Drip Irrigation for Vegetable Production

BOOK 7

IRRIGATION NEW ZEALAND

Contents

This book is part of a series providing a comprehensive training resource for irrigation industry participants in New Zealand.

It introduces drip irrigation as a viable option for vegetable production, giving an overview, descriptions of technologies and an outline of the concepts for successful drip irrigation.

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Vegetables NEW ZEALAND

Introduction

This booklet introduces drip irrigation as an option for New Zealand vegetable growers. Its aims include:

- presenting an overview of drip irrigation
- describing the technologies involved
- explaining key concepts that support successful drip irrigation, and
- highlighting key issues to consider and questions to ask.

It provides sufficient base information for a grower to decide whether to further investigate the use of drip irrigation for their vegetable production operations.

While it has been prepared with vegetable growers in mind, we anticipate the information will be of interest to growers of arable crops and pastures.

When considering any irrigation option, soil, crop, climate, farm layout and manager and operator knowledge specific to the farm must be carefully evaluated.

This book does not replace the need for specific, specialist advice, or describe specific component options. It makes no attempt to explain the hydraulic design processes required to engineer a drip irrigation system. That is specialist work, requiring specialist knowledge and experience.

Making every drop count – drivers for water and nutrient efficiency

WATER EFFICIENCY AND PRODUCTIVITY

Drip irrigated plants need as much water as plants irrigated in other ways. The amount needed depends on climate and the crop. Hotter, drier climates drive higher water use, measurable as evapotranspiration (the evaporation loss from the soil and plant surfaces and transpiration through the pores of the plants' leaves).

If plants do not have sufficient access to readily available water, their growth will slow and ultimately stop. Some plant types require more water than others, and some show a quicker and more severe response to drought. For most crops, the amount of yield lost for each millimetre of drought stress is predictable. There are, however, some cases where moderate drought stress at critical times may enhance yield quantity or quality.

No form of irrigation is 100% water efficient but, of the options, drip irrigation can be extremely efficient. Very high distribution uniformity, frequent small irrigations, reduced soil surface wetness and applying the right amount very close to plant roots all combine to offer high water use efficiency. But to actually be highly efficient drip, like any irrigation, requires excellent design, maintenance, management and operation.

WATER AND NUTRIENT AND SEDIMENT LOSS

Irrigation water is lost from the soil in several different ways:

- Water that passes through the plant and is lost as transpiration is effectively used. It helps the plant take up nutrients and helps the cool the leaves.
- Water that runs across the soil surface and exits the target area, is wasted. It may cause harm by washing sediments and nutrients into water ways. It can also cause ponding and crop losses due to saturation.
- Water removed through drainage is also wasted, and also carries nutrients potentially affecting ground water, rivers and lakes.

Well operated drip irrigation should avoid almost all the wasteful losses, leaving more water available to meet actual crop needs. And by reducing water loss, it reduces nutrient loss as well.

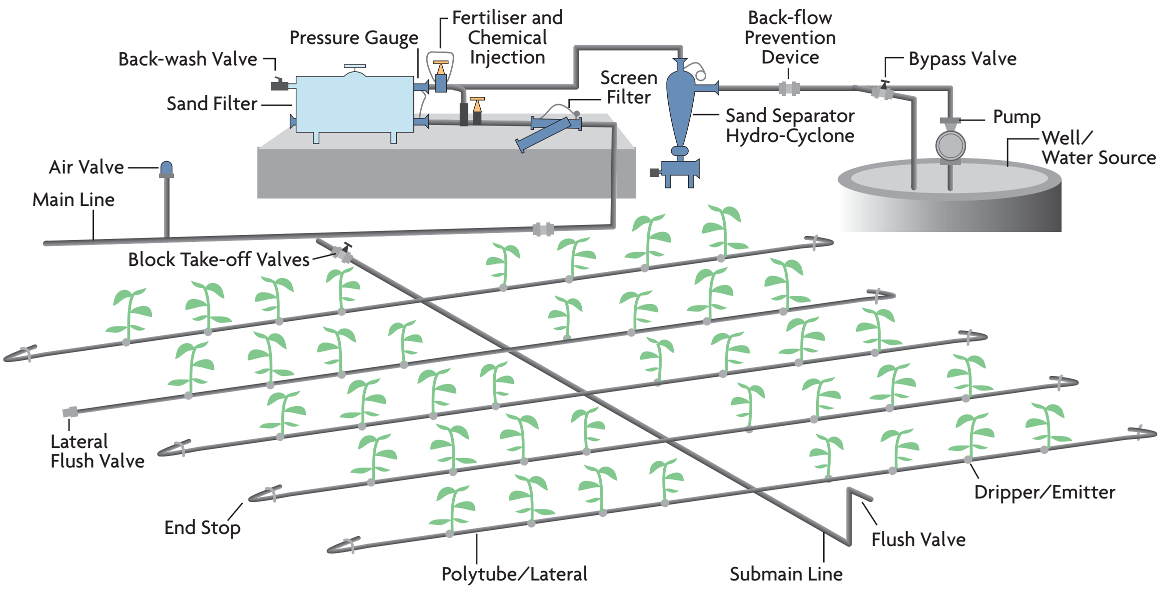

Figure 1. Components and layout of a drip irrigation system. Based on a diagram from Jain Irrigation.

Drip irrigation a glance

Drip irrigation uses lateral pipes ("driplines") with fixed emitters laid in parallel rows. Laterals may be laid on the soil surface ("surface drip") or buried in the ground ("sub-surface drip" or "buried drip").

Each emitter allows flows of several litres per hour. Their flow rate and spacing along the dripline and the spacing between driplines determines the irrigation application intensity (mm/h).

The depth at which subsurface driplines are installed is selected according to crop, soil type, water source, pests, climate, tillage equipment, and producer preference. Some shallow buried drip irrigation systems (<20 cm depth) are retrieved and/or replaced seasonally and have many characteristics similar to surface drip irrigation.

Many research reports refer to these shallow systems as surface drip irrigation (DI) and reserve the term sub-surface drip irrigation (SDI) for systems intended for multiple-year use that are installed below tillage depth[i].

Because drip irrigation emitters have very small outlets (pathways and orifices) and because pressure and flow rates are very low, water quality is extremely important. Sediments, biological growths and chemical residues can all block the outlets and make the system unworkable.

Properly designed and managed drip irrigation has many advantages over other irrigation methods, including:

- elimination of surface runoff
- high uniformity of water distribution
- high water usage efficiency
- flexibility in fertiliser application
- efficient fertiliser use
- ability to apply some agrichemicals
- reduced weed growth
- reduced plant disease
- easy automation
- low labour requirement.

Some of the disadvantages[ii] of drip irrigation are:

- establishment cost can be high
- design and management are quite different to other irrigation types
- trained employees are essential
- maintenance of the dripline system can be time-consuming, especially if buried
- if the driplines are damaged, the cost and effort to repair them can be large
- plugging and leakages can cause a high requirement for repairs
- If using a seasonal/annual system, the extra work involved in laying and retrieving driplines can be significant.

Figure 2. Laying dripline on onion beds.

Drip irrigation for vegetables

INTERNATIONAL USE

Drip irrigation has been widely adopted throughout the world.

The use of sub-surface drip irrigation in the U.S. increased from 163,000 to 260,000 ha in the five-year period from 2003 to 2008, an increase of 59%. In comparison, the surface drip irrigation land area increased from 566,000 to 694,000 ha, or 23%[i]. More than 70% of the lettuce produced in the USA is grown in the Salinas Valley. More than half of that acreage is drip irrigated.

ENVIRONMENTAL BENEFITS

Factors encouraging the use of drip irrigation in California include[iii]:

- water scarcity caused by periodic droughts and reallocation of existing water supplies for urban and environmental uses, and
- minimising environmental impacts of agricultural drainage and run-off associated with flood and sprinkler irrigation.

These pressures are present in New Zealand. Precisely managing water and nutrients is a significant benefit in catchments and sub-catchments where water quality is impacted by nutrient discharge from agricultural operations. Intensive vegetable production can have relatively high nutrient losses. Technologies that reduce these losses should be investigated and applied where economically and practically feasible.

PRODUCTION BENEFITS

While the environmental benefits of drip are important, the production benefits from switching to drip have probably been the most significant reason that growers have adopted drip technology in California. Drip enables farmers to:

- increase yields and improve quality of many crops by better regulating soil moisture using drip
- improve production on lands that were historically difficult to irrigate due to the soil texture or slope
- replace overhead sprinklers with drip in windy regions, greatly increasing the uniformity of irrigation applications
- minimise plant diseases by avoiding wetting of leaves and fruits and over-saturating the root zone.

Surface drip is used on higher-value crops (typically fruits, nuts, and vegetables) and sub-surface drip on lesser-value commodity crops (e.g. corn, cotton, and alfalfa).

Figure 3. Surface placed drip tape is retrieved and reused to produce 8 to 12 lettuce crops on the coast of California. Photo by M. Cahn.

ADOPTION OF DRIP IRRIGATION FOR VEGETABLE GROWING IN NEW ZEALAND

In New Zealand the biggest use, by far, of drip irrigation is in vineyards. Almost all is laid on or above ground. There is some use of buried drip in amenity horticulture and for sports turf installations. Its use for vegetable production, whether surface or sub-surface, is very low.

See the "Grower Experiences" section on pages 9–13 of this book for case studies of drip irrigation use by New Zealand growers.

Economics of drip irrigation

DRIP IRRIGATION HAS MUCH TO OFFER VEGETABLE GROWERS

Intensive farming is under intense scrutiny as the risks of off-farm impacts are evaluated. Water allocation and efficiency of application are increasingly important issues. Growers must ensure maximum productivity per unit of water applied and minimise potential environmental impacts. The drivers for these improvements are coming from industry itself, regulatory bodies and also from markets.

