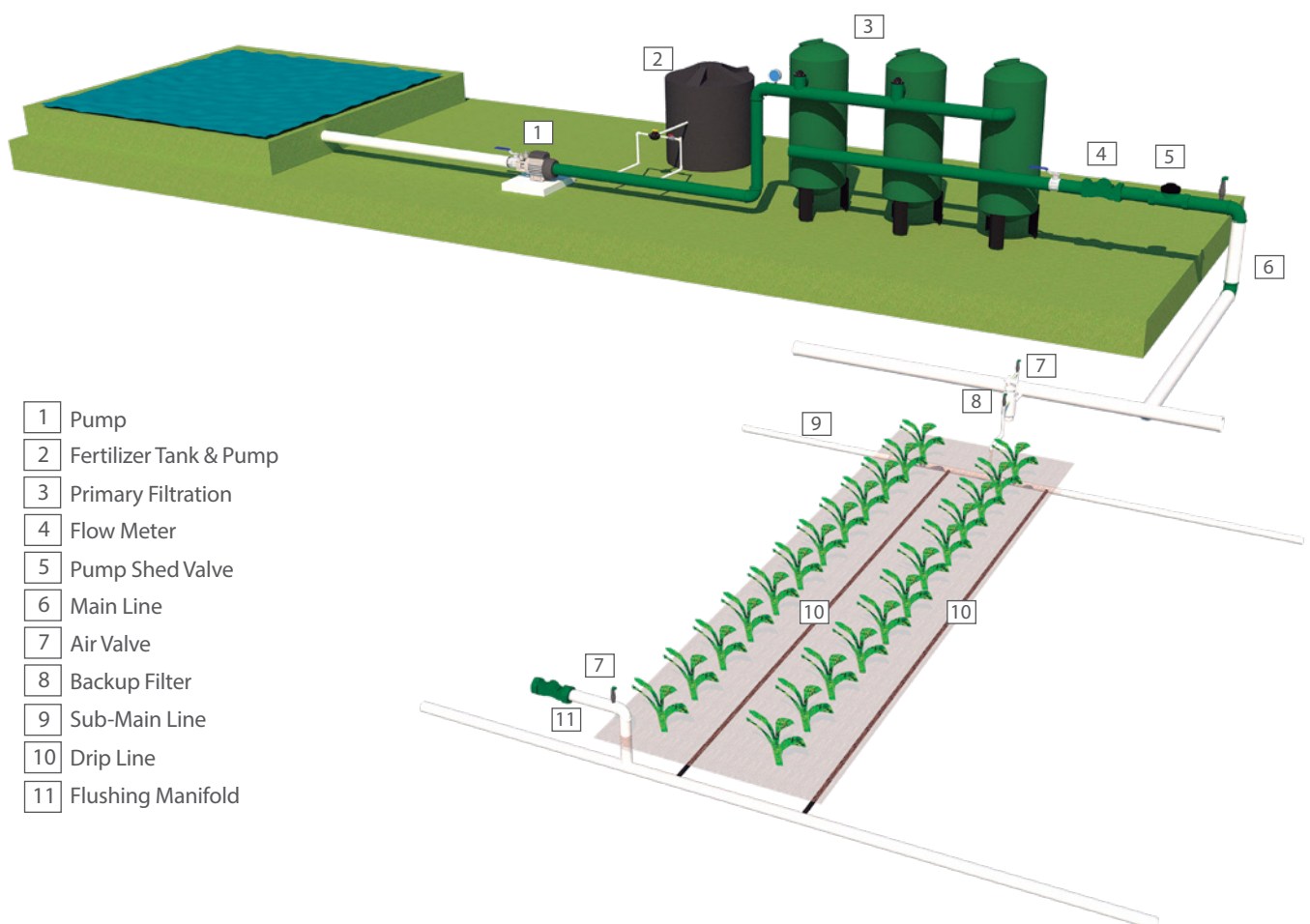
Drip irrigation allows you to remove moisture and nutrient limitations so you can maximize the 365 days you have. The control that drip irrigation provides is exciting. It has allowed me to achieve 20 – 25% tonnage increase whilst still achieving high CCS levels."

Lloyd Greensill
Sugar Cane Grower.
Bundaberg, Australia



SDI System Overview

All SDI irrigation systems contain the same components including pump station, filtration, valves, main-lines, sub-mains, in-field control valves and backup filters, drip laterals and a flushing manifold.



Key Components: Drip Laterals

When you bury a drip lateral (drip line/tape), there is great risk along with great potential reward. Choose an inferior drip lateral, and you will be paying for years to come. Choose a superior drip lateral, and you will be reaping harvests for years to come. A superior drip lateral will provide uniform application so that all your crop receives adequate water and nutrients, and it was also be built to be highly resistant to clogging for many seasons of trouble-free use.

When it comes to SDI, it doesn't pay to take chances. Rivulis T-Tape & D5000 PC / AS are tried and tested SDI drip tapes/lines that deliver results.

Rivulis T-Tape

World famous since first launched in 1977 and continuously enhanced until today.

Integrated emitter provides a unique design that cannot be achieved with inserted emitters. This includes up to 266 inlet filters per emitter, the ability to have very close drip spacing at no extra cost, and a reverse chevron path labyrinth.

