To what extent is subsurface drip suited to the Murray Irrigation region?

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In a nutshell
- There are opportunities for adopting SDI technology in the Murray Irrigation region given the soil types and agriculture systems present.
- In simple terms SDI is highly likely to be viable when it is used for a high value crop, on the best soils, with a high level of management.
- It is essential that growers fully investigate the market demand for produce and the associated prices before investing in the irrigation technology.
- It is also essential that growers be adequately trained in the management requirements of SDI, including understanding of the suitability of their soils and chosen enterprise(s) for SDI.

Subsurface drip irrigation (SDI) has been used increasingly in Australia for a wide variety of perennial crops: trees, vines and vegetables, and for broadacre crop systems. Several irrigators have had great success with the technology including improved yields and quality of produce. However, SDI is yet to be widely applied in the Murray Irrigation area of southern New South Wales.

The Murray Irrigation region comprises the four irrigation districts of Wakool, Denimein, Cadell and Berriquin (Fig. 1). Agriculture is a major industry in the region, with 2400 farms covering an area of more than 748,000 ha and producing a farm gate value of approximately $300 million. Around 51% of the region has been developed for irrigation and the remaining 49% is used for dryland agriculture.

Irrigation supply and infrastructure is provided to the region by Murray Irrigation Limited, who funded a project to examine the opportunities and barriers for adoption of SDI in the region. The key outcomes of this study are presented in this article.

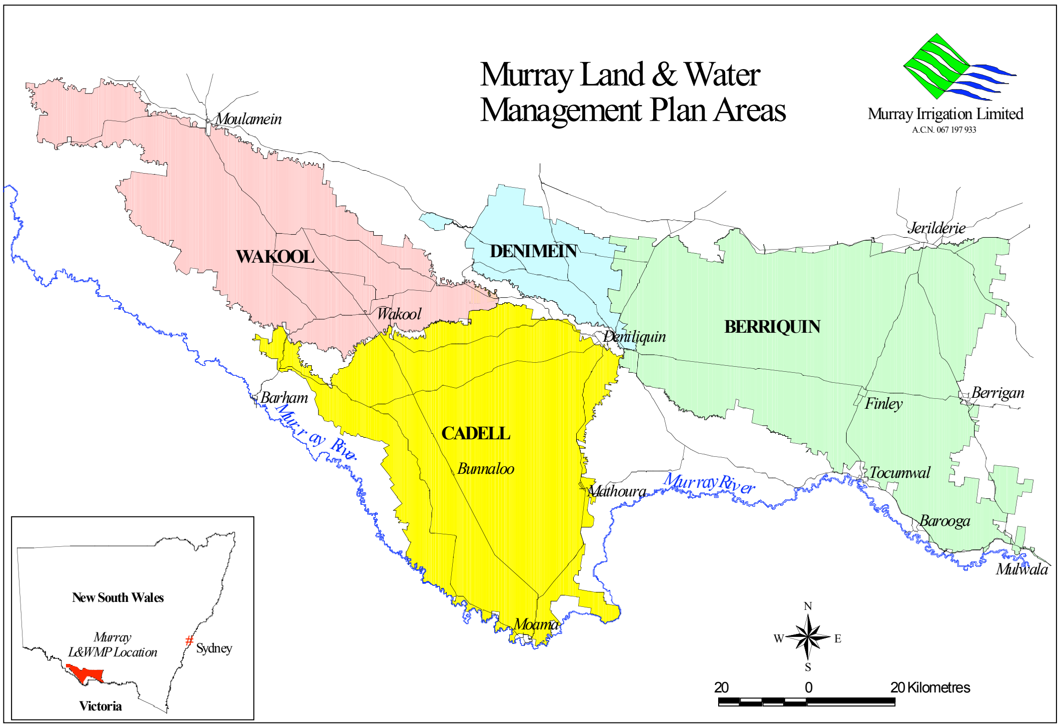

Figure 1: The irrigation districts in the Murray Irrigation region (Source: Murray Irrigation Ltd 2006)

What is SDI?