Drip irrigation offers the most precise control of water and nutrients and a key to addressing the impact risks. Drip irrigation is well suited to intensive systems such as vegetable production. But it must compare favourably with alternatives. It has gained widespread acceptance internationally as a technology that can increase water use efficiency to about 90–95%.

Fertigation (applying nutrients through the drip system) also offers more precise nutrient use and opportunities for increased productivity. Drip with fertigation can minimise nutrient losses.

COSTS OF INSTALLATION AND MANAGEMENT

It is not possible to know costs without a full proposal being assessed. If considering irrigation of any type, take into account the capital cost, the life of the system and the annual running costs including all maintenance, labour, energy and any water charges.

Capital costs
A large part of the expense of installation is the dripline itself, and the amount needed varies according to soil type, crop choice and growing system. The spacing between adjacent driplines typically ranges from 300–400mm to 1,500mm or more.

- At 400mm spacings, 25,000m (25km) of dripline is required per hectare irrigated
- At 1,524mm (1 line/two sweetcorn rows), only 6,560m would be required.

Additional irrigation system capital costs include filtration, mainlines, control units and valves and fertigation equipment.

A well designed system with good materials and very good management and maintenance can last for more than ten years. Some systems in New Zealand have been in place for almost 20 years.

Drip tape disposal or re-use needs to be planned for, with extra costs in removing it at the end of its useful life taken into account. Because the drip line is a major cost component, keeping it longer has significant economic benefits.

Annual costs
Drip irrigation can have significant advantages over many systems in use.

Drip irrigation has a very low labour requirement, especially compared to hand shift pipes and to travelling irrigator systems that require frequent shifting. It does require regular maintenance, especially of filtration and repairs to drip line if damaged.

Placing and removing dripline for each crop increases costs. As well as the extra equipment needed to install and recover dripline, and the labour and tractor time required, the life of the dripline can be reduced.

Semi-permanent dripline placement avoids the annual installation and recovery costs, but does require ability to "farm around" the dripline. It can also require a thicker walled, therefore more expensive, dripline to avoid damage by insects.

Drip systems typically run at a lower pressure and at a lower flow rate than other systems which reduces energy pumping costs. However for a typical vegetable operation, energy costs for irrigation are often relatively low so this saving may be minor.

Nutrient efficiency can be very high, saving on fertiliser costs. However, the fertilisers applied through drip systems can be more expensive as they must be high purity and fully soluble so as to not cause any blockages in the drippers.

There is good evidence of reduced disease pressure as drip keeps moisture off foliage and avoids soil splash, giving agrichemical savings as well.

Associated costs
A number of potentially significant expenses could be incurred, depending on the overall growing systems in place and chosen for drip irrigation.

"Farming around" dripline involves either keeping all cultivation operations shallower than the burial depth of the dripline, or working between adjacent driplines. A no-till cropping system would achieve the shallow working depths needed for buried systems. Precision guidance could enable inter-row/inter-dripline working of either surface or sub-surface systems.

Controlled traffic farming or permanent bed cropping systems offer convenient solutions. With all traffic confined to delineated rows, and the same tracks used again every pass and every year, the drip line is safe. To be successful, tractors need high accuracy GPS and auto-steering. This is costly, but already widely used for cropping. Controlled traffic farming or permanent bed cropping systems also require width matched equipment.

Grower experiences

In 2012–13, a series of Ministry for Primary Industries SFF funded industry workshops[iv] reviewed the potential barriers and issues slowing wider adoption by vegetable growers. Responses were canvassed and collated, arranged into three categories:

- Growers successfully using drip irrigation
- Growers who have used drip irrigation but do no longer
- Growers who are uncertain about using drip irrigation

Growers successfully using drip irrigation today

A comparatively small number of vegetable growers are using drip irrigation. Some are large-scale multi-crop businesses and others are small, single-crop enterprises.

Drip irrigation is often associated with higher value crops which justify investment in tape and pumping/filtration equipment. This may be in association with other high-input management approaches such as plastic mulches and/or plastic tunnels.

Both surface and subsurface systems are being used. Subsurface systems are considered for crops that grow for several seasons or in rotations where the tape can be left in place for multiple crops.

Despite recognising production and environmental benefits, few growers fertigate. The extra 'effort' and in some cases costs can be off-putting. However, fertigating can save fuel, labour, tractor wear and also reduce damage to soil physical structure (especially when the soil is wet).

Growers suggested drip irrigation can reduce weed problems, foliar and root fungal diseases and agrichemical use and application costs.

Drip irrigation is seen to increase crop options in small or irregularly shaped paddocks where overhead irrigation systems are not well suited.

Growers using drip irrigation overcame a variety of challenges through persistence and technical support. Common issues include poor lateral water movement on marginal soils, poor water quality blocking emitters, dripline repairs and maintenance, root intrusion into lines, and disposal of dripline once removed.

An overarching key to success for these growers is close attention to the design, installation, management and maintenance of the system. And drip irrigation is typically being used in conditions where it is well suited.

BOTTOM LINE

Growers recognised the benefits of drip irrigation, found solutions to technical challenges and incorporated it into production systems that allow its use to be profitable.

Growers who have used drip irrigation but no longer do

BOTTOM LINE

Growers recognised the benefits of drip irrigation, but in many cases were unable to find solutions to technical challenges. Given the relative setup costs, the additional 'risk' was not seen as worthwhile – certainly not when the cost and availability of water were not major issues.

Some growers saw benefits of drip irrigation and ran commercial-scale trials. In many cases these trials revealed technical challenges related to site selection, product performance, and/or the design, installation, management and maintenance of the systems.

Limited experience or technical support meant many technical issues were not resolved. While efficiency and uniformity gains were seen as desirable, growers chose lower capital and lower risk irrigation approaches, especially given the comparatively low cost and availability of water.

Some growers associated drip irrigation with a lack of flexibility, noting a higher value crop was needed to 'make the system pay' and drip irrigation was not seen as a good option for some crop types (particularly root crops). This reduced their capacity to respond quickly to different cropping opportunities and constrained crop rotation options.

Growers who are uncertain about drip irrigation

Many growers appear uncertain or unconvinced about the economics of using drip irrigation, especially on a large scale. Many acknowledge the potential benefits but also associate drip irrigation with a greater number of technical considerations and challenges. In regions with normally sufficient seasonal rainfall, the 'payoff' from a drip irrigation system that may not be used on a regular basis is unclear.

However, some growers do see drip irrigation as a way of developing smaller areas without a large investment in fixed irrigation infrastructure. This offers the flexibility to respond to cash cropping opportunities, particularly on otherwise marginal ground. A mobile pumping/filtration system allows for greater season-to-season flexibility in these situations.

Comparatively few growers prioritise the advantages drip offers for irrigation efficiency. In part this reflects the comparatively low cost of water in New Zealand and historically good access to water. They note that many overhead irrigation systems can also achieve good efficiency and uniformity.

Growers typically did not consider yield, nutrient or sediment loses associated with poor irrigation management when making irrigation investment decisions. The true financial cost associated with these combined factors is generally poorly quantified.

Some growers believe that the most profitable use of drip irrigation is linked to a production system that uses tape for several seasons. This often requires other technologies and management approaches, such as GPS to position/locate tape, permanent beds so tape can remain in use for several years, and minimal cultivation to avoid damaging tape and soil physical structure. Adopting all factors simultaneously is seen as risky.

BOTTOM LINE

Growers generally recognised the potential benefits of drip irrigation, but were unsure of the economics or unwilling to consider systems that have higher risk (perceived or real). There has been comparatively little pressure to move from the status quo.

New Zealand case studies

Figure 4. Gordon McPhail.
Photo supplied by LeaderBrand Produce.

CASE STUDY 1: LEADERBRAND PRODUCE, GISBORNE

Gordon McPhail has spent six years working with drip irrigation. The initial focus was on watermelon and squash crops. More recently LeaderBrand have used it for lettuce.

"The benefits are obvious. You can add anything you want: water, nutrients or in some cases chemical, at any level. You're not restricted by any application rate and you can add small amounts, often, so it's always there."

"It's simple to use. It's a matter of turning on the tap and it runs. Drip also requires little maintenance as in people power. One person can operate it," he says. "Drip is easy on soil and an extremely efficient applicator of water and fertiliser. It doesn't waste a lot and any input goes straight to the root zone."

The biggest limitation is cost. LeaderBrand has found drip irrigation viable for high value crops, but several issues limit its application for other crops the company grows.

"There's a large set up cost and a lot of time involved in setting up the system. There are also a lot of restrictions around run length and water pressure that add to set up cost."

A more pressing problem however is drip's susceptibility to blockage because of water quality and nutrient input. This varies with water source and inputs. "The blocking of emitters is our biggest issue. The obvious thing is to run larger emitters however this is not ideal as reduces run length and area."

Gordon believes the time involved in installing and modifying drip to meet a particular crop's requirements is not to be overlooked.

"You have to understand how it works. It's easier for us now because we have been doing it for a while but we are still learning particularly in regards to inputs other than water. There are a lot of intricacies and you can't just apply the same programme between crops or as you would conventionally. You need to be using it for more than just water. In our first couple of years we just used it for irrigation."

Gordon believes disposal versus on-going use of the tape needs to be resolved. The company has chosen to use a low grade tape "because it doesn't fit our cost structure at this stage to use a high grade option and our current systems restrict the ability to remove and re-use."

"Plastic can be recycled but the problem is we pick up a whole lot of dirt. There's just as much cost in recycling as disposing it to landfill but I can see that it's not sustainable. Re-useable tape is the simple answer. It is widely used in temporary horticulture in other parts of the world."

Because of the economics, Gordon doesn't foresee drip will grow within their business model. "Tape is a lot more expensive than conventional overhead irrigation, so we only use it on high value crops. We don't even bother looking at it for lower value crops."