Perfect for SDI – Rivulis T-Tape has a slit outlet that closes at shut-off to help prevent soil ingestion at shutoff.



Rivulis D5000 PC / AS

The world's most advanced pressure compensating (PC) drip line, launched in 2010.

PC drip line enables longer rows than traditional drip line. Additionally, it enables irrigation over sloping grounds while still achieving the same flow-rate per dripper.

Rivulis D5000 is also available in an anti-siphon version that seals in negative pressure. This is a perfect solution for subsurface irrigation as it helps prevent the risk of suck-back at system shutdown.

You will find Rivulis D5000 PC / AS in the most advanced irrigation systems



Key Components: Filters & Valves

Filtration

A good filtration system is the number one item of your system to ensure that you can get the maximum life out of your drip irrigation system. The filtration system is the barrier between contaminants and your drip laterals.

Rivulis F2300 Media System

The Rivulis F2300 Media System filter will provide the ultimate protection for your irrigation system.

Media filters are effective at removing both organic and inorganic contaminants.

Additionally, Rivulis F2300 filters are epoxy lined to give you outstanding protection against corrosion.



Rivulis F7250 Automatic Disc

Disc filtration delivers '3-dimensional' filtration as particles need to pass through a pod of discs.

Each pod is maximized to increase the filtration available, and deliver extremely effective filtration combined with an efficient self-cleaning mechanism.



Rivulis F6400 Semi-Automatic

When developing an SDI system, it is important to have redundancy in the system. Therefore, in addition to primary filtration (the Rivulis F2300 or Rivulis F7250), we recommend a small backup filter on each block.

The Rivulis F6400 is perfect as it is a low cost, highly effective barrier to protect your drip irrigation system.



Control Valves, Air Valves, Fertigation & Monitoring Equipment

Valves, fertigation and monitoring equipment protect your irrigation system, allow automation and help you manage your entire system.

The use of automation with fertigation in an SDI system is one of the greatest labor savings efforts you can implement. With just the push of a button, you can remotely start an irrigation cycle that includes a complex preset fertigation application.

Fertigation Options

Drip Fertigation via Venturi

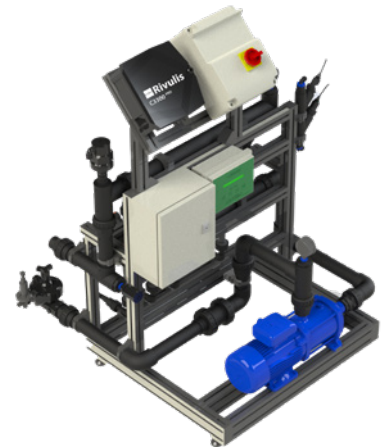


Drip Fertigation via Fertilizer Tank



Fertigation Machines and Automation

Wide range of automatic fertigation machines for accurate nutrient dosage and pH control.



Monitoring Equipment

Monitoring equipment such as pressure sensors and flow meters are important for monitoring and integration to automation systems. Unlike surface drip irrigation where you can see the system working, pressure sensors and flow meters are used with SDI to ensure the system is working at its optimum level.

Rivulis Control Valves

To enable high frequency irrigation, control valves can be automated to give precise irrigation scheduling to each block.

Rivulis has a wide range of plastic and metal valves that protect the irrigation system by reducing pressure to safe levels and maintaining enough pressure for each component to operate effectively in addition to turning the irrigation system on and off.



Rivulis Air Valves

Air valves are a key component of any SDI system.

In addition to allowing air out of the system, vacuum breakers help prevent suction at shut-down which is vital for drip line that is buried.

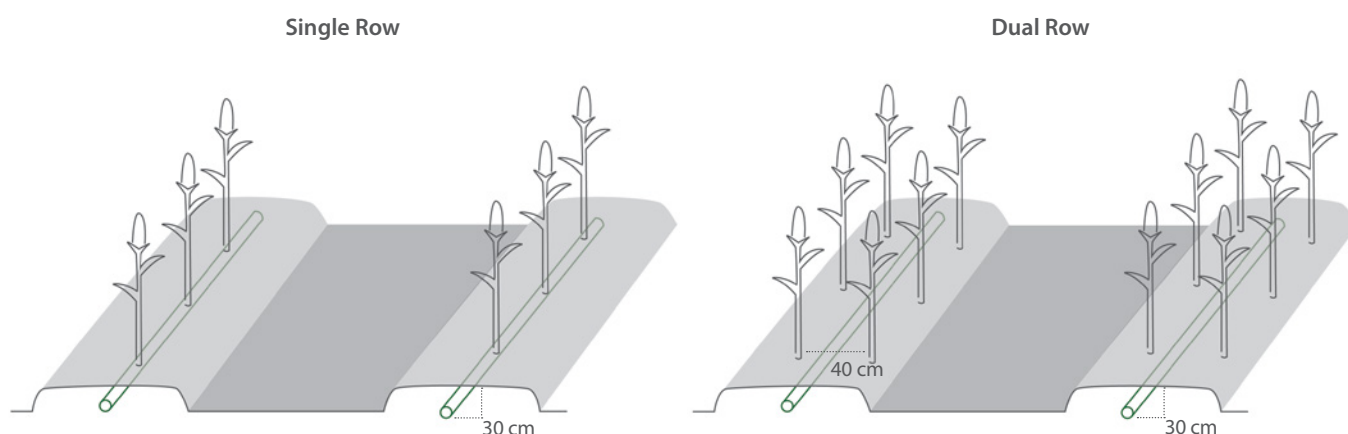


Common Crop Applications

SDI is ideal for numerous crops and applications. The list below provides a summary of some of the most common SDI crop applications.