Subsurface drip irrigation uses underground driplines of either plastic tubing or tape usually buried 10 cm or deeper in the soil, depending on the location of the root zone of the crop to be grown (Figure 2). Water is emitted through drippers located along the dripline usually at an interval of 0.4–0.75 m. To create uniform coverage or to irrigate row crops, the driplines are placed parallel to each other at spacings of around 1.0–1.7 m depending on soil type and widths of crop rows. Both raised beds and flat ground are suitable for SDI. Systems can be designed with driplines having a short-term lifespan (3–5 years) or as permanent installations in which the driplines can last for more than 15 years.

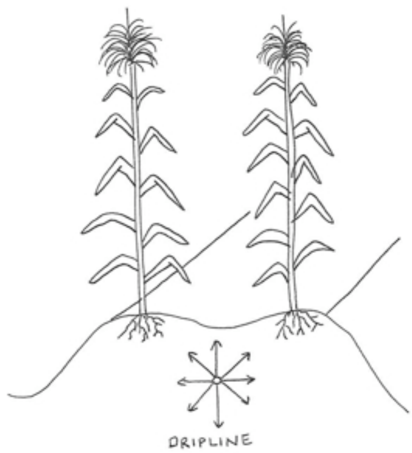

Figure 2: SDI location in centre of raised beds and direction of water movement

Benefits of SDI

The adoption of SDI around the world has increased over the last decade, with farmers converting because of the numerous benefits.
A processing tomato grower near Rochester in northern Victoria found "subsurface drip allows you to open up a lot more country to irrigation, because it can be used on areas where soils and topography are not suitable for flood irrigation. You are able to control a lot more area and the labour requirements are less. This means you can have a better lifestyle compared to other labour-intensive irrigation methods like furrow".

Similarly, a tomato grower near Tatura stated, "subsurface has meant I can control the crop easier and can adapt to climate and rainfall. It has taken a lot of guess work and risk out of production. It has also meant we are not leaching our fertiliser, so our fertiliser and chemical costs are down. I wouldn't consider going back to furrow irrigation".

Other benefits include maintaining soil moisture around the roots at an optimum level and improving disease control by allowing foliage and fruit to be kept dry. Subsurface drip irrigation also has design flexibility, allowing it to be incorporated into existing farm layouts without the need for extensive landforming, vegetation clearance and adjustments to fencing and access tracks.

Water savings

Water savings are a major benefit of SDI technology. Water savings can provide an extra income source, as saved water can be sold or used to expand the planted area. For example, a recent Victorian DPI experiment demonstrated that under experimental conditions, subsurface drip performed similarly to sprinkler irrigation, using approximately 2 ML/ha less water than border check each year, but consistently producing 0.9–1.0 t DM/ha more pasture than border-check irrigation. A CSIRO Land and Water experiment at Coleambally also found subsurface drip irrigated maize out-performed sprinkler and furrow irrigated maize in terms of yield, net irrigation water use and net irrigation water productivity.

Barriers to adoption

Despite the advantages presented in the previous section, several barriers exist for using SDI. Firstly SDI is a fairly recent technology that can be a challenge for growers. Irrigation with SDI requires careful management and persistence on the part of the grower. An irrigator near Newstead using SDI believed 'the biggest issue with subsurface drip is the attention to detail needed at a microscopic level'.

Other disadvantages include line damage being more difficult to repair in comparison to surface drip irrigation and high initial capital costs. There is potential for root intrusion and blockage of emitters if the system is poorly designed or not properly maintained. Germination and crop establishment might require additional sprinkler or surface irrigation and root development can be restricted within a small wetted volume if the system is not managed correctly.

Is SDI suitable for the Murray region?

The suitability of the Murray Irrigation region for SDI was determined by investigating the soil types and current agricultural systems present. The key messages are outlined below.

Soils in the Murray Irrigation region

Five soil groups have been identified to describe soils in the Murray Irrigation region, with each incorporating several soil types. The soil groups are typical of those across the entire Riverine Plain. The suitability of each soil group for SDI is described below.

Sandhill soils cover less than 2% of the total Murray Irrigation area and are mainly restricted to the western parts of the Wakool irrigation district. Sandhill soils are usually suitable for horticulture and lucerne production. However they are not particularly suitable for SDI due to the high level of drainage making it difficult to supply adequate water to the root systems.

