

DRIP IRRIGATION MODULE

SECTION 1

DRIP IRRIGATION - PRINCIPLES

Table of Contents

Table of Contents	2
1 Introduction	3
2 Objectives	3
3 A Brief History on the Development of Drip Irrigation	4
3.1 The start of drip irrigation	4
3.2 Development of laminar flow products	4
<i>The Luz Method</i>	4
<i>The Blass and Mottes Method</i>	4
3.3 Development of turbulent flow products	5
3.4 Development of Pressure compensation devices	5
3.5 Development of integral driplines and tapes	6
4 Definitions, Materials and Dimensions	7
4.1 Definitions	7
4.2 Materials	9
4.3 Dimensions	10
5 Soil Water Plant relationships	12
5.1 Root zone Management	12
<i>Advantages of Concentrated Root Volume</i>	13
5.2 Determining Dripper Spacing	13
<i>Water Movement in the Soil</i>	13
6 The concept of Uniformity	15
7 Brief Overview of types of applications	16
7.1 Drippers – online	16
7.2 Dripline and Tapes	17
7.3 Subsurface	17
7.4 Reuse of Treated Wastewater	17
7.5 Landscape	18
8 Selection and Design principles	18
9 Installation, Operation and Maintenance	20
9.1 Installation	20
9.2 Operation	20
9.3 Maintenance	20
10 Summary and Conclusion	21
11 Questions	22
11.1 Beginner	22
11.2 Intermediate	23
11.3 Advanced	24

1 Introduction

Although drip irrigation is relatively new, it has achieved a distinctive place among more traditional irrigation methods and is rapidly spreading throughout the world. The positive response of crops and plants to this form of irrigation has changed existing ideas and created entirely new growing methods.

The main advantages born from drip irrigation in agriculture are higher and improved yields, dramatic increase in water use efficiencies, and facilitation of other agro-technical operations performed in the field.

Recent product developments, has made drip a vital, integral component in landscape irrigation. Its many advantages include use of treated wastewater and reduced vandalism.

Through the years, there has been great technological improvement with much of this technology coming out of Israel, who have invested much effort and resources into R & D. Netafim are market leaders in this field. This has led to the development of drippers and other drip-system equipment with a very high level of reliability for all types of water and field conditions.

2 Objectives

The objectives of this section are

- ◆ Summarize the history and development of drip irrigation
- ◆ To provide a working knowledge of definitions, materials, dimensions, basic soil water plant relationships and the concept of uniformity
- ◆ To present a brief overview on the types of applications for drip
- ◆ To ensure a good understanding of the above subjects
- ◆ Mention other related subjects which will be covered in more detail in later sections

3 A Brief History on the Development of Drip Irrigation

3.1 The start of drip irrigation

- 1860 Originally developed in Europe as sub-irrigation using clay pipes in a combined system with tube drainage.
- 1913 U.S.A. study in Colorado concluded too expensive for practical use
- 1920 Perforated pipe used in Europe, sub-irrigation experiments conducted.
- 1940 Development of plastics during WW2 made drip more economically feasible
- 1945-1962 Extensive research in underground irrigation (Europe, USA, Israel, Aus, NZ)
- 1962-1970 Commercial investment in drip development, but filtration, design, management and maintenance problems prevented large-scale adoption.
- 1970...New Filters developed, experience overcame previous problems and large scale adoption commenced.

3.2 Development of laminar flow products

Israel began commercial operation of drip irrigation in the 1960's with the help of some key research.

The Luz Method

Ephraim Luz experimented with perforated 4-6mm pipes using 0.1mm holes, discharging 0.1-0.3l/hr at 20m pressure, but these clogged quickly. Later in manufacturing, holes were cut by laser and filtration was improved, but this method did not stand the test of time.

The Blass and Mottes Method

Simcha Blass and Jacob Mottes used a tubelet dripper with an inner diameter of 1.2-1.4mm, a length of 1-3m and a discharge of 2l/hr at 10m pressure. The system was buried at 40cm but suffered clogging from root intrusion. The manufacturing process was taken over by Netafim who produced a long path emitter on a 12mm lateral, again buried underground. However root intrusion problems remained.

Yehuda Zohar proved in his field trials during 1963/64 that the same crop results could be achieved with surface location of the driplines. This became the predominant method, however subsurface systems continue to be developed and refined.

