

FROST PROTECTION

An introductory guide to protecting your investment

Rivulis

www.rivulis.com

The challenge increases

Being a farmer was never easy and facing obstacles and challenges were always part of the game. Competition, tough markets, fresh water availability, land deterioration, new diseases and pests, and the list goes on…

Climate change increases the complexity and the unpredictable nature of the weather, and one of those extreme weather conditions brought forth by climate change is frost. Frost damage poses one of the major threats to agricultural production in recent years.

In 2021, the damage caused by frost alone is estimated to be one of the highest ever to be reported!

> "At least a third of French wine production worth almost €2 billion in sales will be lost this year [2021] after rare freezing temperatures devastated many vines and fruit crops across France."
> *Freshfruitportal.com*



What are we dealing with here…?

There are two kinds of frosts:



Advection Frost

Windy Frost, Arctic Frost or Black Frost

Occurs when a cold air mass (cold front) moves into an area, bringing freezing temperatures with a wind speed usually above 8 km/h.

Possible protection against this kind of frost is very limited.



Radiation Frost

The more common frost encountered in farming

Occurs when with a clear sky and calm winds the temperatures at ground level drop below freezing point.

As temperatures drop, the cold air flows downward to lower topographic areas. That is where most of the damage is seen.

This kind of frost can be dealt with. With the proper tools and understanding even the most severe frost can come and go, and leave no trace when the next day dawns.

Spring frost

Spring frost is the most observed and reported in agriculture.

It is common in temperate countries and damages deciduous crops like vineyards, apples, cherries, kiwi, and blueberries and so on.





These crops are naturally adapted to cold winters and can withstand sub-zero temperatures for long periods of time.

The dosage of cold is required so that they shed their leaves in winter and go into dormancy.

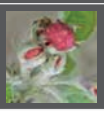
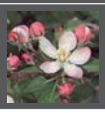
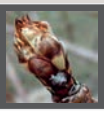
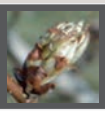
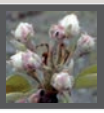
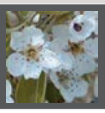
Once they bloom and leaf out, they gradually become vulnerable to frost. The farther away they are from dormancy and deeper into spring the more sensitive they become to frost, and the heavier the damage.

In recent years, due to climate change, frosts can occur even during the month of May (Northern Hemisphere) where in many places the crops are well on their way towards summer, leaving them totally unprepared and ill-equipped.

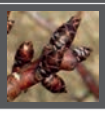
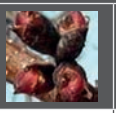
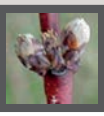
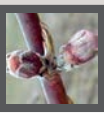
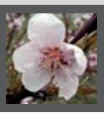
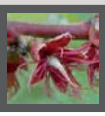
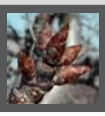
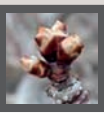
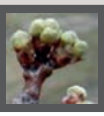
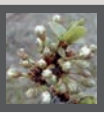
Old standard temperature is the lowest temperature that can be endured for 30 minutes without damage. This chart also shows the temperature that will kill 10 % and 90 % of normal fruit buds.
These numbers were taken from Washington (WSU) and Michigan (MSU) Bulletins. Apple - WSU EB0913, Pears - WSU EB0978, Sweet Cherries - WSU EB1128, Peaches - WSU EB0914, Apricots - WSU EB1240, Tart Cherries - MSU Research. Rpt. 220,
Compiled by Mark Longstroth, MSU Extension Educator, all photos by Mark Longstroth (MSUE)

Critical spring temperatures for tree fruit bud development stages.

Pome fruits

Apples									
	Silver tip	Green tip	Half inch green	Tight cluster	First pink	Full pink	First bloom	Full bloom	Post bloom
Old temp 10% Kill 90% Kill	-8.8°C / 16°F -9.4°C / 15°F -16.6°C / 2°F	-8.8°C / 16°F -7.7°C / 18°F -12.2°C / 10°F	-5.5°C / 22°F -5°C / 23°F -9.4°C / 15°F	-2.7°C / 27°F -2.7°C / 27°F -6.1°C / 21°F	-2.7°C / 27°F -2.2°C / 28°F -4.4°C / 24°F	-2.2°C / 28°F -2.2°C / 28°F -3.8°C / 24°F	-2.2°C / 28°F -2.2°C / 28°F -3.8°C / 24°F	-1.6°C / 29°F -2.2°C / 28°F -3.8°C / 24°F	-1.6°C / 29°F -2.2°C / 28°F -3.8°C / 24°F
Pears									
	Bud scales separating	Blossom buds exposed		Tight cluster	First White	Full White	First bloom	Full bloom	Post bloom
Old temp 10% Kill 90% Kill	-7.7°C / 18°F -9.4°C / 15°F -17.7°C / 0°F	-5°C / 23°F -6.6°C / 20°F -14.4°C / 6°F	No data	-4.4°C / 24°F -4.4°C / 24°F -9.4°C / 15°F	-2.2°C / 28°F -3.8°C / 24°F -7.2°C / 19°F	-1.6°C / 29°F -3.3°C / 26°F -5.5°C / 22°F	-1.6°C / 29°F -2.7°C / 27°F -5°C / 23°F	-1.6°C / 29°F -2.2°C / 28°F -4.4°C / 24°F	-1.1°C / 30°F -2.2°C / 28°F -4.4°C / 24°F