"I struggle to see it stack up taking into consideration our climate, soil and crops. I think we've found a niche for it with good results but unless the area of those crops grow, we won't be using it any more than we are now. You can really over-capitalise with drip and not get the benefits."

Figure 5. Mike Rittson-Thomas.

> "It's very simple to use and generally it's been superb. We've had this little patch next to the State Highway which is green when everything else is brown. People drive past and as they can't see any infrastructure they wonder what's going on."

CASE STUDY 2: MIKE RITTSON-THOMAS
SHEEP, BEEF AND CROPPING FARMER, HAWKE'S BAY

Hearing first-hand from Australian drip irrigation experts convinced Mike Rittson-Thomas to take a punt on the technology. "I thought it sounded better than guns firing water in the air. It seemed a great way to go."

Mike used a local company to supply and establish a drip system for Lucerne. "I wouldn't have done it without our local supplier. He was convinced we could make it work."

Moving to a permanent, underground drip system came with a few headaches. "A design fault meant the wire connecting the controller to the solenoid valves couldn't take the current, so we had a few hiccups there."

"The problems compounded when we couldn't find anyone in New Zealand who had any experience with it. We've got a guy now who knows the system well but when he is not there, we are in trouble again."

Mike would like to see advisory services set up around drip irrigation to support farmers and growers who invest in the technology. Poor industry knowledge of drip in New Zealand in the 1990s made him feel on his own. This was compounded by inconsistent back-up from the irrigation provider.

Mike accepts he's had a good run from his system, although he would have liked it to last longer until the proposed Ruataniwha Water Storage Scheme becomes operational. Over the years, his drip system has accumulated blockages, despite cleaning with an acid flush.

"We were told it would last five or six years and it's lasted for 13 years. It's been fine up until this year, using occasional summer rain as a top-up. But the drought has really shown us where the water is going and where it's not."

"It's very simple to use and generally it's been superb. We've had this little patch next to the State Highway which is green when everything else is brown. People drive past and as they can't see any infrastructure they wonder what's going on."

"I used to do comparisons with a mate down the road who was using another form of irrigation. It was unbelievable how little water we used compared to him and the operating cost advantage was significant. It suits a crop that goes in and stays in for a long time. It has been great for Lucerne."

"The main problem for me is not seeing it put the water on. We have a very fine top soil and the drip is down 300mm so you can't really water the surface. I'd like to be able to water for a month while we get the crop established. If you had some hoses or a boom you could surface water for a month and then use drip until you re-sowed the crop."

"Otherwise it's been really good for us. I can remember researching it and people said you have to be married to your irrigator when they talked about other systems. But with drip you don't have to shift it around so the labour saving is considerable. And we are all looking for a bit more time in our lives."

CASE STUDY 3: MARK REDSHAW
SMALL-SCALE ONION GROWER, HAWKE'S BAY

Mark Redshaw has several years' experience of drip, starting in the United Kingdom laying drip tape in strawberry beds.

"It wasn't much fun. The t-tape laying machine had an unnoticed weld spot and the tape would catch on it. We'd get lots of blow outs in the mounds and water would pour out where the tape was slightly nicked."

As a rep in Pukekohe, Mark tried to promote drip to local growers but met entrenched resistance. "It's harder to get it to stack up in Pukekohe. They get a lot more rainfall than we do in Hawke's Bay so economics ruled it out."

Despite these experiences, Mark decided drip irrigation was a perfect fit for his private onion growing venture on five acres when he moved to Hawke's Bay. "I think it presents a massive opportunity but the biggest problem is setting it up. It's expensive and labour intensive."

Mark's approach wasn't overly technical. "It's been a bit of suck and see. I didn't use pressure reducing valves, but got away with it." He utilised one line of tape between each double row of onions to cut costs. He also tried one row per bed, unsuccessfully on the mixed soil type. He lays the tape on top of the ground and does not peg it down. "Once I put water through it I don't really have any issues."

Mark is a keen advocate for drip. "It puts water where and when you need it and once it's installed, generally it's easy. You can fertigate as well. I didn't, but it gives you that option."

His biggest gripes are cost and labour and unfortunately for Mark, these obstacles are likely to spell the end of his drip usage. The upfront cost of investing in new tape each year is prohibitive and Mark says growers need to do the sums to ensure their crops can pay for it.

His first year was wet and Mark only used the drip system four times. Low usage inspired him to re-use the tape the next year, despite it not being a recyclable version. "I didn't have any issues with cleaning. I cut the ends when I wound it in and then tied them off." "So I got double usage out of one expensive tape. There's no point using it once."

Mark thinks he will invest in a small irrigator for his onions, but doesn't rule out returning to drip irrigation if he were to expand.

"What killed it for me was re-using tape. The second year I re-used it, but the tape had been stretched so it took twice as long to put it out and pull it in. Potentially I could use it one more time but it's such a mongrel to wind in without the proper equipment. You want to be doing three beds at a time."

"I can't see larger growers taking it on, though it really depends on the crop. For a shorter term crop like squash, it's a relatively high workload. For onions it's relatively effective as it's a longer term crop over several months."

"All in all it ran very smoothly and I never had any major issues. If I use tape again, it will be on a grander scale and I'll get the gear to put it out and wind it in. It's expensive to use once, but it's relatively cheap if you can re-use it. It's just the initial outlay."

Figure 6. Mark Redshaw.

"It puts water where and when you need it and once it's installed, generally it's easy. You can fertigate as well. I didn't, but it gives you that option."

> “In terms of cost it was feasible for us and economically advantageous. The labour requirements weren’t onerous as they were integrated into other farm systems. With the tomatoes, we were pulling up the polythene anyway and taking out the plant debris, so it was just part of that process.”

CASE STUDY 4: ROSS FERGUSON
PGG WRIGHTSON IRRIGATION DESIGN AND SALES REPRESENTATIVE, NORTHERN REGION

Ross Ferguson has spent more than two decades working with drip irrigation; firstly as an orchard manager and farm owner, then running the Whangamarino Water Supply Board community irrigation scheme. He now works as an irrigation design and sales representative.

Ross’s family used T-tape and drip irrigation on the family orchard in Te Kauwhata for close to 20 years. It was put it in for stonefruit as a trial, prior to the irrigation scheme being constructed in the 1970s.

Once the irrigation scheme was operating, Ross irrigated the whole orchard and vineyard with drip irrigation. He also watered other vegetable crops with the T-tape drip system including cucurbits, watermelons and rock melons. “I wouldn’t grow outdoor tomatoes without it. That’s how hugely successful it was.”

One of its advantages is the ability to fine tune nutrient and water inputs resulting in improved produce.

“For example in our table grapes, we achieved better size, more even ripening and could also control the timing of ripening to a degree.”

Concerns around the up-front cost of drip and recycling and labour problems didn’t affect their operation.

“In terms of cost it was feasible for us and economically advantageous. The labour requirements weren’t onerous as they were integrated into other farm systems. With the tomatoes, we were pulling up the polythene anyway and taking out the plant debris, so it was just part of that process.”

“We checked and flushed the lines at the same time as checking the wire trellising in the vineyard to make sure the sheep hadn’t done too much damage over winter.”

“We recycled tape for longer than most people. It was sold as single use but we pulled it up, put it in the shed and used the next year. We must have had three or four uses out of a single product.”

Problems encountered included the occasional algae bloom in the local water supply which blocked up the on-farm filters.

“It was pretty demoralising for a while but nothing to do with the drip system itself. Since the early days, automatic self-cleaning filters have been developed. However, in recent years we don’t seem to have had the blooms.”

A more serious issue arose one year when cracks opened up in the clay soil. The plants were stressed before the irrigation was started. Although the drip system appeared to improve the crop, the fruit didn’t size as expected.

“If you hit the ground late with your irrigation when experiencing a dry spell, you couldn’t catch up with drip. It didn’t have the ability to fix the deficit you had created. You had to start early and keep the soil moisture up.”

Ross says drip has lost ground to sprinklers, but still has loyal followers.

“People either seem to like drip or they want to go with another irrigation type, mostly spray irrigation. It’s not usually about cost. There’s always some other driver.”

“Like all irrigation systems drip does have some advantages but it also has disadvantages.”

CASE STUDY 5: TRUE EARTH ORGANICS
SCOTT LAWSON, ORGANIC FARMER, HASTINGS

Scott Lawson runs Lawson's Organic Farms Ltd in Hastings and has used drip irrigation since the early 1990's.

"There was a strong push to trial branded products. A local company imported tape and supported irrigation trials in Hawke's Bay."

Scott started using drip with squash and process potatoes. Since then he has focussed on permanent crops, particularly berry fruit, and moved away from drip for annual vegetable crops.

Scott is adamant drip irrigation remains viable.

"In our system, it doesn't suit the larger scale processing crops or broad acre arable crops but rather the high value row crops. The capital cost of drip infrastructure and then on-going labour costs for installation and recovery post-harvest can be considerable and growers should include these costs in their projections," he says.

Scott is a keen supporter of drip irrigation, but admits to frustrations. The recycling of the tape is a bugbear and the constraints drip places on crop rotations and row spacing need to be factored in. "It can restrict the types of crops you can grow in semi-permanent bed rotations."

Another issue for Scott when starting out was integrating a low pressure drip line system into the existing mainline water supply. "You may have a supply which is running at high pressure for other systems. We have to run a separate low pressure supply system just for drip."

"I still believe there is a future in it. It's about getting the economics right. The direct placement of water and fertigation into the root zone of a crop is its major advantage. It avoids water being placed into the wheel track and other un-profitable areas. It's about irrigation efficiency."

The capital cost of drip remains a limiting factor but Scott says by integrating it with other farm systems and mechanisms efficiencies can be made.