Row Crops

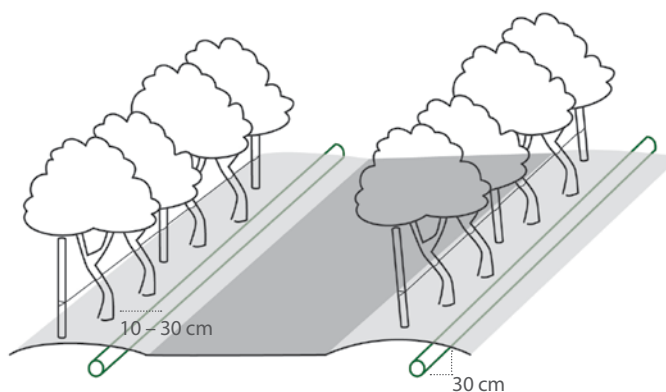
- **Why SDI?** Combination of higher yields and reduced costs provide significantly greater profits in the long term
- **Row crops:** Corn, cotton, sugar cane
- **Recommended drip solution:** Rivulis T-Tape. 15 mil wall thickness. 1 lph with 30 cm spacing
- **Placement:** 30 cm below the surface. Single row design directly below the plant, or dual-row system with plants 20 cm to each side of the drip line
- **Product lifecycle:** 15+ years



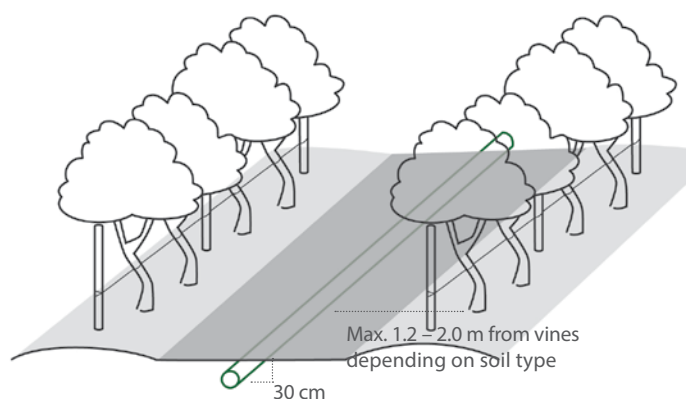
Vineyards

- **Why SDI?** As more pesticides and herbicides are not allowed, SDI provides a solution with minimal water on the surface to protect your crop, reducing weeds and disease
- **Recommended drip solution:** Rivulis D5000 AS. 40 / 45 mil wall thickness. 1.5 lph with 1 m spacing if you have a summer with moderate rainfall, and 50 cm – 75 cm if you have limited rainfall in the summer
- **Placement:** 10 – 30 cm depth to the side of the row of the vines or in the middle between the rows (maximum 2.0 m from row in heavy - medium soils and 1.2 – 1.5 m in sandy soils)
- **Product lifecycle:** 15+ years