Stone fruits

Apricots									
	Swollen bud	Tips separate	Calyx red	First white	First bloom	Full bloom	In the shuck	Green fruit	
Old temp 10% Kill 90% Kill	- -9.4°C / 15°F -	-5°C / 23°F -6.6°C / 20°F -17.7°C / 0°F	- -5.5°C / 22°F -12.7°C / 9°F	-3.8°C / 24°F -4.4°C / 24°F -10°C /14°F	- -3.8°C / 24°F -7.2°C / 19°F	-2.2°C / 28°F -2.7°C / 27°F -5.5°C / 22°F	- -2.7°C / 27°F -4.4°C / 24°F	-0.5°C / 31°F -2.2°C / 28°F -3.8°C / 24°F	
Peaches									
	Swollen bud	Calyx green	Calyx red	First pink	First bloom	Full bloom	Post bloom		
Old temp 10% Kill 90% Kill	-5°C / 23°F -7.7°C / 18°F -17.2°C / 1°F	- -6.1°C / 21°F -15°C / 5°F	- -5°C / 23°F -12.7°C / 9°F	-3.8°C / 24°F -3.8°C / 24°F -9.4°C / 15°F	- -3.3°C / 26°F -6.1°C / 21°F	-2.7°C / 27°F -2.7°C / 27°F -4.4°C / 24°F	-1.1°C / 30°F -2.2°C / 28°F -3.8°C / 24°F		
European plums									
	First swelling	Side white	Tip green	Tight cluster	First white	First bloom	Full bloom	Post bloom	
Old temp 10% Kill 90% Kill	- -10°C /14°F -17.7°C / 0°F	- -8.3°C / 17°F -16.1°C / 3°F	- -6.6°C / 20°F -13.8°C / 7°F	- -4.4°C / 24°F -8.8°C / 16°F	-5°C / 23°F -3.3°C / 26°F -5.5°C / 22°F	-2.7°C / 27°F -2.7°C / 27°F -5°C / 23°F	-2.7°C / 27°F -2.2°C / 28°F -5°C / 23°F	-1.1°C / 30°F -2.2°C / 28°F -5°C / 23°F	

Cherries

Sweet cherries									
	Swollen bud	Side green	Green tip	Tight cluster	Open cluster	First white	First bloom	Full bloom	Post bloom
Old temp 10% Kill 90% Kill	-5°C / 23°F -8.3°C / 17°F -15°C / 5°F	-5°C / 23°F -5.5°C / 22°F -12.7°C / 9°F	-3.8°C / 24°F -3.8°C / 24°F -10°C /14°F	-2.2°C / 28°F -3.3°C / 26°F -8.3°C / 17°F	-2.2°C / 28°F -2.7°C / 27°F -6.1°C / 21°F	-1.6°C / 29°F -2.7°C / 27°F -4.4°C / 24°F	-1.6°C / 29°F -2.2°C / 28°F -3.8°C / 24°F	-1.6°C / 29°F -2.2°C / 28°F -3.8°C / 24°F	-1.1°C / 30°F -2.2°C / 28°F -3.8°C / 24°F
Tart cherries									
	Swollen bud	Side green	Green tip	Tight cluster	Open cluster	First white	First bloom	Full bloom	Post bloom
10% Kill 90% Kill	-9.4°C / 15°F -17.7°C / 0°F	-4.4°C / 24°F -12.2°C / 10°F	-3.3°C / 26°F -5.5°C / 22°F	-3.3°C / 26°F -4.4°C / 24°F	-2.2°C / 28°F -4.4°C / 24°F	-2.2°C / 28°F -4.4°C / 24°F	-2.2°C / 28°F -4.4°C / 24°F	-2.2°C / 28°F -4.4°C / 24°F	-2.2°C / 28°F -4.4°C / 24°F

Winter frost

Tropical and subtropical crops also require frost protection.

Crops like avocado, litchi, mango, berries, citrus, etc are being cultivated for decades outside their natural habitat.

These crops are all evergreen and are not equipped to deal with subzero temperatures. Furthermore, in recent years, countries with relatively warm climates, experience extreme frosts during winter.

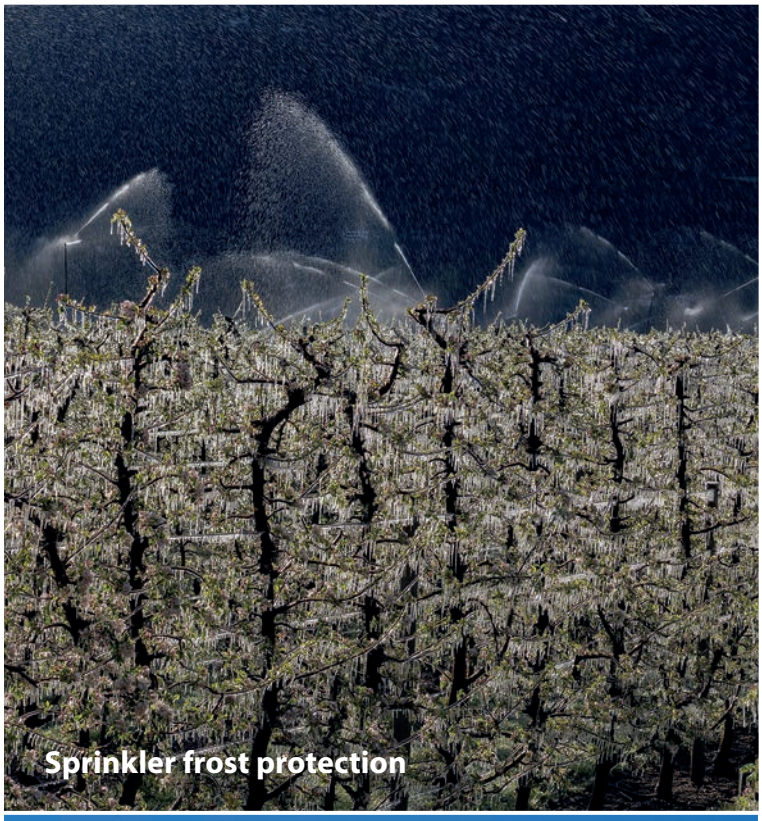
One night or even less of exposure to subzero temperatures for these tropical and subtropical crops can mean total destruction.

Unlike deciduous crops where frost damages the annual production in evergreen trees the frost damage can impact multiple years and even lead to total lost.



Active frost protection methods

Of the common active frost protection methods, sprinkler frost protection is the most efficient and effective.