"If you can be smarter you can bring costs down and technology can assist with this. It also depends on how many years use you get. But labour costs in layout and retrieval remain an issue. Installation with GPS guided tractors is a great help. It's about putting the resources into it to see if it's going to work."

"In our industry I think we will have an increased interest in the use of drip for high value, row crops. This is because we have limited water availability and we need to show that we are using water wisely."

Figure 7. Scott Lawson.

Figure 8. Scott's tractors auto-steer with centimetre accuracy, a real advantage with buried drip systems.

> “With onions it’s a long term investment. As long as we are growing onions we will use drip irrigation as it works for us. Our customers say about 70% of their crops are grown using drip irrigation so they almost expect it.”

CASE STUDY 6: SOUTH PACIFIC SEEDS

South Pacific Seeds (SPS) is investing in drip irrigation. The company grows a variety of vegetable seeds, for mainly European and Asian customers.

Irrigation is critical to the success of their crops. Drip irrigation suits the requirements of some varieties, in particular hybrid onions which prefer even soil moisture and can be susceptible to disease if leaves remain wet for too long.

In Waipara, South Pacific Seeds has used drip irrigation on two farms for around five years. Trial and error has helped the company improve the way it handles drip. In the early days the irrigation system was buried “but we learned you can’t easily get it out again,” says SPS field agronomist, Steve Dunlop.

Installing drip irrigation involves a lot of manpower, so the company moved the timeline forward to ensure staff can get it ready before peak irrigation season starts. SPS also moved away from re-usable drip tape as the labour and time costs of removing and re-applying at different locations proved un-economic.

Unfortunately a recyclable use for drip tape is still to be found but there is hope research will uncover alternative uses. The process to get the tape clean is the major problem and there isn’t enough plastic in New Zealand to justify a wash plant to remove the soil. Another way to remove the soil is being developed and processing existing tape could begin shortly. In the meantime, companies like South Pacific Seeds face a significant upfront cost every season if recyclable drip tape isn’t used.

SPS investigated drip irrigation with other vegetable seed varieties but the results were variable. “It’s expensive to set up so you need to have a high value crop to make it pay. As long as the onions are doing well it pays for itself. It is much more expensive to set up than normal overhead irrigation.” Steve says the company hasn’t given up and a stock seed production trial currently underway features drip.

Drip irrigation can be prone to blockage depending on the quality of water supply and difficult to fix once blocked. But its disadvantages need to be considered against the benefits of focused application. “It’s tremendously efficient with water.”

While Steve says drip irrigation comes with complications, it is also a technology that overseas customers recognise and respond to. “With onions it’s a long term investment. As long as we are growing onions we will use drip irrigation as it works for us. Our customers say about 70% of their crops are grown using drip irrigation so they almost expect it.”

Design and installation

System specification

Regardless of irrigation type chosen for a farm, the first step must be determining what the system will be required to achieve, and what constraints it must operate under. This is known as system specification.

A separate Irrigation New Zealand booklet deals with system specification in detail. Here, the factors specific to drip irrigation are considered.

INTEGRATION WITH WHOLE FARM SYSTEM

The irrigation system must be compatible with the whole farm production system. Drip irrigation can fit very well with vegetable production and many other row crop systems. However, harvesting in very wet conditions can put the dripline at risk if vehicles compact the soil and crush the driplines below.

Permanent

Permanent (multi-season/multi-crop) drip systems spread installation costs over a longer time period, reducing the relative cost. However they can require more expensive dripline, and they do pose constraints on other operations such as cultivation, harvesting and row spacing.

Seasonal

Seasonal systems may use single or multi-use dripline. While single use dripline can be cheaper to buy, it still has installation and recovery costs, and issues with disposal.

Dripline can be placed after crop establishment and removed before harvest if necessary. This removes some constraints but adds costs for laying and recovering dripline and sub-mains. The dripline may not last as long, but dripline has been successfully reused for ten or more crops. Growers typically set up equipment to make these operations as efficient as possible.

IRRIGATION ZONES

An irrigation system seldom waters everything at once, particularly when larger areas are irrigated. Dividing a system into multiple zones enables use of smaller, cheaper pumps, headworks and other infrastructure.

Division into blocks also allows more detailed management, customised to the specific needs of the soil and crop combination. Care is needed to determining the most suitable zones, especially for permanent systems. Different soil types and crops can require different water management and are best separated to allow for individualised irrigation scheduling.

Figure 9. Division into blocks also allows more detailed management, customised to the specific needs of the soil and crop combination.

SOIL CHARACTERISTICS

Drip irrigation relies on the soil to achieve lateral spread of water. This is unlike spray irrigation which throws water from sprinklers to achieve uniform application. The key drivers of lateral spread from drippers are soil texture, texture changes in the profile and compaction.

Texture

Finer textured soils usually allow greater lateral spread than coarse soils because their capillary pull (blotting paper effect) is greater. The capillary pull is in fine pores, the same ones that hold water to be available for the plants. In coarse soils the water tends to go straight down under gravity through larger drainage pores.

Sharp textural changes between soil layers (horizons) can affect water movement. A very coarse textured layer on a fine textured layer will encourage sideways movement and slow downwards movement from one layer to the next. A similar effect is often noticed when a fine textured layer sits above coarse textured layer.

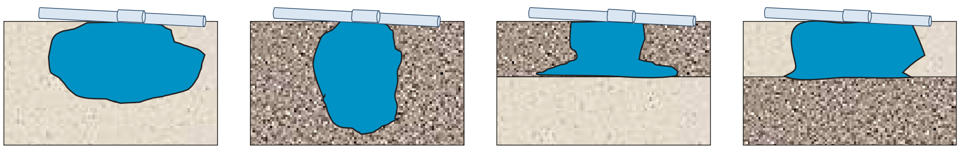

Figure 10. Diagram of water spread from surface laid drippers in different textured soils.

Structure

Lateral spread of water requires effective capillary connections, which are disrupted in rubbly soils. Soils with structure damage from compaction or over-working may also slow permeability and prevent water movement.

Erodibility

The low application intensity of drip systems, and ability to apply carefully controlled quantities, are factors helping reduce erosion risk.

WATER QUALITY

Irrigation system performance is affected by the quality of water available. Many parts of New Zealand have extremely clean water available for irrigation. The aquifer systems of Hawke's Bay and Canterbury are examples. Where the source is a surface supply or poor quality bore, more attention may be required for treating and filtering water before it enters the irrigation system and for maintenance of the system.

Any system used for application of wastes must be carefully managed to avoid very significant blockage problems.

The quality factors that should be addressed can be grouped into physical, chemical and biological categories. These also give some indication of possible treatments.

Physical contaminants

Physical contaminants include sand, silt and clay, as well as debris such as litter or plastic from repair works.

Most physical contaminants can be managed by simple filtration. Keep them out of the system in the first place. Regular system flushing ensures any physical contaminates that do make it through the filters are carried through and out of the system and do not block drippers.

Clay presents a special problem as it is difficult to filter out of the water. Clay particles are extremely fine and will pass even very fine filters. The best solution is to avoid water supplies with high clay loadings. The alternative is regular system flushing to remove clay deposits and avoid build up in driplines.

Chemical contaminants

Chemical contaminants are often water soluble compounds that precipitate inside the irrigation system. In some cases pH change can trigger precipitation; in others some biological factor is responsible.

Common problems are calcium or magnesium carbonates (as inside a hot water jug) and iron or manganese sulphides.

Management includes manipulating the pH of the irrigation water (acid treatment) or dosing the system regularly to remove any build up.

Another potential 'contaminant' is fertiliser. It may cause problems directly by blocking or precipitating, or indirectly if it promotes biological growths.

Biological contaminants

Biological contaminants include algae and bacteria able to grow inside the irrigation system. Some feed on iron or manganese compounds. Others grow in nutrient rich water and may be promoted if nutrients or organic waste is disposed through the irrigation system.

Biological contamination can be difficult to manage. Filtration is difficult and sand/media filters generally used. If a better water supply cannot be found, some form of treatment such as regular chlorine or acid treatment may be necessary.

Water sampling

Considerable care is essential when collecting any water samples for analysis. Water chemistry is highly active, and changes rapidly in different circumstances.

Contact the laboratory you intend using for the analysis, and seek their advice on collecting, storing and transporting the samples to them. They need to know what you want the analysis for, so they can conduct appropriate tests. The lab may supply suitable containers and instructions for sample collection.

Polycarbonate containers are usually suitable if they are clean. You can recycle soft drink or water bottles if they are clean. As a rule, always rinse the clean container three times with the water you are going to have analysed.

Ensure the sample is representative. This means taking it after the system has been running for some time to avoid 'stagnant' water that may have been sitting in pipes for long periods. It is difficult to say how long the system should be run before sample collection! Make sure water fresh from the source is flowing past the sample collection point.

Water chemistry is greatly affected by oxygen, temperature, and light. To avoid oxygen effects, fill containers to the very top and fit the lid underwater to exclude as much air as possible. Samples should be kept cool and dark, such as in a chilly-bin with ice packs.

Samples should be sent to the lab as soon as possible, avoiding delays and transport that will allow the water to heat up.

Tentative guidelines

There are few guidelines for assessing water suitability for drip irrigation. Water chemistry can be a complex phenomenon, and any one quality parameter can be affected by others.

Table 1 lists key quality parameters, and suggests levels that might be considered low, medium or high risk when used for irrigation in drip irrigation systems.

Table 1: Relative risk of contaminant levels.

Contaminant	Low Risk	Medium Risk	High Risk
Suspended solids	50 ppm	50–100 ppm	>100 ppm
pH (acidity)	7.0	7.0–8.0	>8.0
Salt	500 ppm	500–2000 ppm	>2000 ppm
Bicarbonate		100 ppm	
Manganese	0.1 ppm	0.1–1.5 ppm	>1.5 ppm
Total Iron	0.2 ppm	0.1–1.5 ppm	>1.5 ppm
Hydrogen sulphide	0.2 ppm	0.2–2.0 ppm	>2.0 ppm
Bacterial population	10,000/L	10,000–50,000	>50,000/L

Source: Bucks and Nakayama (1980).