Placement next to vines

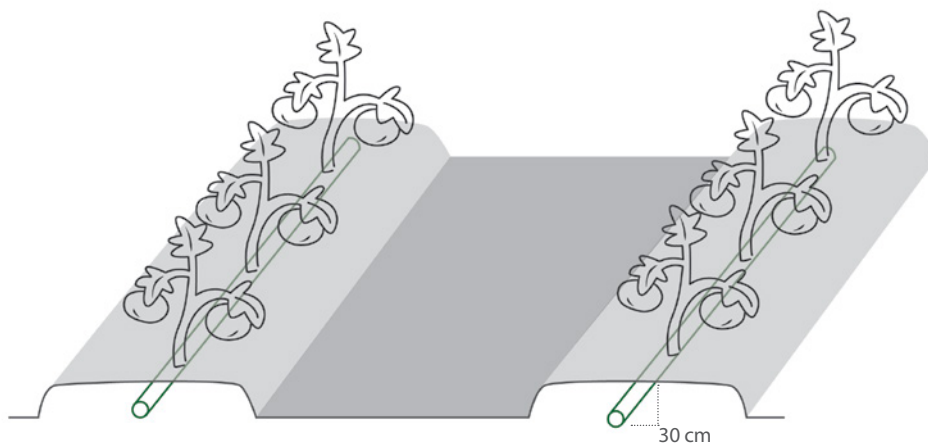


Placement in middle of row



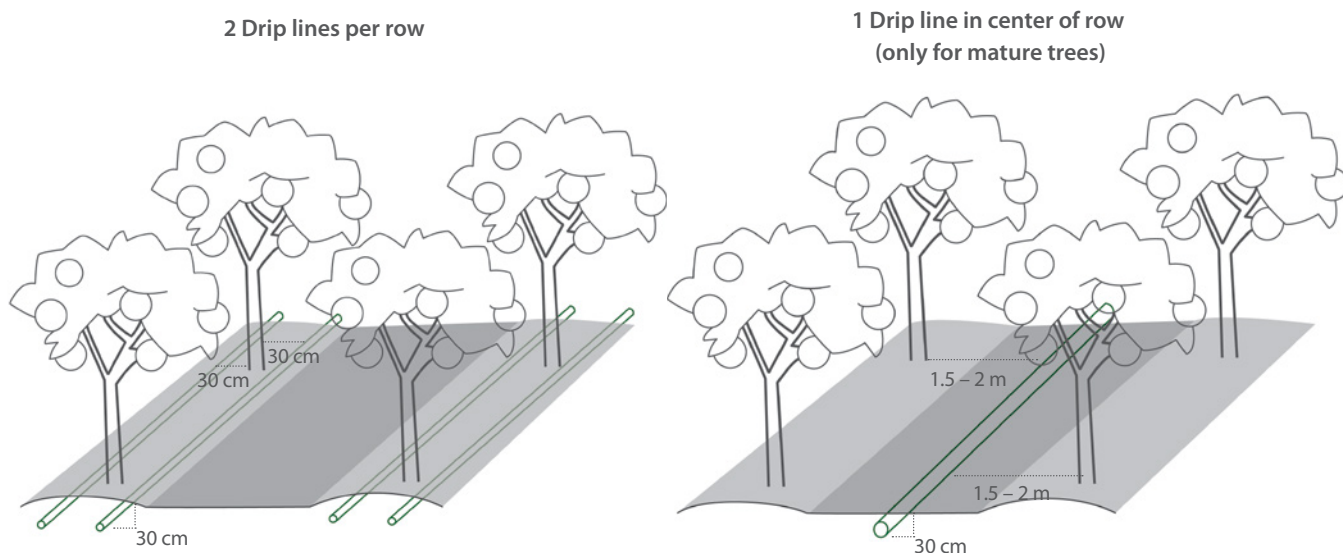
Tomatoes

- **Why SDI?** Keeping the surface dry is critically important to reduce mold and mildew. SDI increases the quality of the tomato crop by allowing you to better control the brix. Additionally, the feeding root grows around the dripper enabling you to easily increase or reduce the plant nutrition
- **Recommended drip solution:** Rivulis T-Tape. 12 – 15 mil. 0.8 lph with 30 cm spacing
- **Placement:** 30 cm below the surface of each row
- **Product lifecycle:** 5 – 7 years



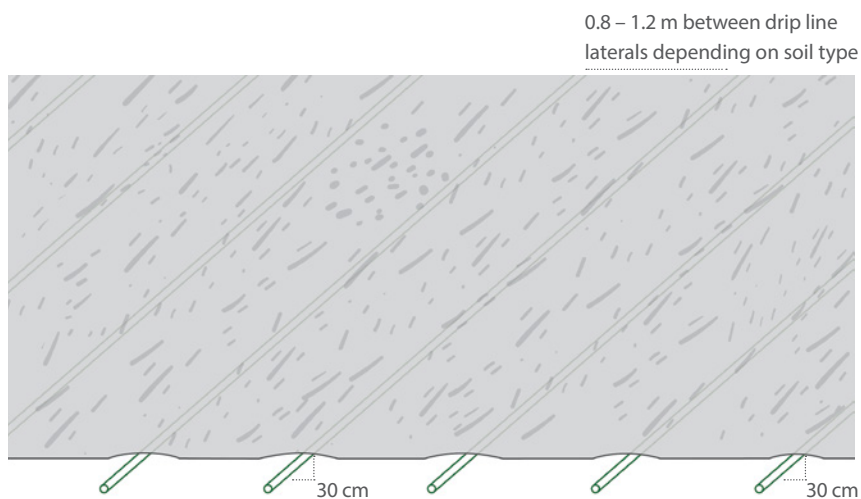
Orchards & Olives

- **Why SDI?** In addition to efficiency gains, harvest is much easier, especially for nut crops which have mechanical harvesting, and is simpler without having irrigation equipment on the surface
- **Recommended drip solution:** Rivulis D5000 AS. 40 / 45 mil wall thickness
- **Placement:** 2 drip line laterals, one on each side of the tree rows, 1 meter apart or in the center if the trees are mature (3 – 4 m centers)
- **Product lifecycle:** 15+ years