Laminar flow Drippers worked on the principle of high head loss, by water flowing through a long path. The friction reduced the pressure so that in the end, there was a slow laminar flow of about 2l/hr. Water moves in a very orderly way with very little mixing between the pathway wall and pathway center. Because velocity near the wall is much lower than the center, particles settle and build up, restricting pathway size and eventually blocking up the pathway. This dripper suffered long term clogging problems hence the need to develop a more aggressive self-cleaning dripper. Refer to Figure 1 below

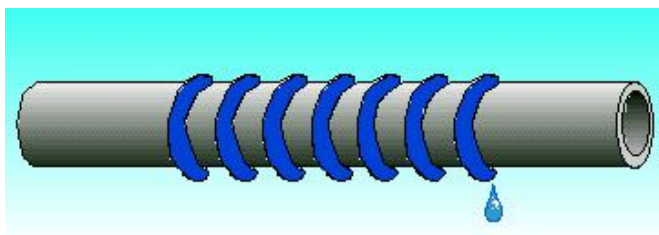


Figure 1

Laminar flow path dripper

3.3 Development of turbulent flow products

The early 1970's saw the development of the turbulent flow path. Water moves in a very unorganized way due to the internal "teeth" design of the flow path. This encourages vigorous mixing of water and maintains a high velocity on the dripper wall, sweeping clay and silt particles to the center of the pathway, so they can be flushed out of the emitter.

Turbulent flow has a greater energy loss than laminar flow. This allowed Netafim to develop wider and shorter pathways, which also have reduced risk of blockage. Turbulent flow drippers are the predominant type of emitter found in drip irrigation today.

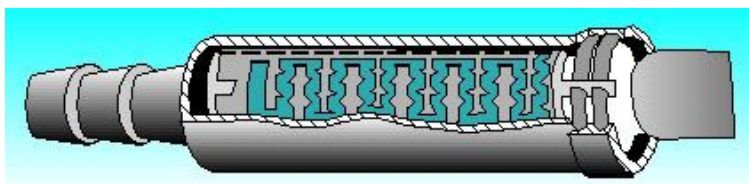


Figure 2

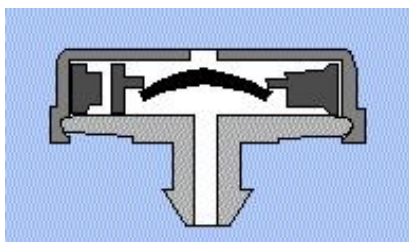
Turbulent flow passage

3.4 Development of Pressure compensation devices

The first pressure compensating emitters were developed by Netafim in the mid 1970's. This requirement arose with uneven and sloping topography and the need to achieve longer run lengths with higher pressure.

Constant dripper flow rate within a given pressure range (0.6 – 40m), is usually accomplished with a diaphragm. Compensation occurs because increasing pressure deforms the flexible diaphragm, which restricts the flow path to maintain a constant output. Refer Figure 3 below

Figure 3

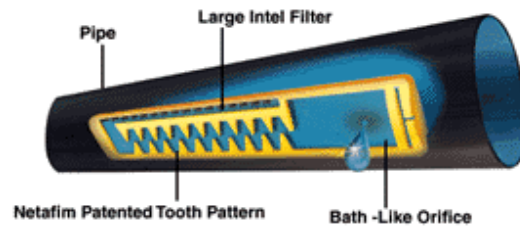


PC Dripper – online/button

3.5 Development of integral driplines and tapes

Until mid 1970, driplines used either inline drippers or external button drippers. This was a manufacturing headache and very time consuming if assembled on farm. The need for an integral dripline was very evident and Netafim started to produce integral driplines. This was made possible due to the development of the Ram and Turbonet drippers. Refer figures 4, 5, 6 and 7 below

Figure 4



"Typhoon" non PC dripline for integral driplines

Figure 5



Ram" or
"Dripmaster"
emitter

Figure 6



"Ram" or "Dripmaster" PC
integral dripline

4 Definitions, Materials and Dimensions

4.1 Definitions

Head Loss - Loss of head pressure in a system

Friction Loss – Energy Loss as a result of two materials rubbing together and burning energy

Pressure Loss – Loss of pressure due to water travelling through a pipe network where friction losses reduce the water pressure over distance.

Velocity – The speed of water movement measured in meters per second (m/s)

Static Head – Pressure at a given point where there is no flow in the system

Throttling – Technique of reducing pressure through a pipe by reducing flow either via a manual gate valve or reducing pipe sizes so that friction loss is increased

Flow Variation (F.V.) – This defines the differences between extreme emitters in a block or along a single lateral.

Emission Uniformity (E.U.) – Estimates the irrigation efficiency, by dividing the minimum emitter flow rate by the average emitter flow rate.

Coefficient of Variation (Cv) – Classification of manufacturing quality of dripper. I.e. the variation of flow, between same flow drippers from brand new.

Flow rate Calculations – Flow rate of a non-compensating dripper is calculated using the following formula

$$Q = K \times P^x$$

Where

Q = Flow rate of dripper (l/hr)

K = Constant

P = Pressure (m)

x = Flow Exponent

Some examples of flow calculations for different Netafim drippers are shown below. What is important to note is that all of the x – Exponent values are less than 0.50. A pressure compensating dripper exponent will be zero because a change in pressure does not affect the flow. The closer to zero that the exponent is for a non-compensating dripper the less effect a change in pressure has on its flow, therefore the dripper becomes closer to a pressure regulating mechanism.