If the water supply is found to have high risk quality parameters, seek advice about its suitability in your situation. It may be that a better water supply can be found, or that some form of water treatment or system treatment is required.

FERTIGATION/CHEMIGATION

Improving fertiliser use efficiency is often possible when using drip irrigation, but a thorough understanding of the main concepts, training, and some experience is necessary. Many growers have found that they could reduce nitrogen fertiliser applications significantly using fertigation because less nitrogen was lost by leaching.

Design

The goal of all designs should be providing the crop with equal or nearly equal access to the applied water. This is difficult if crops with different row spacing are grown on permanent sub-surface drip irrigation. Mismatched crop row/bed and dripline spacing may result in inadequate irrigation and in increased mechanical damage to the system.

Adoption of similar row/bed spacing for crops on a farming enterprise may be advantageous, provided that the crops produce adequate yields under that spacing. The use of a real-time kinematic global positioning system (RTK-GPS) for sub-surface drip irrigation installation and cultural practices during the cropping season should be strongly considered. RTK-GPS allows the distance between seed beds, sub-surface drip irrigation laterals, and tillage implements and other machinery to be controlled to within a few centimetres.

Accurate lateral and crop placement can be critical in addressing germination challenges, controlling the wetting front relative to the crop root zone (important for saline conditions, chemigation, and fertigation), and minimising mechanical damage by tillage and other machinery, among other factors.

Design considerations must account for field and soil characteristics, water quality, well capabilities, desired crops, production systems, and producer goals. It is difficult to separate design and management considerations into distinct issues as the system design should consider management restraints and goals.

TYPICAL LAYOUT

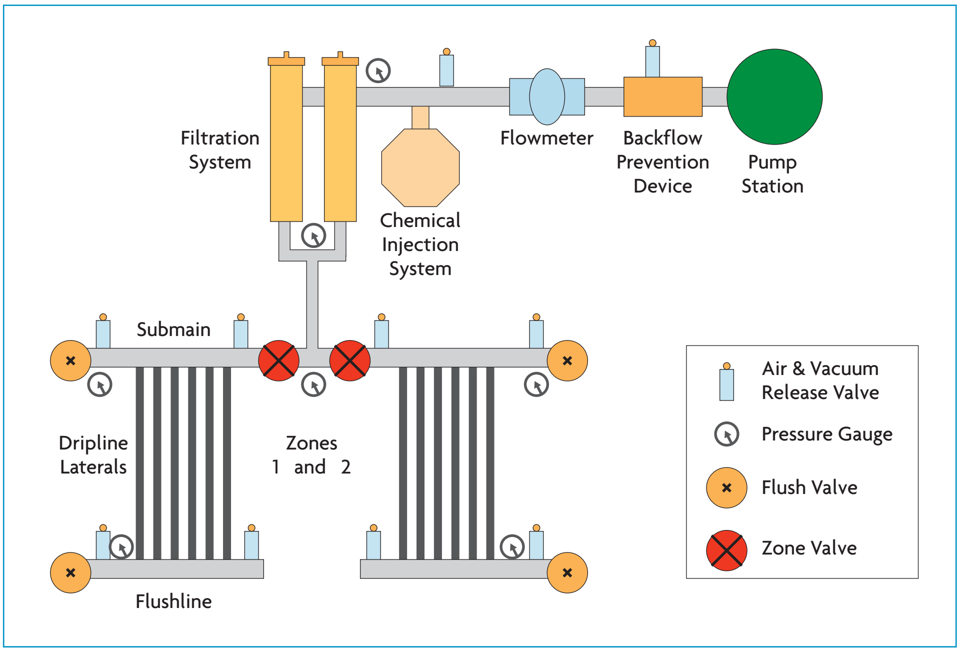

Figure 11. Schematic of Sub-surface Drip Irrigation System (Components are not to scale).
K-State Research and Extension Bulletin MF-2576, Sub-surface Drip Irrigation Component: Minimum Requirements.

CRITICAL DESIGN ISSUES

Key design questions that must be resolved at the very start are:

- daily water demand
- system life
- dripline depth and spacing
- emitter spacing and flow rate.

Daily water demand

The actual water use by a crop will be the same, regardless of how it is applied. However, surface drip and sub-surface drip systems can be very efficient. Therefore they may need less water than crops irrigated by other more wasteful means.

The system should be designed to meet the likely demand at the peak of the season. Usually this is the average daily water use during a week in the peak demand time of year (January for most crops in New Zealand). If drip is used only on early season crops, peak demand may be much less.

System life

Maintenance is the biggest issue limiting the effective life of drip irrigation systems. Water quality is very important. Physical damage from other operations is also a key factor.

Assuming good quality headworks and main lines are installed and the system is well maintained, the main issue influencing system life is the quality of dripline installed.

There are two main types of dripline: thin wall single use “tapes” and thicker wall re-useable “tubes” or “hoses”. Both have the emitters built into them at manufacture, and are supplied with set emitter flow rates and spacings.

Thicker walled hoses can be expected to last longer than thin walled tubes. The thin wall tapes are less durable and more prone to damage and not suited to applications where they are re-used.

Figure 12. Pressure regulators ensure pressure does not exceed maximum allowed.

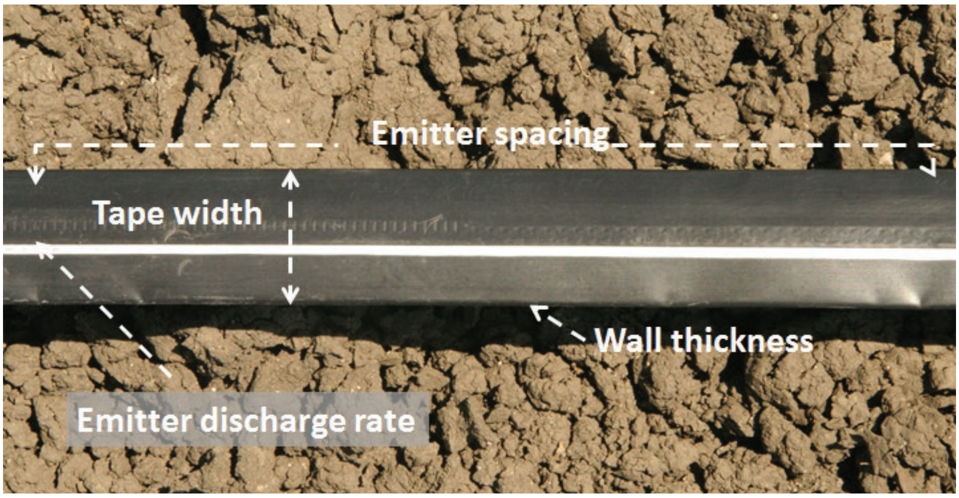

Figure 13. Selection criteria for dripline. Photo by M. Cahn.

The thicker walled tubes are better suited to repeated use, whether left in place or re-laid before each crop. However if tubes are to be recovered and reused, considerable care should be taken to ensure damage is minimised during field operations and in storage.

DRIPLINE

Drip systems use emitters built into the lateral at manufacture. In thinner-wall laterals, the emitters are generally part of the lateral wall material itself, with precision made holes and joins creating a low-flow outlet. In thicker-wall laterals the emitters are often a separately molded component, inserted into the lateral as it is being formed.

When selecting dripline, the factors to determine are:

- emitter flow rate (discharge)
- emitter spacing
- tape width or hose diameter
- dripline wall thickness.

Pressure and flow effects

The maximum length of a dripline is limited by elevation change and pipe friction.

In an unregulated emitter, increasing pressure will increase flow rate. In compensating emitters, the pressure effect is reduced. Different products have different abilities to compensate for pressure variation. The better the compensation, the longer the lateral lines can be while still providing high emission uniformity.

Water flowing downhill in a pipe increases in pressure, but water flowing uphill loses it. Because drip irrigation works at low pressures, even a small change in ground level can cause significant pressure change. This needs to be considered as part of design. Compensation helps manage the effects of elevation change, but even fully compensated dripline has limits, as the pipe and joints have maximum pressures they can sustain.

Water flowing in pipes loses energy through friction. On flat ground, this is measureable as reduced pressure. The pressure loss is higher if water flow is higher, the pipe longer or the pipe diameter smaller.

Closer emitters and higher flow rate emitters require more water to flow along the dripline, increasing friction. So, closer or higher flow emitters mean shorter maximum run lengths.

Another issue to watch for relates to flushing the driplines to remove any build-up of debris. The flow must be enough to lift and carry debris, and prevent it from settling again. Design is also critical for systems with flushing sub-mains, which creates many ring-mains in the system. Some laterals can have water entering from both ends, which means debris is never flushed out but collects in the middle of the lines.

Installation depth

The best installation depth depends on site, management and crop factors. There is no one right answer. If too deep, seedlings may not be able to access the water and an additional irrigation type may be required to get the crop established[v]. If not deep enough, it may be damaged by equipment.

Dripline spacing must also be determined early in the design process. Sub-surface dripline spacing is often a multiple of the crop row-spacing, but can be independent, especially if a range of crops with different spacings are grown.

Emitters

While dripline spacing is often a function of crop row spacing, emitter spacing is usually related to the plant spacing along the row or the soil's ability to spread the water sideways.

The aim for most row crops is a continuous wetted strip along the planted row. Each plant should receive the same amount of water. The smaller the plant's root zone, the higher the irrigation uniformity needs to be.

Emitter flow rate has a large effect on the horizontal (sideways) spread of water away from the emitter outlet. If water is released only slowly, the soil's capillary pull can move it further sideways before gravity pulls it down. So, for a given applied depth of irrigation, a lower flow rate emitter tends to give a wider wetted strip than a higher flow rate.