Alfalfa (Lucerne) or Broadacre Full Cover Crops

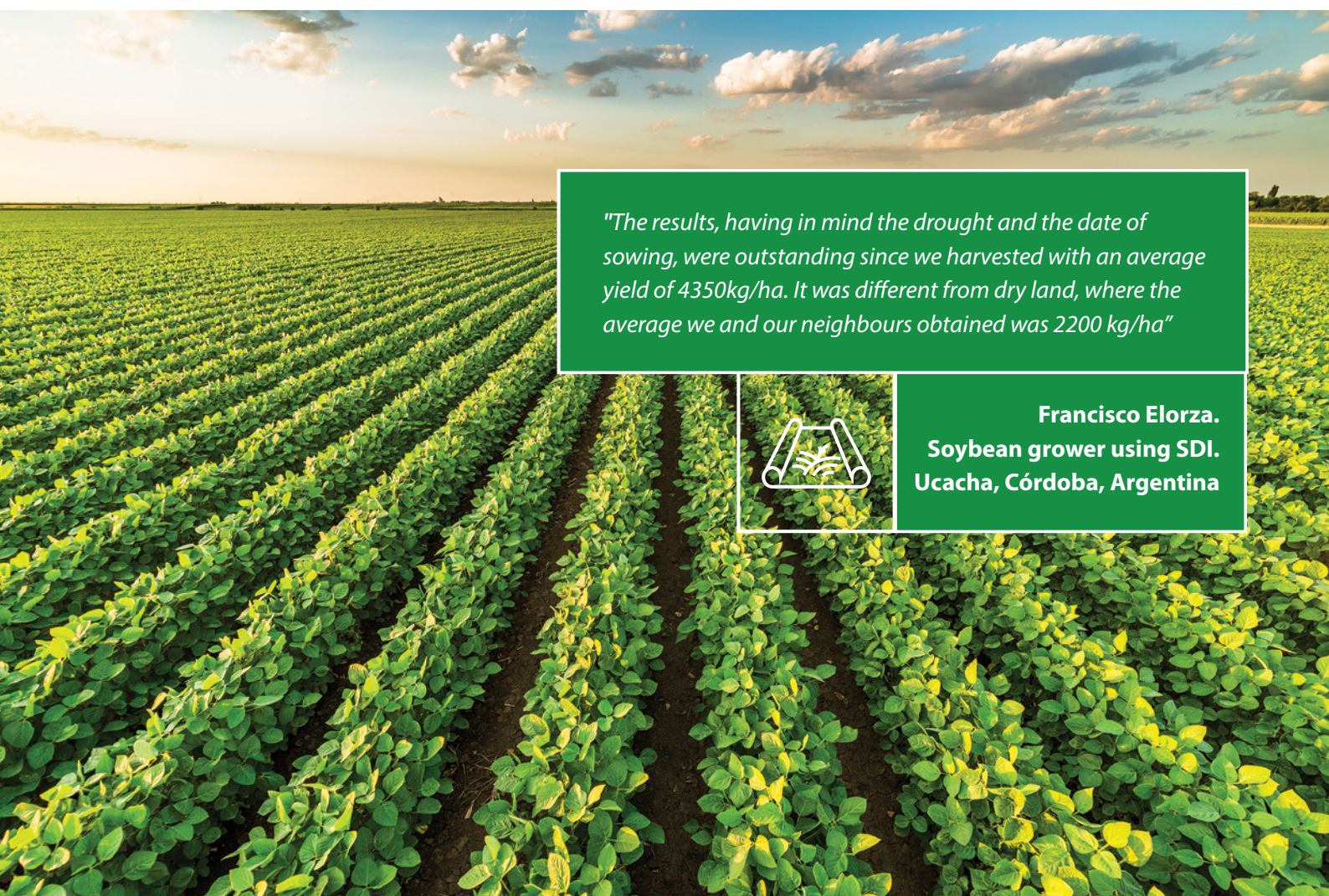
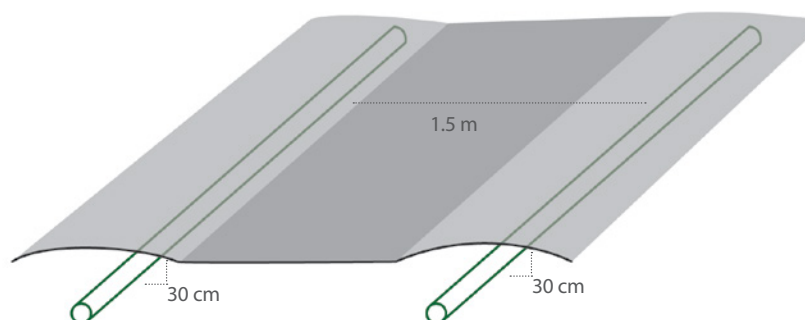
- **Why SDI?** Higher efficiency and the ability to irrigate right up to harvest
- **Recommended drip solution:** Rivulis T-Tape. 15 mil wall thickness. 1 lph with 30 cm spacing
- **Placement:** 30 cm below the surface. 80 – 120 cm spacing, depending on the soil. GPS technology not required because you have uniform wetness
- **Product lifecycle:** 15+ years



Rotation Crops

- **Why SDI?** As crop prices fluctuate, and due to the need to manage disease, crop rotation is becoming increasingly important. SDI provides a solution for crop rotation
- **Recommended drip solution:** Rivulis T-Tape. 12 – 15 mil. 1.0 lph with 30 cm spacing
- **Placement:** 30 cm below the surface and 150 cm row spacing provides suitable irrigation for numerous crops if you have GPS. Alternatively use a broadacre/alfalfa system designed for maximum flexibility and no need for GPS placement

Flex-Rotation Crop SDI System



"The results, having in mind the drought and the date of sowing, were outstanding since we harvested with an average yield of 4350kg/ha. It was different from dry land, where the average we and our neighbours obtained was 2200 kg/ha"