Sprinkler frost protection


Helicopter frost protection


Wind machine frost protection

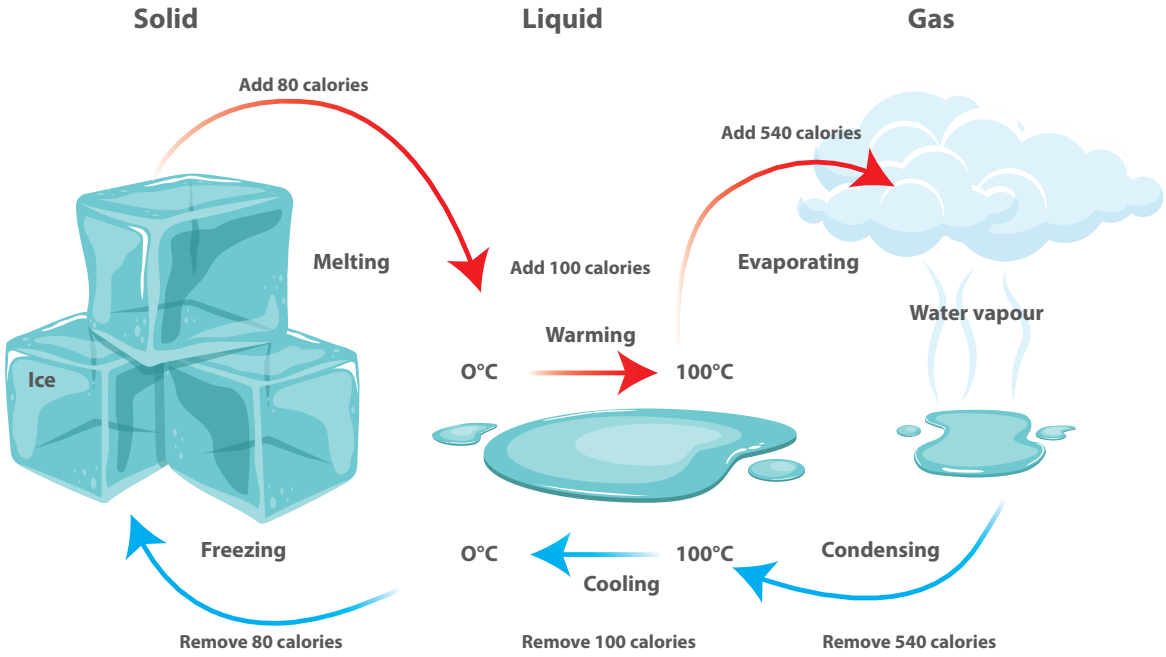

Heater frost protection

Frost protection using latent heat

The principle

When water freezes, it releases heat to its environment. For any substance or material, a solid state is always in a lower energy level. Moving water from a liquid state to a gas state means raising it to a higher energy level therefore requiring the use of energy. The same goes the other way around. The transition of water from liquid to solid means reducing the energy level. The excess energy that is being released actually radiates to the environment as heat.

Latent heat is how water can save your plantation or vineyard from frost.



Latent heat of fusion - 80 calories

Latent heat of vaporisation - 540 calories

Not just for frost...

The double combo!

Many areas in the world experience severe winters and extreme summers. While a frost protection system can provide protection for winter or spring frost, it can also provide a very good and efficient climate control system.

During a heat wave, having a sprinkler frost protection system, is perhaps the best thing you could wish for.

In the occurrence of a heat wave of high temperatures and very low RH (Relative Humidity) a Rivulis frost protection systems will help save the crop. By activating the system, the air humidity levels will rise substantially and the temperatures will drop, in-turn, alleviating plant stress almost.

Cooling only systems can use lower flow rates but still require good design and water analysis.

Active frost protection with sprinklers

The use of sprinklers for frost protection is one of the most well known, efficient, and reliable methods of frost protection. There are different methods, but the principals are universal.

A minimum application rate of 3.0 mm/h is required. This is enough to provide protection at temperatures as low as -3˚C. Another 0.5 mm/h is required for every additional drop of one degree.

For example: if the temperature is -4.0˚C, the minimum application rate will be 3.5 mm/h (35 m3/ha/hour).

We will divide the sprinkler frost protection to 3 methods:



Overhead full cover

Targeted individual protection





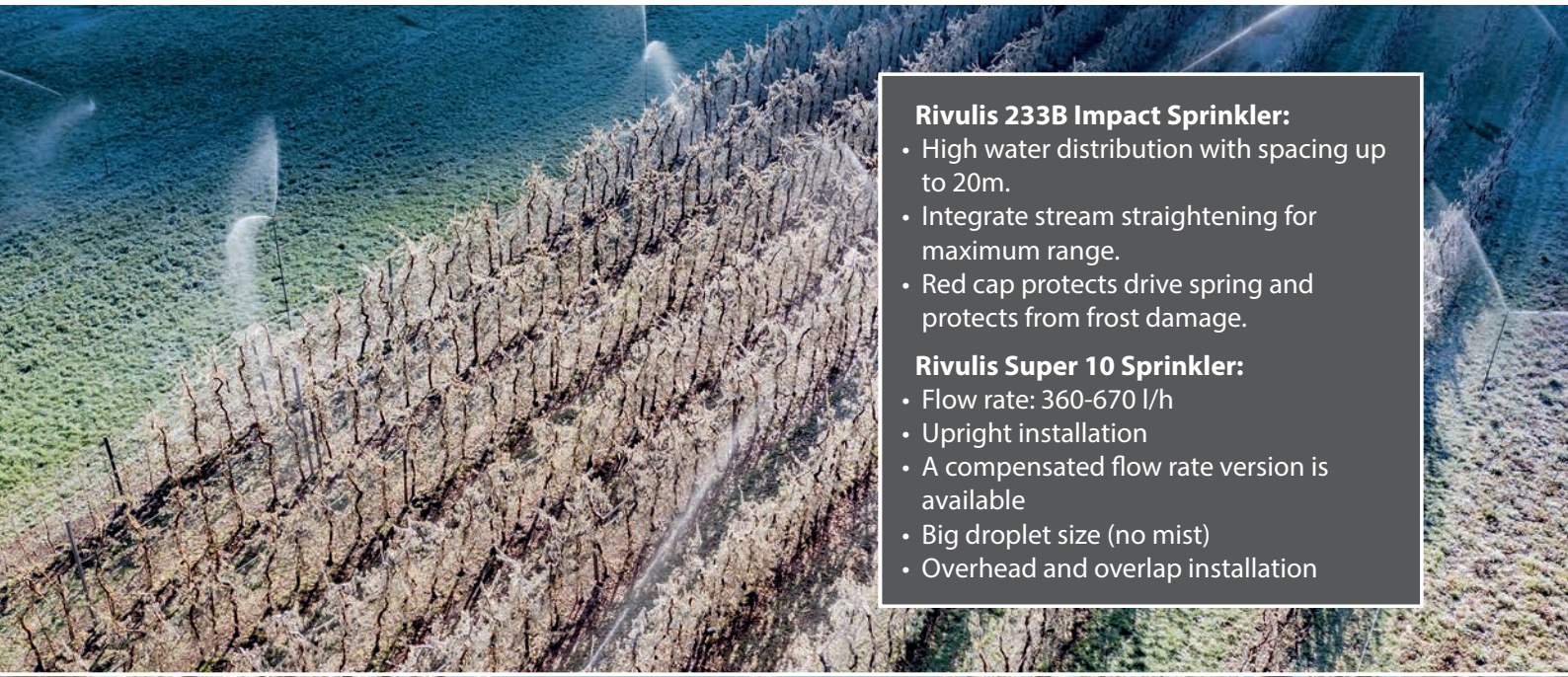
Under-tree protection

Overhead full cover protection

Using a large sprinkler such as the Rivulis 233B for wide spacing, or the Super 10 for smaller spacing, overhead full cover frost protection is a good solution that can give very good frost protection to the crops with minimum investment (provided the use of a good design, right product and implementation).

The overhead full cover method uses heavy duty, high grade, resilient sprinklers positioned strategically over the canopy of the plantation. The whole plot receives high application rate with no blind spots and nothing is left to chance.

The overhead full cover method requires a relatively very low number of sprinklers per Ha and is therefore easy to maintain. The drawback of this system is need a high volume of water to operate.



Rivulis 233B Impact Sprinkler:

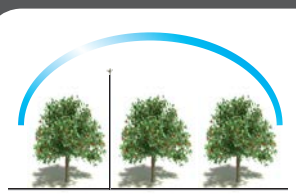
- High water distribution with spacing up to 20m.
- Integrate stream straightening for maximum range.
- Red cap protects drive spring and protects from frost damage.

Rivulis Super 10 Sprinkler:

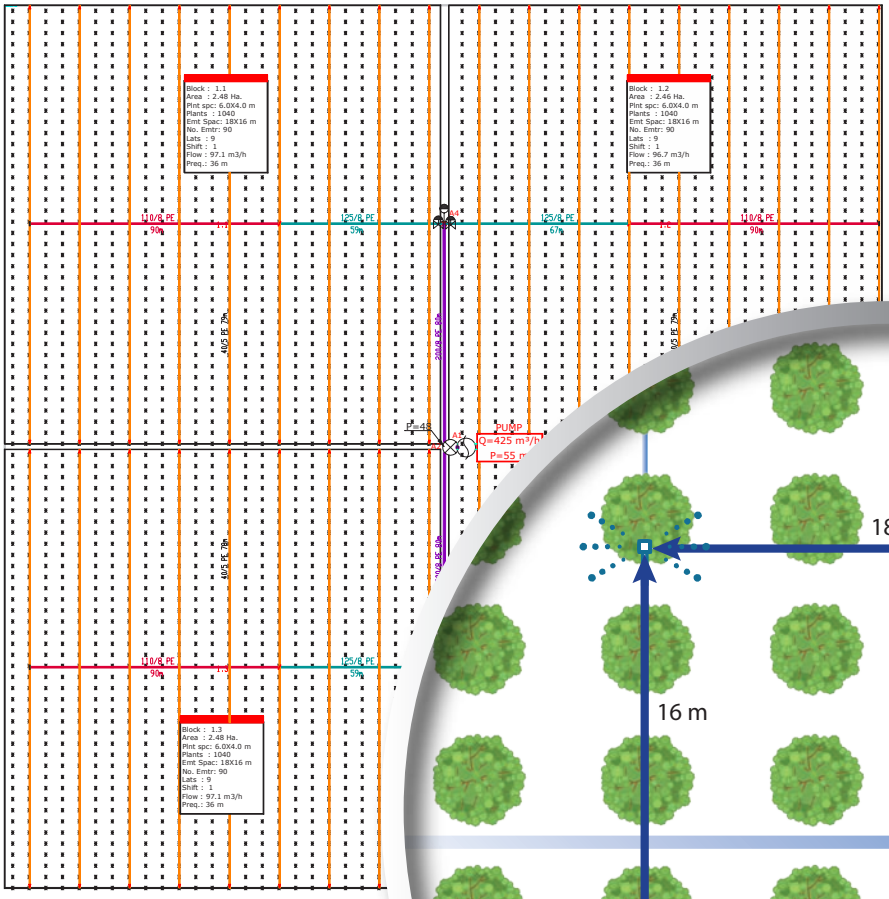
- Flow rate: 360-670 l/h
- Upright installation
- A compensated flow rate version is available
- Big droplet size (no mist)
- Overhead and overlap installation



Typical design for overhead full cover protection



FLAT AREA





Design and Irrigation Data

Design/irrigation parameters	Units		
Crop		Orchard	
Irrigation area (net)	Ha.	10	
Water source type			
Crop spacing	m	6X4	
Type of irrigation system		Frost Protection	
Emitter type		Metal Impakt Sprinkler	
Emitter flow rate	l/h	1050	
Emitter spacing	m	16	
Lateral spacing	m	18	
Number of laterals per row		1	
Irrigation rate	mm/h	3.65	
Average peak consumptive use	mm		
Irrigation interval	days		
Water application per irrigation	mm		
Time of irrigation per operation	h		
Number of operations per cycle		1	
Max. discharge per operation	m³/h	388	
Min. discharge per operation	m³/h		
Max. total irrigation time per cycle	h		
Min. required emitter pressure head	m	30.0	
Required pressure head at water source (outlet)	m	55.0	
Existing pressure	m		