To balance a lower flow rate per emitter, a larger number of emitters are needed to deliver a given application rate (mm/hour of irrigation). This can be achieved with closer emitter spacing along the dripline, or by closer spaced driplines.

Figure 16. Correct emitter spacing and flow rate will give full row wetting, sufficient to germinate new crops. Photos by M. Cahn.

Figure 14. Drip hose with in-built compensating emitters.

Figure 15. Inside of compensating emitter: bottom, the strainer; centre, inside of emitter showing rubber diaphragm and top, flow path and outlet.

EXAMPLE CALCULATIONS

Case A:
2 l/h emitters at 400mm spacings on driplines 800mm apart:

$$2\,l/h \div (0.4m \times 0.8m) = 6.25\ mm/h$$

Case B:
1 l/h emitters at 400mm spacings on driplines 800mm apart.

$$1\,l/h \div (0.4m \times 0.8m) = 3.125\ mm/h$$

Case C:
1 l/h emitters at 400mm spacings on driplines 400mm apart.

$$1\,l/h \div (0.4m \times 0.4m) = 6.25\ mm/h$$

Figure 17. Buried PVC header for sub-surface drip.

Figure 18. Lay-flat header for temporary surface drip. Photo by John Deere Water.

Figure 19. Layflat header hose ready for rolling out.

MANIFOLDS

Headers (sub-mains)

Headers or sub-mains deliver water to the start of the individual driplines. As with the driplines, pipe friction and elevation causes pressure changes and limit the maximum length of a header.

The material chosen for headers depends on several factors. Surface laid headers are usually lay-flat hose. This allows vehicles to drive across the header without damaging it. Buried systems usually use PVC pipe. Polyethylene is more likely to twist and cause leaks from off-takes.

Flushing sub-mains

Flushing sub-mains are manifolds that capture any excess flow from the ends of the driplines. Generally they are closed, allowing the system to correctly pressurise. The flushing sub-main is intended to allow for convenient system flushing. One outlet, rather than many lateral ends, can be opened to flush out any debris.

System design is critical to ensure flushing sub-mains work correctly. The system must be able to generate sufficient flow to move sediments and flush them along the laterals and to waste. This may mean only part of a block can be flushed at one time.

Design must also ensure all laterals flow into the sub-main when flushing. Because a system of many ring-mains is created, flow can enter any lateral from either end. If not correctly designed, the result is pooling of sediments part way along laterals, with subsequent blockage and system failure.

HEADWORKS

Pumping and control

Selection of pumps and control systems for drip irrigation is the same as for any other type of irrigation. The correct pump will deliver the desired flow and the required pressure.

The most notable difference is the low operating pressure of drip irrigation which is often only a few metres of head (tens of kilopascals, kPa). Care is needed to ensure the system does not over-pressurise as many of the lateral fittings may pop apart.

Water metering

For many commercial scale installations, water metering is a legal (consent or National Policy Standard) requirement. However water meters should be viewed as critical management tools and should be fitted. Particularly with buried dip systems, they are a key way to monitor for excessive leakages or blockages.

Mobile headworks

There is a significant cost to setting up headworks with filtration, fertigation, chemigation and zone controls. When drip irrigation is used for vegetable crops, and a crop rotation shifts from block to block, mobile headworks make it easy to shift the whole package simply and cheaply.

Figure 20. Twin filters set up to enable automatic back flushing. Filtered water from one filter flows back through the other to ensure proper cleaning.

Figure 21. Semipermanent headworks with filters, solenoid valve take-offs and air relief.

Figure 22. Solenoid valve take-offs.

Figure 23. Air relief valve.

FILTRATION

Importance of water quality assessment

Water quality issues are one of the greatest risk factors affecting drip irrigation. Because drip uses very low flow rates, low pressures and very small outlets, blockage is a real concern. A thorough analysis of water is essential.

Water quality is discussed in the *Water quality* section on pages 16–18.

Filter type selection

The type of filtration required depends on the quality of water to be used. Filters can only remove material that is bigger than the flow path through the filter. As a general rule, the filter should remove all material greater than 1/10th diameter of the emitter flow path. Filters mesh is measured in “microns” (one thousand microns = one millimetre).

Sand particles are relatively easy to remove. Very fine sediments are hard to remove. Biological contaminants require special attention.

Table 2: Filtration options for a range of contamination issues.

Issue	Filter Option	Notes
High loads of sand	Centrifugal separator	Requires an after strainer to ensure all material is captured
Sand and coarser silts	Screen or disk filter	
Bacteria and algae	Sand/media filter	May also need chemical treatment
Chemical contaminants		Usually requires chemical treatment.

Back-flushing

Back-flushing is a key part of system maintenance. It involves using clean water to push residues back off the strainer or filter medium and flush it to waste.

If sediment loads are high, back-flushing should be automated, often based on either pressure drop or a set time interval.

Figure 24. Solenoid valve allows automatic block switching.

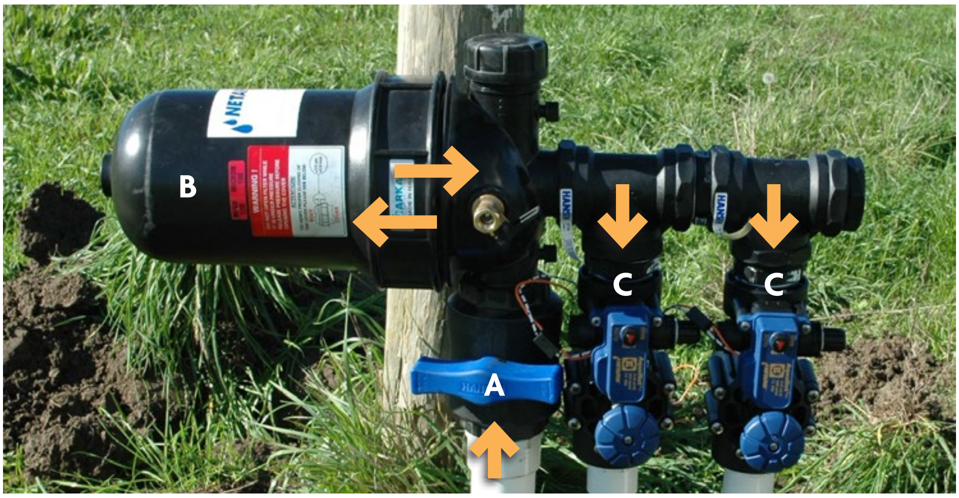

Figure 25. In-field take off with manual inlet valve (a), disk filter (b), and two electric solenoid valves controlling irrigation blocks (c). Flow directions shown with arrows.

Figure 26. Electric solenoid valve with in-built adjustable pressure regulator and manual close.

Figure 27. Simple time-based battery-operated in-field zone controller.

ZONE CONTROLS

Basis

Zones are based on both management needs and hydraulics considerations.

- The system manager should be able to selectively water different crops and schedule crops on different soil types as required.
- The designer may divide areas into blocks to optimise pump, headworks and distribution pipe selection.

Automation

Drip systems are easy to automate. Many options for control are available with the selection process considering cost, time saving and management sophistication.

The simplest systems enable blocks to be programmed to run for a set time before turning off. More complex systems allow multiple blocks to operate at the same time, cutting in and out to meet management goals while remaining within the system's constraints (pumping rate, consented take rates etc.).

Some systems monitor system flow, and turn off once a pre-determined depth of irrigation has been applied. Others monitor soil moisture in the field, and aim to apply irrigation to return to a set soil moisture level.

Installation

This section relates only to those aspects of installation specific to drip irrigation for vegetable crops. Many principles will of course apply to dripline used in other situations.

The pumps, headworks and mainlines of a drip system are the same as for any other irrigation system type. Their installation is not covered in this book. The main emphasis therefore is on laying driplines and sub-mains or header pipes.

SURFACE VERSUS SUB-SURFACE

Surface laid dripline is easy to install, visible and easily uplifted. It is also prone to damage.

Buried systems require more effort to install well, are not visible and can still be damaged. They are more difficult to remove when necessary.

GROUND PREPARATION

Because dripline constrains cultivation operations, any major earthworks should be done in advance of installation. Considerations include surface levelling and the condition of the soil profile, to allow efficient installation and to ensure best water movement once the system is running.

Once the dripline is in place, remediation is difficult.

Levelling

The aim should be for a level plane surface, ideally sloping away from the sub-main.

Drip irrigation runs at low pressure, so small changes in ground level can affect emitter flow rates. A sloping field counters some of the pressure loss from friction and can allow longer dripline runs. Compensating emitters minimise any pressure change effects but are more expensive.

Lower areas in the field tend to get extra water as the dripline empties at the end of each irrigation event. Higher points drain first so get less water. These effects are more obvious when frequent short duration irrigation schedules are implemented. An even field grade can minimise them.

HEADWORKS

Main lines

Laying mainlines is as for any equivalent scale irrigation system.

Drip systems often use PVC pipes for mainlines. Care must be taken to install suitable thrust blocks if required, and to ensure all joints are water tight and remain so.

Sub-mains

Sub-mains, also called “headers” or “manifolds”, distribute the irrigation among the dripline laterals. Off-takes are set into the sub-main and connected to the dripline.

In surface drip systems, the sub-mains may be lay-flat hose which can be driven over by vehicles entering the crop. Care should be taken to avoid straining connections and off-takes to avoid damage and leaks.

In permanent buried systems the sub-mains are usually PVC pipe or sometimes polyethylene pipe. PVC is less likely to twist and loosen off-take connections. It is preferred to reduce the risk of leaks developing at the off-takes.

The sub-main is often laid somewhat deeper than the dripline. Vehicles and machinery are likely to pass across the sub-main, and sufficient depth of soil is needed to protect it.