Table 1

Dripline Product	Nominal Flow Litres per hr	Flow rate formula
Streamline 60/80/100/125	1.05	$Q = 0.373 \times P^{.45}$
Streamline 60/80/100/125	1.6	$Q = 0.568 \times P^{.45}$
Super Typhoon 100/125	1.1	$Q = 0.390 \times P^{.45}$
Super Typhoon 100	1.6	$Q = 0.530 \times P^{.48}$
Super Typhoon 125	1.65	$Q = 0.546 \times P^{.48}$
Super Typhoon 100	2.5	$Q = 0.828 \times P^{.48}$
Super Typhoon 125	2.6	$Q = 0.861 \times P^{.48}$
Python 100/135	1.05	$Q = 0.373 \times P^{.45}$
Python 100/135	1.55	$Q = 0.513 \times P^{.48}$
Python 100/135	2.5	$Q = 0.887 \times P^{.45}$
Ozline 135	0.8	$Q = 0.276 \times P^{.48}$
Ozline 135	1.1	$Q = 0.370 \times P^{.45}$
Ozline 135	1.6	$Q = 0.563 \times P^{.48}$
Ozline 135	2.6	$Q = 0.861 \times P^{.48}$
Dripline 2025	1.2	$Q = 0.416 \times P^{.46}$
Tiran 20	2.0	$Q = 0.662 \times P^{.48}$

Netafim drippers lead the industry with the lowest exponents and therefore have the best flow / pressure relationships.

Wall Thickness – (A measure of the dripline wall thickness is commonly expressed as Mil) One Mil is 1/1000” (one thousandth of an inch). There are 40 mil to a metric mm. Example Streamline 80 refers to a wall thickness of 8mil or $8/40 = 0.2\text{mm}$. Python 150 has a wall thickness of 15 mil or $15/40 = 0.38\text{mm}$

Dripper Labyrinth – Pathway through which water flows through a dripper. It has a length, breadth and depth. A larger cross sectional area and shorter length offers higher resistance to clogging.

Field Capacity (F.C.) – Moisture level where the large pores in soil are full of air and the small pores are full of water. This is the ideal soil/water/plant condition. All excess water has drained, and the soil reservoir is “full”.

Wilting Point (W.P.) – Moisture level in the soil where the plant cannot replenish the loss of moisture to the atmosphere and the plant wilts.

Available Water (A.W.) – Also know as RAW (readily available water) is the amount of water between Field Capacity and Wilting Point, which is readily available for the plant to absorb.

Saturation – All pores of the soil are full of water and most of the air is pushed out.

Pan Evaporation (Ep) – The quantity of water evaporated from Class A pan (mm)

Evapotranspiration (E.T) – The process whereby plants take up water via the root system, transport and metabolize the water and finally transpire water from leaves in the form of water vapor.

Potential Evapotranspiration (ETo) – Potential Evapotranspiration calculated to match water use by a well-watered, mown grass crop.

ETo (Grass reference) = 76% - 82 % of Pan Evaporation (Ep)

Crop Coefficient/Factor – Percentage of Ep based on type and stage of crop

Precipitation rate - Calculation of mm/hr of water applied to the irrigated area. One liter of water applied over 1m² = 1mm

4.2 Materials

Netafim driplines are made from a high-density polyethylene

Netafim Drippers are made from polypropylene impregnated with a carbon based master batch, to ensure UV protection in the long term.

Diaphragm used in the ram dripper is made from EDPM rubber, which is resistant to most chemicals.

4.3 Dimensions

Firstly looking at Driplines and Tapes

Table 2

Product	Max P (m)	OD (mm)	ID (mm)	Wall thickness (mm)	Mil
Streamline 60	6.5	16.4	16.1	0.15	6
Streamline 80	8.5	16.4	16	0.2	8
Streamline 100	10	16.5	16	0.25	10
Streamline 125	14	16.5	15.9	0.31	12.5
Super Typhoon 100	10	16.5	16	0.25	10
Super Typhoon 125	14	16.5	15.9	0.31	12.5
Super Typhoon 150	18	16.5	15.7	0.38	15
Python 100	9	21.3	20.8	0.25	10
Python 135	12	21.5	20.8	0.34	13.5
Python 150	13	21.6	20.8	0.38	15
Ozline 135	10	25.7	25	0.34	13.5
Ozline 150	11	25.8	25	0.38	15
Dripline 2000	30	17	15.2	0.9	36
Dripline 2025	30	22.6	20.8	0.9	36
Tiran 17	35	17	14.6	1.2	48
Tiran 20	35	20	17.6	1.2	48
Miniscape 8mm	30	8	6	1	40
Scapeline 16	30	16	13.2	1.4	56
Techline 16	40	16	13.2	1.4	56
Dripmaster 17D	40	16.4	14.4	1	40
Dripmaster 20	40	19.9	17.5	1.2	48
Dripmaster 2025	30	22.6	20.8	0.9	36

As can be seen from the above table, Netafim has the widest range of driplines on the market. Coupled with an excellent range of drippers and flow rates, Netafim are able to provide a versatile package for any commercial, agricultural, industrial or landscape irrigation project.