Francisco Elorza.
Soybean grower using SDI.
Ucacha, Córdoba, Argentina

Designing the Perfect SDI System

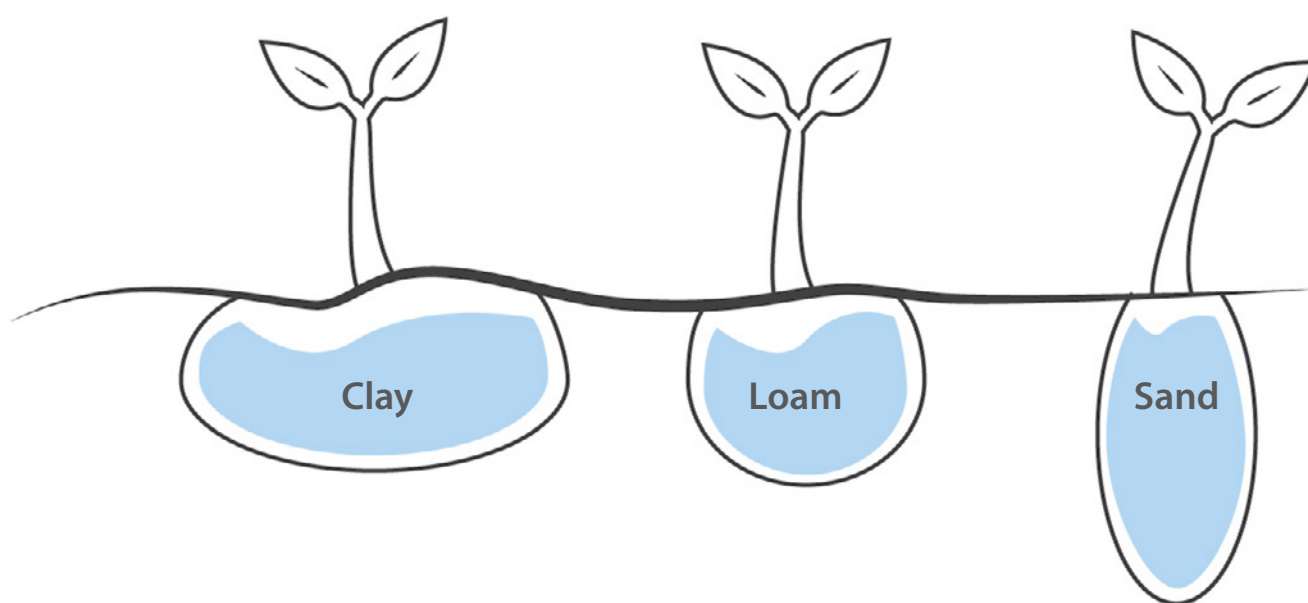
SDI is much simpler than it appears on the surface (or below the surface). Coupled with the right partner – Rivulis, the installation of an SDI system can be achieved easily.

The following pages provide a high level outline of the basic steps for a SDI system.

Choosing the Drip Line Configuration

Good irrigation design matches the crop water need to the soil environment and then to the hydraulics of pipe size, dripper flow rate and spacing, pump efficiency, head loss and energy costs.

It is important to recognize that water applied below the surface moves differently than water applied above the surface. This is due to capillary movement (how water is drawn through the soil) verse the effect of gravity (that pulls water down). As a general rule of thumb, water will travel 2/3 down and 1/3 up from its location.



Water flows both horizontally and vertically depending on the soil type.

A soil analysis is included in the design brief to determine the best drip system for your crop.

Dripper Spacing

To maximize the capillary movement through the soil, drippers need to be closer together in subsurface than on surface because of the downward water movement in the soil profile.

Closer dripper spacing ensures a fully wetted line across the crop, which leads to uniformity. Close dripper spacing is critical.

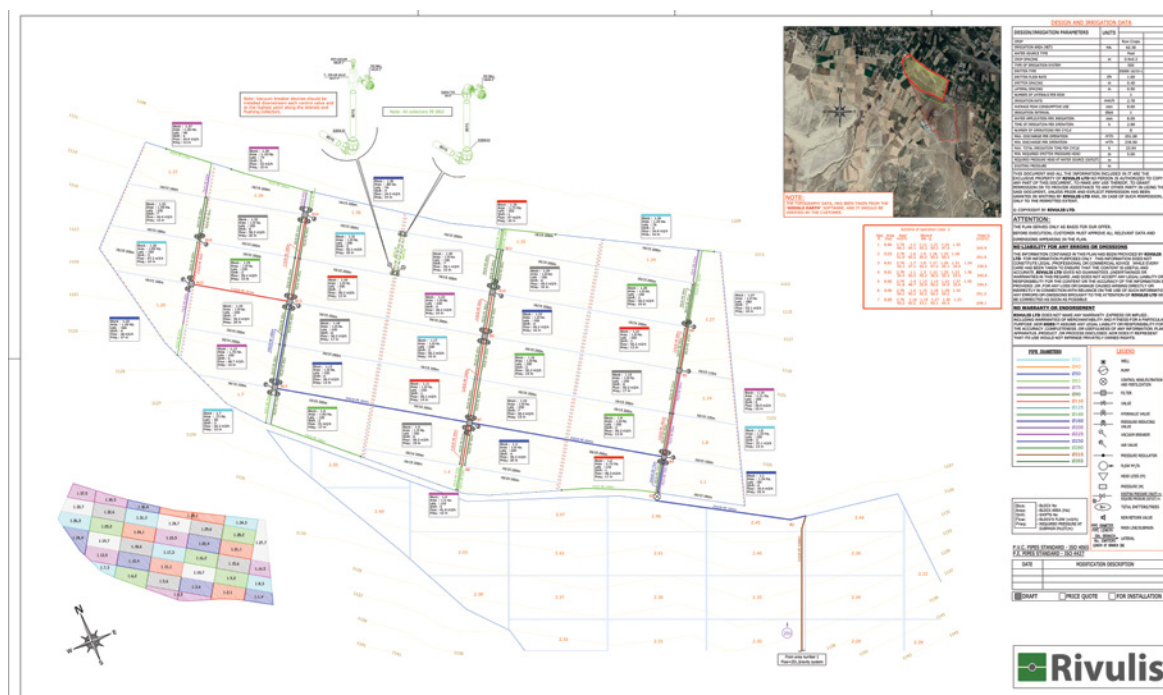
Do not compromise on wider spacing. Generally 30cm is ideal for many crops.