Fit air-release valves to sub-mains as specified by the design.

Figure 28. Cross-ripping an area prior to buried dripline installation.

Figure 29. Cultivation to provide ideal soil conditions for installation and water spread.

Figure 30. Laying buried dripline: RTK-GPS guided tractor, roller for depth control.

Figure 31. Laying tape with a bed-former. Photo by Paul Le Feuvre.

Figure 32. Ensure all joints are correctly made and water tight.

Figure 33. PVC sub-main (header) with off-takes connected to buried driplines.

Figure 34. Flushing point for permanent drip in a vineyard.

Flushing sub-mains

Flushing sub-mains require installation of removable flushing caps. Consider where the waste-water will be discharged when flushing. Ensure the flushing point rises high enough above ground to avoid backwash of dirty water when flushing flows cease.

Off-takes

Flush the mainline and sub-mains before fitting off-takes. This removes all foreign matter from the system.

Off-takes connect the dripline into the sub-main or manifold. They require a hole to be drilled into the sub-main, and a pressure fitted connector installed. There is usually a rubber grommet ensuring a good seal between the connector and the wall of the sub-main.

It can be easiest to install the sub-main and off-takes in a trench, then overlay the dripline and connect it to the off-takes.

Ensure the off-takes are aligned to avoid any undue stresses on the off-takes and avoid kinking the dripline.

LAYING DRIPLINE

It is much easier to lay dripline correctly the first time than to fix mistakes. This is especially so when dripline is buried. The notes below relate particularly to buried drip.

Soil preparation

Cultivation/ripping the area before laying buried dripline helps avoid "guttering" or water flow along the ripped irrigation installation lines. Cross ripping is preferred. This also helps the laying machine maintain a straight line when installing the dripline.

A level soil surface makes laying buried dripline easier. Equipment runs better on a well-prepared surface, helping achieve uniform installation depth.

Alignment and spacing

There are many advantages of laying the dripline as accurately as possible. If it is in straight, evenly spaced rows, other operations can most easily fit around it.

When laying dripline on existing beds, the beds themselves may be sufficient to guide equipment. However it is preferable to use high-accuracy GPS systems. The ready availability of RTK-GPS makes this accessible and affordable and gives ease, surety and recording of placement.

Figure 35. Laying machine set to place two rows of dripline at 1.5m centres.

Lateral laying equipment
There are many options for laying out dripline. Essentially all involve a spindle on which rolls of dripline can be mounted, and a way to draw it along the row.

Some surface systems leave the spindles and rolls or multiple rolls at the end of the block and pull the dripline out along the row. Others fix the end of the dripline and drive the spindle and rolls along the row laying the dripline as they pass. This tends to reduce risk of stretching the dripline.

Buried dripline generally involves fixing the dripline end and un-reeling it as a machine passes along the field. A hollow tine guides the dripline into the soil, with the depth controlled by a surface roller.

Ensure enough length is left to make a secure connection to the sub-main off-take hoses and to the flushing sub-mains as well.

Depth control
Depth control is important as it affects the ability of water to reach the surface and sets the safe working depth for subsequent soil operations.

Check depth regularly by digging and measuring to actual installed depth.

Care of dripline
Dripline is easily damaged and care must be taken when laying it. Any sharp points on laying equipment can severely weaken the dripline and increase splits and other leaks.

This is especially important when using thin-walled drip tapes. The wall thickness is only tenths of a millimetre so the tape must be treated as very fragile.

Critical points are the entry into the tine, and corners around which the dripline is pulled, and the exit point. Weld marks and splatter may be enough to compromise the dripline.

Joining
It will be necessary to make joints as the dripline is being laid. Take care to ensure fittings are well seated, and pressure fittings secure. There will be some strain on joints as the dripline is laid into the soil, and again whenever the system is pressurised.

Ensure the correct fittings are used for the dripline being laid. Tolerances can be small, and the wrong fittings are likely to fail.

Connecting to sub-main
Avoid getting soil into the dripline.

Cut the dripline to length and connect to the off-take. Some installers connect directly to the off-take connector, others use a short length of standard lateral hose between the connector and the dripline.

Ensure the connections are secure. Consider using some backfill soil to keep the sub-main in position and to support connections if necessary.

It is often helpful to place soil under each off-take before back-filling the trench. This helps avoid joints being pressed out of line and leaks developing.

Closing lateral ends
Before closing the lateral ends, the system should be flushed to ensure no soil, PVC sawdust, thread tape, grass or other foreign material remains.

Ends may be connected to a flushing sub-main or folded over and secured.

Figure 36. Pinning the dripline ends before pulling the dripline into the soil.

Figure 37. Installation depth should be checked regularly. On this machine, the back roller controls the depth.

Figure 38. Dripline is wound off the spool and through a shank into the ground. Care to avoid sharp points on equipment is essential.

Figure 39. Joining dripline mid-row (left). Joint to be pulled into soil by machine. Ensure all connections are secure. Once buried they are difficult to check and repair.

Figure 40. Checking system pressure at the headworks of a larger drip irrigation system.

Figure 41. Checking pressure at the end of a dripline.

Figure 42. Check flow rates, block by block, are as specified in the design.

Figure 43. Measure individual emitter flows at key points.

Commissioning

Commissioning an irrigation system is the final stage of installation and the first test that the design and installation are successful. Commissioning must verify that the system performs as intended and achieves the level agreed between purchaser and supplier.

A separate Irrigation New Zealand book describes the commissioning process in detail.

Some of the field checks that must be made are:

- Control systems operate correctly
  - Check the pump turns on and off as intended
  - Check performance of the controller and each solenoid valve
  - Check performance of each specialist valve such as pressure regulators and air releases
- System pressures are as specified
  - Check at the pump outlet
  - Check before and after filters
  - Check at each block off-take
  - Check at the beginning of the first and last laterals in each block
  - Check at the end of the first and last laterals in each block
- System flow rates are as specified
  - Check as each block is operating
  - Check flows from emitters. As a minimum, perform a block by block calibration.

Management

In many ways, drip is just another form of irrigation. All the usual management rules apply. There are however some specific issues.

Maintenance

NEED FOR REGULAR MAINTENANCE
Every irrigation system requires maintaining. Every system should have a defined maintenance schedule.

There is no particular recipe, as needs will vary according to system type, water source (quality) and the environment in which the system is operated. But keeping to a well planned maintenance schedule will help avoid gradual performance decline or even catastrophic failures.

Maintenance may be preventative or corrective. Preventative maintenance seeks to avoid problems. In drip systems, preventative maintenance is critical to prevent or inhibit debris or depositions from plugging, clogging or blocking the drippers.

Corrective maintenance attempts to put the system back on track once problems have become apparent. It aims to remove obstructions that have caused blockages. This is an undesirable situation, because not all obstructions can be removed.

Constant monitoring is the best way to determine whether a preventative maintenance programme is working. A drop in performance indicates increased maintenance activity is needed. On-going, problem-free operation might give you confidence to reduce maintenance activity a little.

One feature of drip systems is a very large number of outlets or emitters, each of which is very small. These are also prone to blocking if any debris gets into them. So there can be a lot of places to block and a lot of checking required.

The wall of drip tape and even drip hose if very weak, so easily damaged. Leaks must be identified and repaired if the benefits of drip are to be gained.

PREVENTATIVE MAINTENANCE

Pre-season system checks
Permanent and semi-permanent systems require a pre-season check. Irrigation New Zealand Checklists are available to guide this.

A pre-season check starts with a "system tune-up" or basic review to fix obvious problems.

Start at the water source, and work through the system to the end:

- Check water intakes are clear
- Check and clean all filters
- Check pump operation is normal
- Check the water meter is functioning
- Check the controller is functioning
- Flush the mainline.

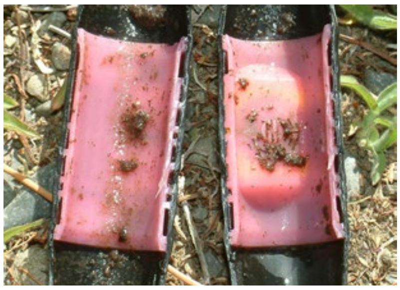

Figure 44. Dissect a selection of drippers to check for impending problems. This dripper shows high levels of algae which may block the small pathways.

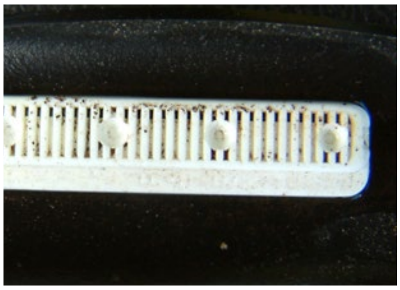

Figure 45. Fine sand particles collecting inside emitter.

Figure 46. Strain flushing water through a stocking to determine what contaminants are present.

Figure 47. Checking water from a lateral for presence of contaminants or debris.

Figure 48. Check water inlets are clean and free of obstructions.

Figure 49. Check and clean filters.

Figure 50. Check pump operation is normal.

For each separate block:

- Check each block control is functioning correctly
- Look for and repair any obvious leaks
- Flush the sub-main
- Flush out the laterals

Do a routine system check once the system tune-up is complete.

System flushing

Flushing is a central part of any maintenance programme. Flushing involves opening flushing valves on the mainline, then sub-mains, then laterals. To be effective, flushing requires high velocities so debris is scoured from the pipelines. This means flushing needs to be conducted in a staged fashion, block by block, maybe line by line, ensuring pressures and flows are adequate.

Flushing always begins at the start of the system – generally with the filters. As each stage is cleared of debris, flushing can move to the next. The mainline is flushed before the sub-mains, sub-mains before laterals.

Required flushing intervals depend mainly on water quality, loadings and weather conditions. Many parts of New Zealand have extremely clean water available for irrigation.