Now looking at the emitters themselves

The most noticeable differences between Netafim drippers and other brands of the market is the depth of the dripper. From the examples below, in all cases the dripper flow path depth is the very close to, or is the same as the width. This is very important when particles enter the dripper flow path. Their size is related to the dripper filter so once they enter the flow path they have a wide and deep cross sectional area to move in. Because the dripper has a short flow path and angled teeth, the particles cannot sit still and are moved out of the dripper. Therefore these drippers are self-cleaning and less prone to clogging than drippers with smaller width-depth dimensions. Refer to Figure 7 below

Table 3

Dripper	Nom Flow L/hr	Dripper Flow Path		
		Length (mm)	Width (mm)	Depth (mm)
Streamline	1.05	12.8	0.52	0.44
Streamline	1.60	12.8	0.67	0.52
Typhoon	1.10	22.8	0.62	0.60
Typhoon	1.75	20.0	0.70	0.70
Typhoon	2.80	18.1	0.82	0.85
Ram	1.6	19	1.00	1.00
Ram	2.3*	15	1.04	1.04
Ram	3.5	15	1.22	1.22
Tiran	2	135	1.0	1.1
Tiran	4	95	1.38	1.38
Tiran	8	46	2.0	2.0

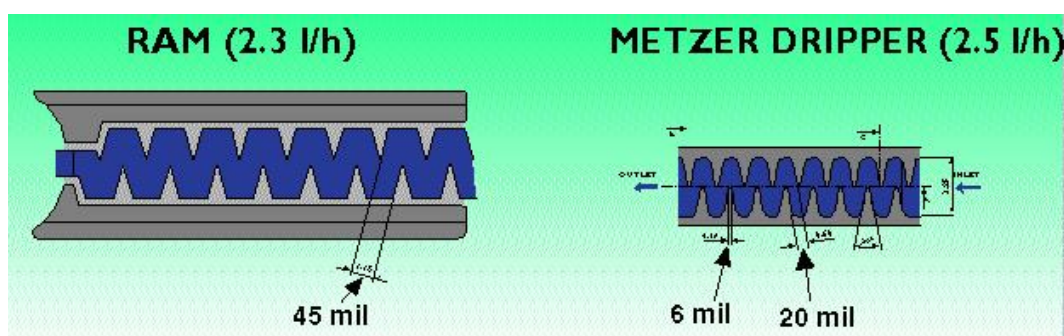


Figure 7

Comparison of Netafim flow path to others of higher flow

5 Soil Water Plant relationships

Water flow through a plant from its roots to its leaves is called *Mass Flow*. It is much greater than the amount of water the plant needs for its direct nourishment. Mass flow carries essential elements to the canopy. In order to generate energy for this process the plant roots must *Respire*. The optimal concentration of air needed in the soil to ensure free breathing of the roots is about 10% of soil volume.

The goal is to ensure maximum moisture in the soil and optimal air concentration. If this goal is achieved we can maximize yield and quality. Control of the soil environment is called *Root Zone Management*.

5.1 Root zone Management

Soil is a porous media and soil pores vary greatly in size. Water in the soil is held by capillary forces, which are stronger than gravitational forces. Water can flow in the soil in two basic patterns

- ◆ *Saturated Flow* which equals piston flow
- ◆ *Non-Saturated Flow* from a point source emitter.

Research has shown that in order to avoid stress to plants, irrigation should be applied to replenish the moisture when the plant reaches not more than 20 - 50% of Available Water.

Example

How can we calculate the proper intervals between irrigation cycles in tree crops?

<i>The crop</i>	peach trees 6m x 3.6m
<i>The soil</i>	medium to heavy
<i>A.W.</i>	466,830 litres per Ha, per 300mm of depth of soil
<i>Effective root zone depth –</i>	900mm
<i>Daily consumption of peach orchard –</i>	74,700 litres/Ha/day in peak season
<i>Irrigation threshold –</i>	50% of A.W.

Max amount of water available for trees in the given root zone is
 $466,830 \times 3 \times 50\% = 700,245$ liters per Ha.

Option 1 – If we irrigate 100% of area (flood or sprinklers) the interval will be
 $700,245 \times 100\% / 74,700$ which is a 9 -10 day interval between irrigation cycles.

Option 2 – If we irrigate 50% of the area (mini-sprinkler) the interval will be
 $700,245 \times 50\% / 74,700$ which gives us a 5 day interval.

Option 3 – If we irrigate 25% of the area (drip) the interval will be:
 $700,245 \times 25\% / 74,700$ which gives us a 3 day interval.

In all three options we are irrigating the orchard at intervals which keep the trees from being stressed. Will the results of each option be the same? NO. The more concentrated the root zone the more effective the root system will be.