Legend

	Well		Pressure regulator
	Pump		Flow m³/h
	Control head,filtration and fertilization		Head loss (m)
	Filter		Pressure (m)
	Valve		Existing pressure (inlet) m. / Required pressure (outlet) m.
	Hydraulic valve	M	Total emitters/trees
	Pressure reducing valve		Non return valve
	Pressure sustaining valve	PIPE DIAMETER / PIPE LENGTH	Main line/Submain
	Vacuum breaker	DIA. BRANCH / No. EMITTERS / LENGTH OF BRANCH (M)	Lateral
	Air valve		Line End / Reducer

Pipe Diameters

Ø32	Ø140	1 Valve
Ø40	Ø160	2 Valves
Ø50	Ø200	3 Valves
Ø63	Ø225	4 Valves
Ø75	Ø250	5 Valves
Ø90	Ø280	6 Valves
Ø110	Ø315	7 Valves
Ø125	Ø355	8 Valves

Targeted and strip method individual protection

This method uses overhead micro sprinklers such as Rivulis AquaMaster 2005 & AquaSmart 2002 or Flipper for Stript method.

In this case, a single sprinkler is positioned above each and every tree, and its flow rate and the wetting area it provides protect the specific tree.

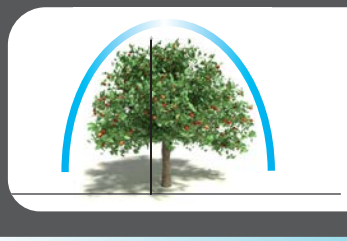
Targeted protection has the distinct advantage using lower flow rates compared to the overhead full cover method. Subsequently, the water requirements per Ha are also much lower. Besides the fact that lower water requirements provide operational savings, it also means that with a given amount of available water, the farmer can actually provide protection for a larger area.

The targeted protection method provides localized frost protection by targeting the trees and the trees alone, thus, avoiding the irrelevant spaces between the rows. Providing that the system was properly designed, the targeted protection method is much more water use and economically efficient.

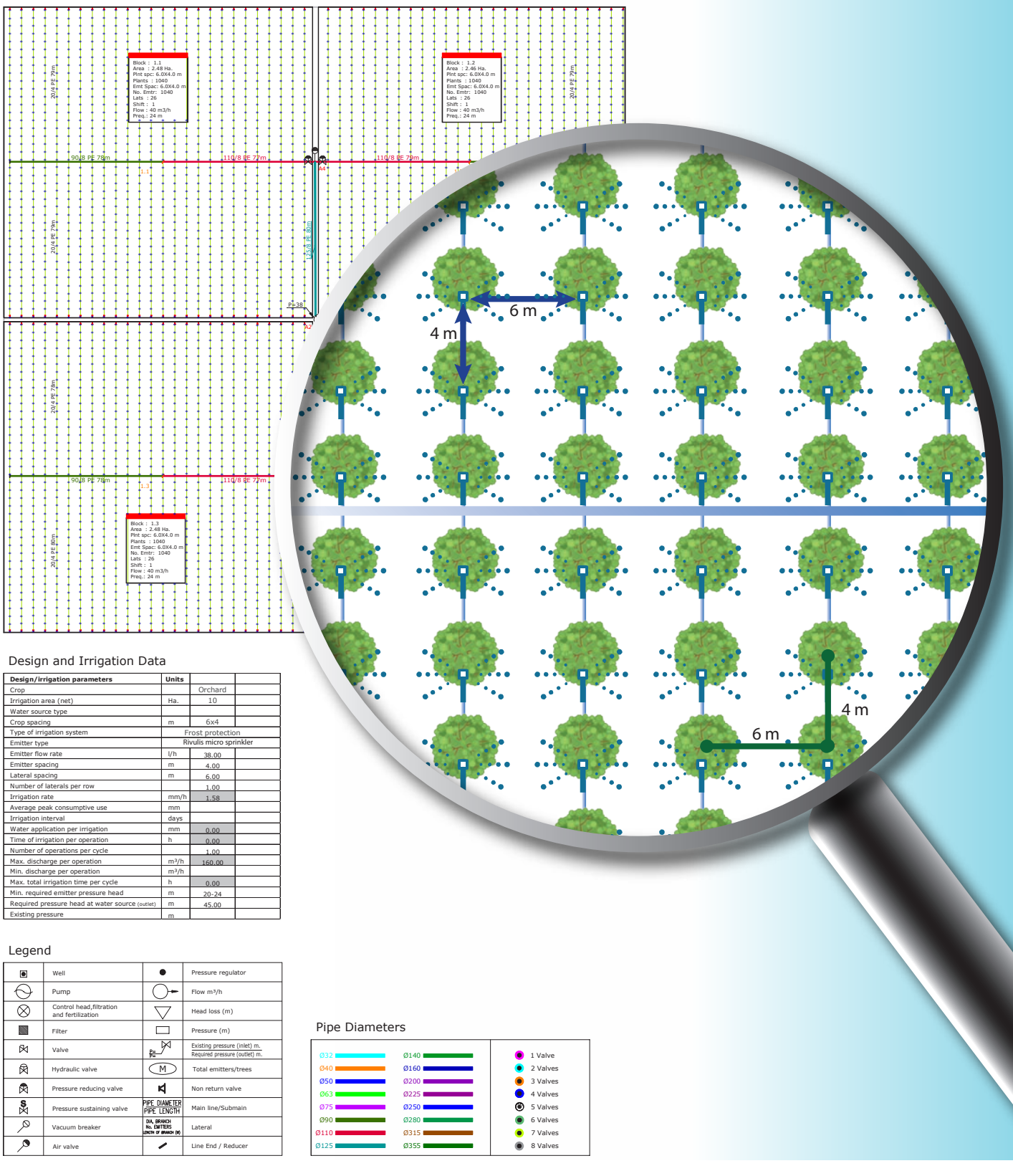
Tropical and subtropical crops that might be subjected to winter frosts are very suitable for this approach and can benefit a lot from a targeted frost protection.