Where the source is a surface supply or poor quality bore, more frequent flushing is required – every few months if relatively clean, monthly if there is significant sediment load or biological contamination. In severe cases, fortnightly flushing may be necessary often accompanied by chemical treatment.

Clay and very fine silt particles are virtually impossible to filter out. Because these are very small, they can pass through drippers or sprinklers. However, regular flushing is the best way to reduce system deposits, which may build up, dry out, and cause severe problems.

Some systems have a lateral flushing valve fitted to each lateral. Some of these have a relatively small opening, and can prevent the flow rates needed to scour debris from the lines.

Water treatment

If filtration is insufficient, chemical injection may be required to avoid system blockages. Chemical treatment to prevent blockages takes three different forms: Chlorination, Acid Injection and Herbicide Injection. The treatment to use depends on the type of problem that exists; biological, chemical or physical.

Netafim presents Table 3 that identifies potential blockage problems and which treatment is best suited to combat them.

Table 3: Problem, cause and preventative treatment of water for drip irrigation.

Problem		Treatment
Biological	Algae	Chlorination
	Red Iron Sludge	Chlorination
	Any Organic Material	Chlorination
	Slimy bacteria	Chlorination
	Iron or Manganese Bacteria	Chlorination
Chemical	Iron/Manganese Sulphides	Acid Injection
	Calcium Carbonate precipitation	Acid Injection
	Magnesium Carbonate precipitation	Acid Injection
	Any Inorganic Material	Acid Injection
Physical	Root Intrusion	Herbicide Injection

ROUTINE SYSTEM CHECKS

With the system clean and running correctly, check critical performance indicators for each block:

- Check pump pressure
- Check pressures before and after filters
- Check pressure at each block control point
- Check lateral pressures at the beginning and end of the first and last laterals
- Check system flow rates
- Check lateral flow rates if individual water meters are fitted
- Check sample emitter flows

SYSTEM CALIBRATION

Any irrigation system should be calibrated at least annually to verify its level of performance. System calibration checks the design flows are achieved, the application intensity (mm/h) remains correct, and that water is applied evenly or uniformly across the area.

Drip systems have low flows and pressures and very small openings which together make them very prone to blockage if water quality is imperfect. When checking drip irrigation performance, individual emitter discharges are checked. This means extra work for buried systems as the drippers must be excavated.

In a brand new well designed system, overall system performance is determined by necessary pressure variation within the lateral network, emitter performance characteristics and variation in manufacture.

In older systems, these influences are compounded by damage to and deterioration of components, and by physical blockages of very small orifices. So the nature of the system, with low pressures and very small orifices, requires that water quality be high.

CORRECTIVE MAINTENANCE

If preventative maintenance has failed, corrective action will be required. The first point however is that corrective treatments may not rectify your problem! Remember that prevention is better than cure.

Disk filters

The disks should be removed from the element (spine) and soaked in an acid solution for up to 12–24 hours. Hydrochloric acid, (HCL), obtained from a farm or swimming pool supplier, mixed to 30–40% solution, (3–4 litres of acid mixed with 10 litres of water), will remove any buildup of organic and mineral salts from the grooves in the discs.

System treatment (including dripline and emitters)

Two treatments often considered as corrective maintenance are heavy acid injection treatment and super chlorination.

Safety Note

Acids and chlorine products are highly corrosive. They must be used with care. Both have the potential to cause significant harm to people and equipment if used incorrectly. Always wear protective clothing and have a source of clean water readily available.

Heavy acid injection

Heavy acid injection to lower the water pH to a level of 2 is normally considered as a corrective treatment.

Such a treatment would be considered for root intrusion or a high percentage of dripper/emitter blockages caused by mineral deposits. Several treatments may have to be conducted in order to reverse severe conditions. System flushing is always part of such treatment procedures.

Super chlorination

Super chlorination is the process of injecting chlorine in high concentrations, normally between 20 to 50 ppm. This process is also considered corrective maintenance and is normally conducted when there is a very high concentration of organic matter, worms, eggs etc growing in the dripline.

Irrigation scheduling

PLANT WATER USE

Drip irrigated plants need as much water as plants irrigated in other ways. The amount needed depends on climate and the crop. The nature of drip irrigation allows frequent small applications of water to keep ideal conditions in the root zone.

VARIANCE FROM FULL WETTING IRRIGATION

Because drip may only water a fraction of the total root zone, there is less water available, so frequent, timely application becomes essential. There is less room for scheduling error.

Managers must take account of the reduced area of wetting when setting application volumes. If the crop needs 5mm of irrigation (equivalent to 5mm of rain) but only half the area gets wetted, the wetted area gets 10mm of irrigation.

The importance of this is ensuring the applied volume does not cause the irrigation to go deeper than the crop roots, or the water will be wasted.

SOIL MOISTURE MONITORING

Soil moisture monitoring is a key management tool. With drip systems that do not fully wet all the soil, care is needed when siting soil moisture monitoring equipment. If sensors are placed directly under the dripline they are likely to record wetter values. If sited outside the wetting zone they may show drought. The management reality is somewhere in between.

Experience will help guide placement of monitoring equipment and interpretation of results. A spade is a very useful tool: dig holes and see what is really going on!

SCHEDULING AND ROOT INTRUSION

Irrigation scheduling can affect the risk of root intrusion and soil siphoning. Root intrusion is often related to dry soils and water-stressed plants. Moisture monitoring and scheduling will help avoid plant stress, and thus minimise conditions that encourage root growth into drippers. If crops do require 'drying off', pulsing irrigation to maintain moisture around the dripline, or treatment with herbicides that kill root tips but not the plants are options.

NUTRIENT MANAGEMENT AND FERTIGATION

A nutrient budget and management plan are essential parts of crop management regardless of irrigation or irrigation type. But drip irrigated crops do have some particular features that need consideration.

If a drip system does not wet all the soil, and the un-irrigated parts dry out, the plant may experience nutrient deficiency. The nutrients are there, but not available.

This is one benefit of fertigation, as the nutrients are applied with the irrigation water. Fertigation allows timely application of measured doses of nutrients direct to the plant root zone. This enables a rapid response to any identified nutrient shortages and also helps reduce leaching.

Figure 51. A Neutron Probe gives accurate measurement of soil moisture.

Figure 52. Soil dielectric sensors give good readings in typical vegetable cropping soils.

Figure 53. Mobile fertigation rig.
Photo by M. Cahn.

Figure 54. Mobile fertigation rig with concentrates in separate containers.

Selecting chemicals
Fertilisers need to be soluble and compatible with the water used for drip irrigation systems. They must not react with salts present in the water to precipitate of system blockage risk increases.

Most forms of nitrogen fertiliser are very water soluble, including urea, nitrate, and ammonium, but calcium in some formulations may precipitate with bicarbonate, a common constituent of water in New Zealand.

Studies have shown that some nutrients, including phosphorous, do not travel far from the emitters. Usually this is not a problem as driplines are close to the planted rows. However, it is possible that plants without roots near the emitter may not receive sufficient nutrient.

DETERMINING DOSE RATES

Supplying the right amount of nutrient involves matching the nutrient concentration with the system flow rate and duration of application. The fertigation is only recommended during the middle period of an irrigation event. It takes time for the system to fill and to empty, and fertigation should occur only between those times.

EXAMPLE CALCULATION

Apply 25kg of urea nitrogen per hectare to a 1 ha block using a system with 2 L/h drippers at 400mm spacing and laterals 760mm apart. The total irrigation duration is three hours.

Solution
Assume the full nutrient dose should be applied within 1 hour during the middle of the irrigation event. Therefore the application rate must be 25 N kg/h.

Each hectare receives water from 32,895 emitters. $10{,}000\ m^2/ha \div (0.40m \times 0.76m) = 32{,}895$ *emitters*

Therefore the system applies 65,790 litres to the hectare in 1 hour. $2\ l/h$ *per emitter* $\times\ 32{,}895$ *emitters* $= 65{,}790\ l/h$

The nitrogen concentration of the fertigation must be: $25{,}000\ g/h \div 65{,}790\ l/h = 0.38\ gN/l$

If the dilution into the irrigation system is 1:100 nutrient solution:water, the nutrient solution must contain 38 g/L of nitrogen or 83g/L of urea (100 times stronger than the dilute fertigation in the irrigation system).

Recovery and disposal of used dripline

RECOVERY EQUIPMENT

Growers successfully using drip irrigation usually develop equipment to facilitate efficient dripline removal, and if required, storage for re-use.

Many alternatives have been developed. Most involve a lifting mechanism to free the dripline from the soil or crop, and a method of winding dripline on to a reel. Some systems brush clean the dripline, and some are able to repair it as leaks or joins are identified.

ISSUES WITH REUSE

Dripline can be subjected to damage, causing leaks and blockages which immediately impact performance.

Dripline intended for reuse should be carefully checked for leaks and flushed while in the field. If necessary it should be chemical treated before being recovered. This cleans the dripline out and reduces the risk of blockages.

Damage done in the field can be made worse during recovery operations. Care should be taken to avoid stretching and weakening the dripline, and to avoid kinking or nicking which causes holes or weakness points.

Re-use also implies storage. In storage the dripline is also at risk of damage whether by people or animals such as rodents.

ISSUES WITH DISPOSAL

Disposal problems are one of the downsides noted by growers using dripline. There are no convenient recycling options at present so dumping is the likely fate. This is one of the factors encouraging multi-crop and multi-season use, whether left in-situ or recovered and re-laid.

Figure 55. Lifting buried dripline prior to recovery for re-use.
Photo by P. Le Feuvre.

Figure 56. Dripline laid on surface, ready for recovery. Photo by P. Le Feuvre.

Figure 57. Splicer to repair dripline for re-use. Photo by M. Cahn.

Figure 58. Splicing done correctly does not leak. Photo by M. Cahn.

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NOTES

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