Primary Reasons why a Concentrated rootzone is more Effective

- ◆ Superior Aeration – Drip irrigation allows optimum combination of air and water. Other irrigation methods such as sprinkler and flood create piston flow, driving the air out of the effective rootzone for a period of a few hours to a few days – depending on soil type. This prevents the roots from functioning properly as they cannot generate energy to uptake nutrients and synthesize essential organic compounds.
- ◆ Improved Micro conditions – Soil moisture surrounding a rootlet is much lower than the soil moisture between the rootlets. The small envelope of dry soil covering the rootlet, slows its ability to absorb water and nutrients. In light soil this phenomenon happens very quickly and the situation can arise where average soil moisture is high but the plant cannot absorb water. A Concentrated root zone has a much higher density of roots and rootlets in any given unit of soil and so the effectiveness of fertigation supplied to the soil is much greater.

Advantages of Concentrated Root Volume

- ◆ Frequent Irrigation cycles provides stable soil moisture levels and optimal water supply to the plant.
- ◆ Non-Saturated water flow guarantees proper aeration for root activity and nutrient uptake.
- ◆ Correct air/water balance in soil produces highest quality plant development and yield.
- ◆ Concentration of roots in a limited wetted, volume greatly increases the effectiveness of fertigation
- ◆ Leaching of minerals/nutrients from the rootzone is minimized
- ◆ Precise rootzone management allows us to create and control conditions. Sometimes stressing a plant is a valuable management technique. A concentrated root zone allows this technique to be accomplished quicker and with greater control.

5.2 Determining Dripper Spacing

Soil type is the main factor when determining dripper output and spacing between drippers. It affects the patterns produced by drippers in the soil and how fast water moves in the soil. Although a drip system may deliver water uniformly, the soil profile is not uniformly wetted. Immediately under each dripper there is a saturated zone of soil, with little air available for plant roots. By correct selection of output and spacing, these areas can be minimized, while maximizing the volume of soil with a balanced zone of air and water.

Contrary to older methods of one dripper per plant, the most efficient method of using drip irrigation is to create a continuous wetted strip along a plant/vine row. The wetted strip is not always visible between drippers on the soil surface but should be present not more than 30cm below the surface, depending on soil type. Here the plants will develop a dense root system along the row, utilizing the maximum area that can be made available by the system. Saline fronts between drippers will be eliminated; the root system will be larger, more efficient and less vulnerable to water and nutrient stress.

Water Movement in the Soil

The movement of water in the soil depends on the soil characteristics and the dripper discharge. In coarse textured soils e.g. sand, the infiltration rate is high, the horizontal movement is small. In fine textured soils, e.g. clay, the infiltration rate is low and the horizontal movement greater, because of smaller air spaces between particles and stronger capillary action.

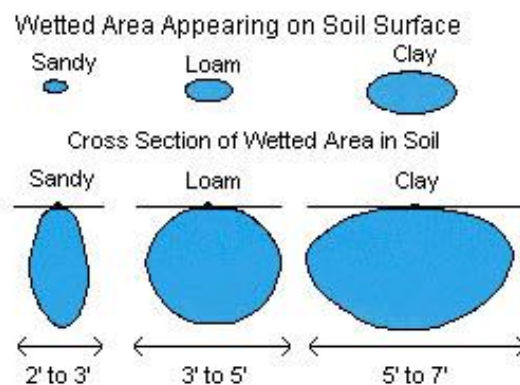
Main and opposing force affective water movement in the soil are

- ◆ Gravitational force, which pulls the water down.
- ◆ Capillary force, which causes sideways and upward movement

Refer Figure 8 below

Figure 8

Drip wetting patterns in
different soil textures



6 The concept of Uniformity

The concept of uniformity mainly applies to non-compensating driplines because Pressure Compensating driplines are designed for 100% uniformity. We can see from the flow rate calculations, as we increase pressure in a non-compensating dripper, so the flow increases. It is not directly proportional (100% pressure increase \cong 36-39% flow increase), but this relationship, together with pipe lateral length, topography and slope determine the uniformity of a lateral or block of laterals.

Flow Variation (F.V.) This defines the differences between extreme emitters in a block or along a single lateral.

$$F.V.(%) = \frac{(Q_{\max} - Q_{\min})}{Q_{\max}} \times 100$$

Where

Q_{\min} (l/hr) = lowest emitter discharge along the lateral or within the block

Q_{\max} (l/hr) = maximum emitter discharge along the lateral or within the block

Emission Uniformity (E.U.) Estimates the irrigation efficiency by dividing the minimum emitter flow rate by the average emitter flow rate, and considering the CV

$$E.U. (%) = (1 - 1.27 \times Cv/\sqrt{n}) \times \frac{Q_{\min}}{Q_{ave}} \times 100$$

Q_{\min} (l/hr) = Lowest emitters discharge along the lateral

Q_{ave} (l/hr) = Average emitters discharge along the lateral

Cv = Coefficient of variation

n = number of emitters per plant (in a row crop system = 1.0)

Coefficient of Variation (Cv) – Classification of manufacturing quality of dripper. I.e. the variation of flow, between same flow drippers when brand new.

$$Cv (%) = \frac{\text{standard deviation}}{\text{mean}} \times 100$$

Classification	Cv
Excellent	< .03
Average	.03-.07
Marginal	.07-.10
Very Poor	> .10

Netafim drippers have a Cv of < 0.03

Flow Variation is a more easily understood measure of uniformity and we can estimate Flow Variation if we are given an Emission Uniformity figure.