Typical design for targeted individual protection



FLAT AREA



Design and Irrigation Data

Design/irrigation parameters	Units		
Crop		Orchard	
Irrigation area (net)	Ha.	10	
Water source type			
Crop spacing	m	6x4	
Type of irrigation system	Frost protection		
Emitter type	Rivulis micro sprinkler		
Emitter flow rate	l/h	38.00	
Emitter spacing	m	4.00	
Lateral spacing	m	6.00	
Number of laterals per row		1.00	
Irrigation rate	mm/h	1.58	
Average peak consumptive use	mm		
Irrigation interval	days		
Water application per irrigation	mm	0.00	
Time of irrigation per operation	h	0.00	
Number of operations per cycle		1.00	
Max. discharge per operation	m³/h	160.00	
Min. discharge per operation	m³/h		
Max. total irrigation time per cycle	h	0.00	
Min. required emitter pressure head	m	20-24	
Required pressure head at water source (outlet)	m	45.00	
Existing pressure	m		

Legend

	Well		Pressure regulator
	Pump		Flow m³/h
	Control head,filtration and fertilization		Head loss (m)
	Filter		Pressure (m)
	Valve		Existing pressure (inlet) m. Required pressure (outlet) m.
	Hydraulic valve	M	Total emitters/trees
	Pressure reducing valve		Non return valve
	Pressure sustaining valve	PIPE DIAMETER PIPE LENGTH	Main line/Submain
	Vacuum breaker	DIA, BRANCH No. EMITTERS LENGTH OF BRANCH (M)	Lateral
	Air valve		Line End / Reducer

Pipe Diameters

Ø32	Ø140	1 Valve
Ø40	Ø160	2 Valves
Ø50	Ø200	3 Valves
Ø63	Ø225	4 Valves
Ø75	Ø250	5 Valves
Ø90	Ø280	6 Valves
Ø110	Ø315	7 Valves
Ø125	Ø355	8 Valves

Under-tree protection

Sprinklers positioned under the trees in a plantation also have the ability to provide frost protection. In some cases, this might act as an incentive for choosing one kind of irrigation approach over another. In other cases, plantations which are being irrigated by under-tree sprinklers can benefit from it by already having a functional frost protection system.

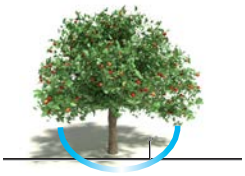
Sprinklers such as Rivulis AquaSmart 2002, AquaMaster 2005 & Rondo are well suited for both irrigation and frost protection purposes.

Some people favor this kind of frost protection method because it does not necessitate an additional system and it is already there from day one.

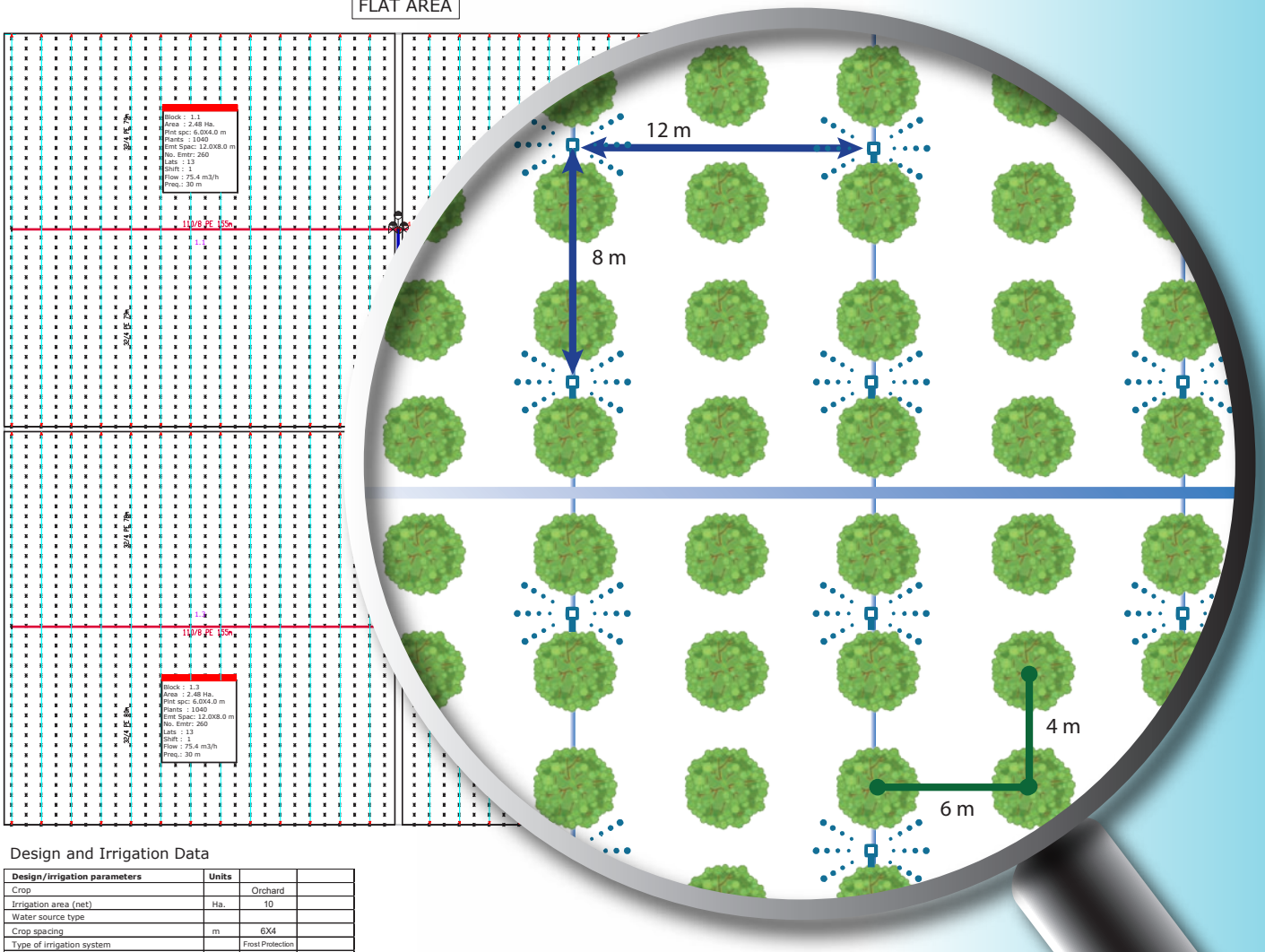
However, the under-tree method is limited. This method can provide frost protection under temperatures no lower than -2.5˚C. Even then, under certain circumstances, while providing protection to the lower layers of the tree, some damage can occur in the higher layers. In short, under-tree protections is an adequate option, but only for specific conditions.