Final Design

Incorporating all the field and crop requirements, a hydraulic design is made incorporating every component from the water source to water distribution. Every component is chosen for optimum hydraulic performance.

Rivulis has multiple Design Centers around the world and specialized tools like the Hydraulic Tool that can develop an irrigation system specific to your unique requirements.



A final system design by the Rivulis Design Team

Installation

1A	Install drip laterals before planning, per design plan using SDI installation equipment	
1B	We highly recommend using GPS guidance and tracking when installing drip laterals for row crops so that future crops can be accurately planted in accordance with the drip line layout. Note, GPS is not required for permanent crops such as orchards and vineyards, or for cover crops such as alfalfa, but it is very important for crops that need to be replanted such as cotton and sugar cane where the drip line distances between each row may be significant.	
2	Sub-mains and flushing laterals are buried which is conducted via trenching.	
3	Once installed, the drip laterals are then connected via risers.	
4	In-field block valves are installed that include field valves controlled, air-valves, backup filters and automation	
5	Submains are connected to the mainline & pump shed that contains the primary filtration, automation and fertigation system.	
6	The system is flushed and tested prior to use.	

Irrigation Scheduling

Knowing when and how much to irrigate is key for SDI success.

Your irrigation schedule should be planned before you design a system. This enables you to design a system based on your crop needs.

Rivulis has the expertise and experience to guide you in defining the right irrigation schedule for your crop or field needs. Here is a quick guide for calculating your irrigation scheduling.

Irrigation Scheduling Formula: $Q_{\min} = ET_{\text{peak}} \times A \times 1,000,000 / T \times E_a$

- $Q_{\min}$ = the flow rate for the block (l/hour). This is what you are calculating – how much water you need for irrigation
- ET_{peak} = peak water requirement (mm/day) – how much water your crop needs
- A = size of the block (ha)
- T = how many hours are available for irrigating (hours/day)
- E_a = the irrigation efficiency of the system (%)

Based on the above, you can easily calculate the irrigation demand for your crop. The frequency of irrigation will depend on the water holding capacity of the soil. Clay soil requires less frequent irrigation than sandy soil. Your goal is to maximize the water available to the crop and minimize water loss to deep drainage.

SDI efficiency of the system has a multiplication impact on the amount of water you need

The above formula can be used for all irrigation types, but the big differentiator is E_a – the efficiency of the system. As it is a multiplier, this number can have a huge impact on how much water is required.

According to the Food and Agriculture Organization of the United Nations, drip irrigation has significant benefits with the following indicative values:

Irrigation Methods	Field Application Efficiency
Surface Irrigation (border, furrow, basin)	60%
Sprinkler Irrigation	75%
Drip irrigation	90%

Source: FAO. Annex 1: Irrigation Efficiencies <http://www.fao.org/3/t7202e/t7202e08.htm>

Maintenance

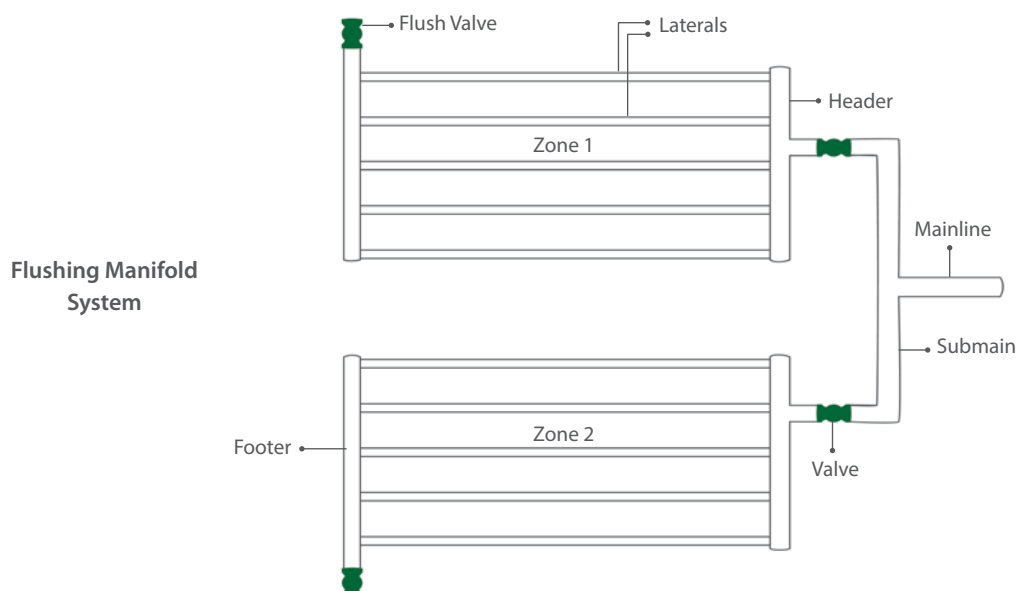
The maintenance of a SDI system is easy if conducted at regular intervals

Flushing

The key maintenance task is to flush the drip laterals, by opening the end of the drip lateral to clean out contaminants that may have entered the system. This can be conducted manually with each drip lateral by using a flush manifold at the end of the line, or an automatic flush manifold.