For example an E.U. of 90% equates approximately to an F.V of 20%. This means that if the highest flow dripper in a lateral (or a block) is flowing at 1.0 l/hr the lowest will be 0.8l/hr.

Netafim suggests the following guidelines of uniformity for different crops, especially when a fertigation system is used for crop nutrition

	F.V.	E.U
High value crops e.g Grapes,	$\leq 10\%$	$\geq 97.5\%$
Medium value crops e.g Citrus, Bananas, Vegetables	$\leq 15\%$	$\geq 92.5\%$
Low Value crops e.g. Sugar Cane	$\leq 20\%$	$\geq 90\%$

7 Brief Overview of types of applications

7.1 Drippers – online

Table 4

Type of Crop	On line drippers	Driplines and Tapes
Orchards	√	√
Nurseries	√	√
Greenhouse	√	√
Silviculture		√
Row crops		√
Plantation		√
Other field crops		√

Online/external button drippers are not common in large-scale agricultural projects due to the cost-effective economics of integral driplines. Online drippers are more commonly found in Nurseries, Orchards and Greenhouses.

Figure 9



Non PC and PC
Online drippers

7.2 *Dripline and Tapes*

Dripline and tape with integral drippers is more commonly found in medium – large scale agricultural projects. Types of crop, duration, farm machinery, insect problems are some of the factors determining selection of wall thickness. Because thick-walled driplines have a much longer life, they are normally selected for long-term crops. In Australia we can generally find the following applications

Table 5

Type of Crop	Heavy Wall Dripline	Thin Walled Tapes
Grapes	√	
Citrus	√	
Orchards	√	
Silviculture	√	
Bananas	√	√
Vegetables		√
Sugarcane		√
Fodder		√
Cotton		√

Thin walled tapes and Heavy Walled drip lines are covered in detail in the later Sections 3 and 4 of the “Drip Irrigation” module.

7.3 *Subsurface*

Subsurface Drip Irrigation (SDI) can be designed with heavy wall drip lines or thin walled tapes. The largest areas of permanent subsurface irrigation in Australia are found in Cotton and Sugar Cane. In these crops only tape products are used.

Other applications for SDI are numerous including different agricultural crops and the landscape environment. It is a safe and useful means of utilizing recycled wastewater.

SDI is covered in detail later in Section 5 of the “Drip Irrigation” module

7.4 *Reuse of Treated Wastewater*

Reuse of treated wastewater is a growing market in Australia. Drip irrigation is ideally suited to this system because of its low infiltration rate, zero aerosols and suitability for subsurface installation.

Netafim have developed Dripmaster Purple – denoting the international color for wastewater. The RAM dripper is most commonly used due to its large labyrinth, self-cleaning mechanism and physical barrier to root intrusion. The RAM dripper has a proven track record in wastewater reuse and should be the first choice in any system.

Any wastewater system can benefit from drip irrigation including, mines (heap leaching, landscape re-establishment), city councils, schools, resorts, remote communities etc.

Reuse of treated wastewater is covered in detail later in Section 2 of the “Water - Sources and Quality” Module.

7.5 Landscape

Drip irrigation in landscape is becoming a vital component. There are some excellent benefits and the most logical applications are for:

- ◆ Road Medians, and narrow beds
- ◆ Poor infiltration soils
- ◆ Establishment of road batters and drains
- ◆ Subsurface turf and beds using wastewater
- ◆ Areas with constant windy conditions
- ◆ Areas with restricted watering times
- ◆ Areas with saline water

Netafim has developed some unique products for the landscape environment

- ◆ *Techline* PC dripline, which uses industry 13mm barbed fittings and is available in low flow 1.6l/hr
- ◆ *Scapeline* non PC dripline, which uses industry 13mm barbed fittings
- ◆ *Techfilters* – Specialized filters that release Treflan, a chemical that prevents root intrusion
- ◆ *Flori controllers* – 1 or 3 station, standalone controllers that irrigate according to soil moisture
- ◆ *Netafit valves* – Unique AC and DC solenoid valves. Available in 25, 40 and 50mm. 40mm and 50mm models can be upgraded to automatic pressure reduction.
- ◆ Dripmaster Purple – 17 and 20mm PC drip line to denote wastewater reuse.