Typical design for under-tree protection



FLAT AREA



Design and Irrigation Data

Design/irrigation parameters	Units		
Crop		Orchard	
Irrigation area (net)	Ha.	10	
Water source type			
Crop spacing	m	6X4	
Type of irrigation system		Frost Protection	
Emitter type		Rivulis sprinkler	
Emitter flow rate	l/h	290	
Emitter spacing	m	8	
Lateral spacing	m	12	
Number of laterals per row		1	
Irrigation rate	mm/h	3.02	
Average peak consumptive use	mm		
Irrigation interval	days		
Water application per irrigation	mm		
Time of irrigation per operation	h		
Number of operations per cycle		1	
Max. discharge per operation	m³/h	302	
Min. discharge per operation	m³/h		
Max. total irrigation time per cycle	h		
Min. required emitter pressure head	m	25.0	
Required pressure head at water source (outlet)	m		
Existing pressure	m		

Legend

	Well		Pressure regulator
	Pump		Flow m³/h
	Control head,filtration and fertilization		Head loss (m)
	Filter		Pressure (m)
	Valve		Existing pressure (inlet) m. / Required pressure (outlet) m.
	Hydraulic valve	M	Total emitters/trees
	Pressure reducing valve		Non return valve
	Pressure sustaining valve	PIPE DIAMETER / PIPE LENGTH	Main line/Submain
	Vacuum breaker	DIA, BRANCH / No. EMITERS / LENGTH OF BRANCH (M)	Lateral
	Air valve		Line End / Reducer

The system shown uses Rivulis sprinklers for irrigation and frost protection. The Rivulis sprinklers has a wide wetting radius.

If you use Rivulis AquaSmart 2002 or Rondo micro-sprinklers, you will need closer sprinkler spacing, and by consequence, generally a lateral for every row of trees.

Pipe Diameters

Ø32	Ø140	1 Valve
Ø40	Ø160	2 Valves
Ø50	Ø200	3 Valves
Ø63	Ø225	4 Valves
Ø75	Ø250	5 Valves
Ø90	Ø280	6 Valves
Ø110	Ø315	7 Valves
Ø125	Ø355	8 Valves

Getting the right design

In the previous pages, there are examples of typical designs of the three common active frost protection methods using sprinklers. However, there is no one size fits all.

In fact, every system is unique and is impacted by:

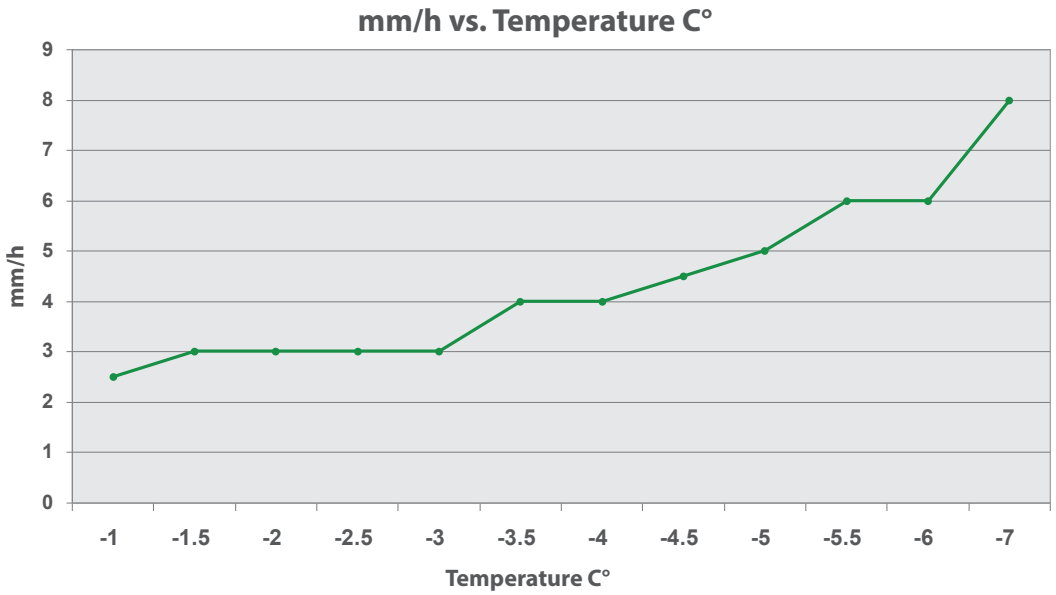
- **Method:** Overhead / individual / under-tree frost protection
- **Application rate required:** Heavily impacted by the minimum temperature it will need to provide protection for (see graph below)
- **Sprinkler used:** Rivulis AquaMaster 2005, AquaSmart 2002, Rondo, Super 10 & 233B
- **Crop spacing and layout**

Rivulis Hydraulic Design Services

Don't leave it to chance. Rivulis has decades of experience of designing frost protection systems around the world. Our team of engineers will design for you a system that gives you the best chance of protection against frost, while also providing a system that is economical, both in terms of up-front and ongoing costs.



Water requirement: mm/h vs temperature



When to start up your frost protection sprinkler irrigation system

Knowing when to activate your frost protection system is critically important. There are multiple theories and models and calculations to determine the precise point of activation. We will try and make things as simple as possible.

Be careful

When water evaporates (turning from liquid to gas) it absorbs energy and cools its environment.