A flushing manifold is recommended. Flushing is a part of periodic maintenance for a SDI system. A flushing manifold is an automated system which allows you to clean the irrigation system.

An additional benefit of installing a flushing manifold is that it can also be used as a submain into order to feed water from both sides, in turn increasing the run lengths possible for each drip lateral.



Chemical Treatment

The second part of maintenance is the correct periodic chemical treatment. For organic contaminants, a chlorine treatment is used, whereas for inorganic (sediment or colloidal) an acid treatment is used.

Rivulis can prescribe a maintenance plan to ensure the ongoing performance of your irrigation system.

FAQ:

Which Rivulis drip tapes are right for my SDI system?

Rivulis T-Tape and Rivulis D5000 PC/AS are proven drip irrigation solutions for drip irrigation. Rivulis T-Tape is generally chosen when the ground is flat and the row length is 150 – 300 m. Rivulis D5000 PC/AS is chosen for sloping ground, or when longer run lengths are required. Having said that, there are unique Rivulis T-Tape solutions that can provide 690 m run lengths, and there are occasions where Rivulis D5000 PC/AS will be chosen for other benefits. The Rivulis design team will help you choose the best product for your needs.

If I bury flat drip line or tape, will it still operate? Do I need to use a round drip line?

The total porosity (ratio of empty space to total volume) of soil ranges from 40 – 60% in general. The remaining space is air. If the appropriate pressure is applied, flat drip lines will expand and function at full performance when buried underground.

Will soil get into the drip line / tape?

Rivulis has specifically designed and engineered their SDI drip tape and line products to prevent soil and contaminants from getting into the system. Rivulis T-Tape features a slit outlet that closes upon system shut off. Rivulis D5000 PC 15 mil wall thickness is the only PC drip line available that has a slit outlet and also closes at shut-off. For heavy wall thicknesses, Rivulis D5000 AS offers an anti-siphon (AS) function that seals the dripper during negative pressure.

These advanced drip tape/lines, when coupled with vacuum breakers, are extremely effective barriers against soil ingestion.

How long will an SDI irrigation system last?

To get the most out of your SDI irrigation system, you need to properly maintain it with flushing, chemical treatment and other maintenance measures. As we have demonstrated in this brochure, properly maintained, large commercial SDI systems can last for decades.

I've heard that roots and rodents can damage a subsurface drip system, is this true?

Roots and rodent damage can be prevented with proper operation and maintenance of your SDI system. Plant roots only chase water if they cannot find it. Therefore, the simple and effective solution to prevent roots damaging drip line is to not stress the plants to the degree that they chase water. By keeping a moist area around the drip line, plant roots will not need to reach to the drip line itself. Furthermore, if needed, chemical treatment can be applied at very low cost and is extremely effective and simple.

In regards to rodents, it is a similar scenario. Prevention is the best method and you can prevent rodents from damaging your SDI system by having good farm hygiene, deep tillage before planting, and using appropriate baiting.

If the drip irrigation is underground, how do I know it is working?

A common concern expressed is that unlike other irrigation, you cannot see SDI working. There are a number of ways you can ensure that your plants are receiving the water they need.

Your SDI irrigation system is calibrated to work at a certain pressure and flow rate. By measuring these two variables, you can have confidence that your irrigation system is working. Conversely, changes in these measurements will alert you to a problem. For example, reduced flow will indicate blockage and increased flow rate will indicate a leak.

Coupled with measurement of pressure and flow is soil moisture monitoring. This can vary from a simple tensiometer to measure water tension to soil moisture sensors that measure the water content in your soil.

Rivulis offers Manna Irrigation Intelligence, a solution that monitors crop growth via real time temporal resolution. Manna can help fine tune irrigation schedules as well as identify potential system problems.

SDI sounds complex, where do I start?

The Rivulis team consists of design, agronomy and technical support experts throughout the world and are experienced in designing, installing and supporting SDI solutions.

We partner with you every step of the way to ensure an irrigation system that meets your crop needs.



"The other key advantage which relates to production, is the ability to apply water in a constant way in small quantities...you can apply fertilizer, and you can apply nutrients based solely on their need... There is no doubt that drip irrigation is an excellent tool, streamlining the entire process and ensuring great results.

Despite the higher costs, the results of the harvest and the increase in production even things out. Last year was not an exceptional year, and we were 25% more below production costs, which highlights another benefit of the system; economic results.

The application of water in small quantities in a constant and precise way is the main trait that allows us to increase production, lower costs, and have good results

The results we've had have greatly surpassed our expectations. In regards to production we've had an average increase of 60% more, growing all the way up to 100% within the years we've used the system.

We've been using the system for more than 13 years and both the drip tape and the crop have continued working properly."

**Hector Manuel Perez Turner
Sugar Cane Grower using SDI in
2000ha of production.
Mexico.**



Subsurface Drip Irrigation (SDI)

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