8 Selection and Design principles

Selection of a dripline when designing a drip system will depend on various factors

- ◆ Type of crop
- ◆ Spacing of crop down the row
- ◆ Type of soils
- ◆ Dripper spacing
- ◆ Dripper flow
- ◆ Run lengths
- ◆ Slope

Refer Table 6 below

Table 6

Crop	Common Dripper Spacings (m)	Common Dripper Flows (l/hr)
Grapes	0.5, 0.6, 0.75	1.6, 2.3, 3.5
Citrus	0.5, 0.6, 0.75	1.6, 2.3
Cotton	0.4, 0.5, 0.6	1.1, 1.6
Bananas	0.4, 0.5, 0.6, 0.75	1.6, 2.3, 3.5
Sugarcane	0.4, 0.5, 0.6	1.1, 1.6
Vegetables	0.2, 0.3, 0.4	0.8, 1.1, 1.6
Melons	0.2, 0.3, 0.4	0.8, 1.1

Once the dripper flow and spacing has been selected, the dripline diameter can be determined before design starts. This can be easily done, by referring to maximum run length charts supplied by the manufacturer. Most charts give maximum run lengths according to a given flow variation, various dripper spacings and flows on flat ground. More detailed charts will give these run lengths also according to different degrees of slope for non compensating driplines.

More recently manufacturers are providing easy to use software programs which use the parameters of slope, end pressure required, dripper flow and spacing and other variables to help select the correct diameter dripline. Netafim has three diameters of tape products and three diameters of heavy wall in agriculture.

Table 7

Diameters	17mm	20mm	25mm
Heavy wall	Dripline 2000 Tiran 17 Dripmaster 17	Dripmaster 20 Tiran 20	Dripline 2025 Dripmaster 2025
Light Wall	Streamline Super Typhoon	Python	Ozline

Assuming one has selected the dripline type, flow and spacing the design engineer will require a scale plan of the area. Generally with slopes greater than 3% pressure compensating driplines are used. If a pressure compensating dripline, is to be used, then a scale plan with spot heights is the minimum survey material to be supplied. For non-compensating driplines it is very important to have a survey showing accurate topography in the form of contours, or a very detailed spot height survey. Before a design engineer can complete a design he will also require other important information such as:

Water source location and flow rate available.

Any limitations on volume of water source (e.g. water license, existing pump etc)

Existing irrigation equipment/pipes to be used

Maximum block sizes according to harvesting, management practices, variety breakups, soil types, headlands etc

Row Directions

Row Spacing

Surface or Subsurface

Water requirement i.e. Volume/plant/week or Precipitation rate per week

Time window for pumping

Maximum flow variation required

Design principles are covered in detail in the paper – Hydraulics and Irrigation design

9 Installation, Operation and Maintenance

9.1 Installation

Installation can be summarized under the following areas

- a. Pump, Primary Filtration and Headwork's
- b. Mainline
- c. Field valves and Secondary Filters, field headwork's
- d. Submains
- e. Laterals and Emitters
- f. Flushing manifolds (Subsurface Systems)
- g. Automation and Fertigation equipment

Micro - irrigation installations should be carried out or supervised by qualified personnel. Poor installation can lead to failure of the system due to individual component or complete system faults. The downtime from failure invariably happens at critical points in the crop growth cycle and can lead to crop loss.

9.2 Operation

Operation of micro-irrigation systems can be summarized as follows

- a. Pump controls and pump start
- b. Primary Filtration system – Automatic or manual
- c. Headwork valves (Pump control, Quick relief, Surge control etc), pressure gauges
- d. Water meter
- e. Secondary filters
- f. Field valves (Pressure reducing, Automatic, Manual, Isolating, Air Release, Vacuum Release)
- g. Pressure check points
- h. Injection Points
- i. Flushing points
- j. Automatic controls
- k. Fertigation

Each of these components will have a specific function for the successful operation of the system.

9.3 Maintenance

Drip maintenance is very a important, though often neglected tool, needed to help the system run at peak performance and increase life expectancy.

This can be achieved by implementing a simple but strict program. The best way to determine whether this program is working is to constantly monitor and record your system flow rates.

Drip maintenance can be divided into two simple categories, Preventative and Corrective.

- ◆ *Preventative* maintenance is a procedure or group of procedures to prevent or inhibit obstructions from plugging, clogging or blocking the drippers, providing these procedures are conducted timely and accurately.
- ◆ *Corrective* maintenance is a procedure to remove the obstruction that has caused the dripper to be blocked. This is a very dangerous position as not all obstructions can be removed.

Maintenance is covered in detail in Section 2 “Drip Irrigation System Maintenance” of the “Irrigation Practices” Module

10 Summary and Conclusion

Drip irrigation requires a different approach to traditional methods of irrigation. The art and science of drip has come a long way from its early beginnings. It is important to have a good understanding of.