However, when the sprinklers are first activated, they actually cause the temperature to drop. It is only when the evaporation ceases that the actual frost protection begins.

In other words, activating the system too late might cause more harm than good.

The drier the air, the longer the evaporation process. The higher the RH (relative humidity) the faster the evaporation ceases.

Knowing the "Dew Point" (temperature at which air reaches 100% relative humidity) allows you to determine the point of system activation.

Dew points are sometimes available on line. However, knowing the RH and the temperatures, the table below can help you find the dew point quickly.

RECOMMENDED STARTUP TEMPERATURES FOR FROST PROTECTION AT VARIOUS DEW POINTS	
Dew point temperature °C	**Startup air temperature °C**
-9.5	+4.0
-9.0	+4.0
-8.5	+3.5
-8.0	+3.5
-7.5	+3.0
-6.5	+3.0
-6.0	+3.0
-5.5	+2.0
-5.0	+2.0
-4.5	+1.5
-4.0	+1.5
-3.0	+1.0
-3.0	+1.0
-2.0	+0.5
-1.5	+0.5

Generally, crop sensitivity to freezing temperature increases from first bloom to the small nut / fruit stages. This is when a crop is most likely to be damaged. Sensitivity is also higher when warm weather has preceded a frost night.

Recommendations for starting and stopping temperature that are given here can be used for either over-plant or under-plant sprinklers. All sprinklers in a protection area should be activated when the air temperature drops to the temperature selected from table above. This ensures that the wet-bulb temperature will be above the critical damage temperature. Emitters can be turned off when the air temperature exceeds the value from table.

DEW-POINT TEMPERATURE (°C) FOR A RANGE OF AIR TEMPERATURE AND RELATIVE HUMIDITY						
Relative Humidity	**Temperature °C**					
%	**0.0**	**2.0**	**4.0**	**6.0**	**8.0**	**10.0**
100	0.0	2.0	4.0	6.0	8.0	10.0
90	-1.4	0.5	2.5	4.5	6.5	8.4
80	-3.0	-1.1	0.9	2.8	4.8	6.7
70	-4.8	-2.9	-1.0	0.9	2.9	4.8
60	-6.8	-4.9	-3.1	-1.2	0.7	2.6
50	-9.2	-7.3	-5.5	-3.6	-1.8	0.1
40	-12.0	-10.2	-8.4	-6.6	-4.8	-3.0
30	-15.5	-13.7	-12.0	-10.2	-8.5	-6.8

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Rivulis AquaSmart 2002 / AquaMaster 2005 Micro Sprinklers

✔ Targeted individual protection (AquaMaster 2005 Model Only)
✔ Under-tree protection



AquaSmart 2002



AquaMaster 2005

Model	AquaSmart 2002	AquaMaster 2005
Flow rates (l/h)	20, 28, 35, 47, 55, 70, 95 (at 2.0 bar presure)	30 – 365 l/h
Flow regulation	Yes	No
Operating pressure (bar)	1.5 – 4.0	1.5 – 3.0 bar
Anti-Insect	Standard on all models	Standard on all models
Inlets	4/7 barb, female, quick thread, 3/8" BSP thread	4/7 butterfly barb, quick thread, 3/8", 1/2" BSP

Rivulis 233B impact metal sprinkler

✔ Overhead full cover protection
✔ Targeted individual protection



- High water distribution
- Easy service
- Durability for optimal performance

Model	233B Metal Impact Sprinkler High Angle
Flow Rate (l/h)	790-3540
Flow regulation	No
Operating Preassure (bar)	3.0 - 5.0 bar
Inlet	3/4" male or female threaded
Nozzles	1 or 2
Nozzle sizes (mm)	3.5 - 6.0

Rivulis Super 10 sprinkler



✔ Overhead full cover protection
✔ Targeted individual protection

Model	Super 10
Flow rates (l/h)	360 l/h - 670 l/h at 2.5 bar
Flow regulation	Optional
Operating pressure (bar)	2.5-4.0 bar w/o regulator 3.0-5.0 bar with regulator
Inlets	1/2" male threated

Rivulis Flipper micro sprinkler

The most efficient frost protection for vineyards and other row orchards

- ✔ Spreads water in a very long and narrow strip
- ✔ Saves up to 70% of water compared to conventional overhead systems
- ✔ Safe operation under frost conditions
- ✔ Optional flow regulator for hilly terrain or long rows



Performance table

Nozzle color	Vineyard with 3.0 m row spacing	% of water saving	Vineyard with 2.5 m row spacing	% of water saving
Black	14.0	65	16.0	58
Violet	16.6	58	20.0	50
Brown	16.0	60	19.0	52

* When Flippers are at maximal spacing, at 2 bar

Amount of water (m^3/ha/hr) required by flipper

frost protection system* and water saving compared to conventional 40 m^3/ha/hr system

Nozzle color	Flipper color	Flow rate (l/h) (at 2 bar)	Maximal recommended spacing (m) between flippers**
Black	Black	25*	6.0
Violet	Black	35*	7.0
Brown	Brown	43*	9.0

* For regulated unit: 2.5-4.0 bar
** When Flippers mounted 1.0 m above the target

The keys to frost protection success:

- High quality hydraulic design.
- Reliable head control with sufficient filter capacity.
- Ensure the system is ready and test it well before a frost event is expected.
- Be in the field to monitor during the event.
- Keep an eye on hydraulic components as they can freeze.
- Monitor temperatures constantely.
- Stay informed about the weather.
- Monitor flow and pressure of the system.
- Be ready to act with tools and spare parts.
- Make improvements as needed after frost events.



FROST PROTECTION



Case study outcomes are for information purposes only and actual results may vary. This literature has been compiled for worldwide circulation and the descriptions, photos, and information are for general purpose use only. Please consult with an irrigation specialist and technical specifications for proper use of Rivulis products. Because some products are not available in all regions, please contact your local dealer for details. Rivulis reserves the right to change specifications and the design of all products without notice. Every effort has been used to ensure that product information, including data sheets, schematics, manuals and brochures are correct. However information should be verified before making any decisions based on this information.