- ◆ Soil, water and plant relationships
- ◆ Terminology and formula
- ◆ Hydraulic relationships and uniformity
- ◆ Product characteristics and limitations
- ◆ Water quality and design criteria

Installation, operation and maintenance must follow a plan if the system is to be successful. Successful drip systems provide the grower with a valuable tool to achieve the best quality and quantity of production with the lowest water volume and cost.

11 Questions

These are divided into Beginners, Intermediate and Advanced levels

11.1 Beginner

1. Which type of dripper is more susceptible to clogging ?
 - a. Laminar Flow dripper
 - b. Turbulent Flow dripper
 Give a brief explanation for your choice
2. Name two Netafim drippers that are used to produce integral driplines.
3. What are the two main advantages of a concentrated root zone?
4. What are the two opposing forces affecting water movement in the soil?
5. Which group of dripper spacings below are more suited to clay soils and which are more suited to sandy soils?

Group 1: 30cm, 40cm 50cm

Group 2: 60cm, 75cm 90cm

Clay =

Sandy =

With reference to water movement in soil, describe the reasons for your choices.

6. What are the main factors affecting uniformity of a non-compensating dripline?
7. What is Cv a measure of?
8. Name four factors that are taken into consideration when designing a drip irrigation system?
9. Which Netafim dripper/drip line is highly regarded as suitable choice for reuse of treated wastewater?
10. What is the international color used to denote wastewater in a pipeline
11. What size fittings are used with the Landscape range of Netafim drip lines?
12. Name three situations where you would choose a drip system in Landscape over traditional pop-ups?

11.2 Intermediate

1. Name the two main ways that water can move through the soil
2. What is the optimal percentage of air in the soil to allow roots to breathe effectively?
3. What does the term Wilting Point mean for a soil?
4. What does RAW stand for and give a brief description
5. In general, at what percentage of AW should irrigation be applied to the soil in order to avoid plant stress?
6. What is the Flow Exponent of a Pressure compensating dripper?
7. A non-compensating dripper with a flow exponent of greater than 0.5 is behaving more or less like a pressure-compensating dripper?
8. A Netafim non-compensating drip line has an average dripper flow of 1.4l/hr at a pressure of 4m, what would the flow rate (in general) increase to if the pressure was doubled?
9. Which calculation is a more accurate measure of uniformity?
 - a. F.V (Flow Variation)
 - b. E.U. (Emission Uniformity)Give a brief explanation for your choice.
10. What is the wall thickness (in mm) of Python 80?
11. For a high value crop using fertigation, what is the preferred maximum Flow Variation in a non-compensating drip system?
12. How would you rate a dripper with a Cv of 0.70?

11.3 Advanced

1. With a pressure of 14 m what is the flow rate of a 1.65l/hr Super Typhoon 125 dripper
2. For a flow of 1.2l/hr what is the pressure required to operate a Python 135 1.1 l/hr dripper
3. Using Ram 2025 2.3l/hr @ 60cm spacing DOUBLE Lateral, in a block of bananas, how many metres of dripline would I use if the flow rate of the block was 110 M3/hr
4. If the row spacing in Question 3 above was 6m what is the precipitation rate?
5. With a maximum emitter discharge of 2.4l/hr and a minimum of 1.9l/hr in a block design, what is the resulting flow variation?
6. Would this be acceptable for a vineyard using high value liquid fertilizer for fertigation purposes?
7. You have been supplied with technical data on Netafim's range of drip lines. You are preparing a design brief for the design of 5 ha of grapes and 9 ha of Cotton, the general parameters are given below. After you have checked the technical data, nominate your choice of drip line series and diameter, dripper spacing and dripper flow. In each case give your reasons for the selection. For both designs the area stated is the minimum size and must irrigate as a complete block.

5 Ha Grapes

Dimension of block = 250m long (in the direction of the rows) x 201m wide
 Slope of row = Undulating between 3% - 5% downhill
 Length of rows = 250m
 Row Spacing = 3.0m
 Available flow = 45000l/hr
 Soil Type = Sandy Clay Loam

9 Ha Cotton

Dimension of Block = 450m long (in the direction of the rows) x 200m wide
 Slope of row = 1% Downhill
 Length of rows = 450m
 Row Spacing = 2.0m
 Available Flow = 86000 l/hr
 Soil Type = Sandy

8. Calculate the precipitation rate for each Crop based on your selections.
9. If the Crop Factor for a particular crop was 1.1 during the month of January and we were scheduling our irrigation to meet the water requirements based on Pan Evaporation :
 What percentage of evaporation do we need to replace on a daily basis if there is zero rainfall?
10. From your answers in Question 8, assume the following
 Grapes: Crop Factor = 0.9 Daily Ep = 8mm
 Cotton: Crop Factor = 0.75 Daily Ep = 11mm
 For each crop calculate how long would you have to irrigate for, in order to replace evaporation.
11. How many litres of water would be required in each case for Question 10? And show how you calculated your answer (there are 2 methods, see if you can detail both of them)
 Grapes= Cotton=