Red-brown earths or duplex soils are common in the Murray Irrigation region, covering approximately 40% of the overall area (300,000 ha) and two-thirds of the Berriquin irrigation district. The topsoil is sandy-loam to light clay loam overlying a clay subsoil. The lower topsoil (A2 horizon) may be bleached. These soils are suitable for SDI if carefully managed and are capable of growing high value crops.

Compared to red-brown earths, **transitional red-brown earths** are less common in the Murray Irrigation region and have shallower and usually more clayey topsoils and more clayey and deeper subsoils. The subsoil may be sodic and if so, then growth problems can occur due to the lower permeability. This renders such soils less suitable for SDI.

Self-mulching clays cover small areas scattered over the region. They have a uniform clay content, well-developed surface structure, but can be prone to compaction when wet. Self-mulching clays are particularly suitable for SDI and are known to successfully support tomato crops in conjunction with SDI. However, issues can arise due to the cracking nature of this soil when it dries. To ensure that it is not a problem, a wetted pattern needs to be maintained around the dripline at all times. Even in winter, the system must be operated for approximately one hour per week (unless there has been significant rain) to ensure the soil does not crack open. As most irrigation districts close their channels over the winter, this requirement can pose a management challenge. It may be necessary to establish a small on-farm storage dam or try to maintain a reasonable level of water in one of the channels to help maintain the soil moisture. Even though these soil types only make up around only 6% of the land area in the Murray Irrigation region, this corresponds to approximately 43,600 ha. This is a substantial area with the potential for more intensive development of crops using SDI.

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Figure 3: SDI is suitable for self-mulching clays (Source: RMCG)

Non self-mulching clays are widespread in the western parts of the Murray region and are characterised by a shallow crust-like topsoil, a poor structure that is usually dispersive and poor infiltration and permeability. These soils are not suitable for SDI as the poor soil structure prevents adequate access to soil moisture by the crop.

Agriculture in Murray Irrigation region

Due to the high initial capital cost, SDI can only be justified for the production of medium to high value crops.

Rice could be considered a medium value crop and trials have been conducted in the region with SDI for the production of rice. Unfortunately, weed control has proven to be too difficult when the rice crop is not flooded. Also, early in the reproductive growth of rice it is necessary to have at least 25 cm of water on the crop to prevent cold damage to the developing pollen, and resulting grain sterility. For these reasons, it is not considered feasible to grow rice using SDI at this point.

Winter crops such as **wheat, canola** and **barley** can be grown as rotation crops and "finished off" in the spring using the SDI system, but it would not be economical to install SDI specifically to grow these crops. The use of SDI for the production of forage crops is currently considered feasible where the forages are part of a "cut and carry" system as opposed to a grazing system. For example, **lucerne** for hay or silage and **maize** for "green chop" or silage would be considered feasible.

However, the use of SDI for irrigating perennial and annual **pastures** is not currently recommended. The main concern is that most pasture species are relatively shallow-rooted, requiring the driplines to be closely spaced and placed at a relatively shallow depth. The lines are then susceptible to damage by grazing animals, especially cows.

Annual **fruit** and **vegetable** crops such as melons, tomatoes, onions and asparagus are highly suited to SDI due to the relatively high value of the end product and the ability of drip irrigation to significantly enhance yield and quality. **Potatoes** also respond very well to drip irrigation, but the method that is used is not strictly within the definition of SDI (shallow burial of the tape).

Figure 4: Tomato crops are suited to SDI (Source: RMCG)

Maize production using SDI has recently been highlighted in the media due to the production of a very high yielding crop (21 t/ha of grain) at Sawers Farms in Boort, Victoria. The SDI system on which this crop was produced was originally installed for the production of processing tomatoes, but the owner has found that there is less risk associated with the production of maize for grain.

Maize for popcorn and the manufacture of corn chips could be considered if contracts can be secured. Sweet corn for the fresh market and processing could also be considered, but a large venture in the MIA has recently failed and growers in the Rochester, Victoria area also abandoned this crop due to competition on the fresh market and pesticide resistant grub infestations.
Chickpeas grown with SDI could yield up to 6 t/ha in favourable seasons, and most importantly, the size of chickpeas is what determines their end use. With careful

selection of varieties and careful crop and water management, potentially 60% of the yield could be made up of "large" peas commanding a premium price.

Figure 5: Shallower potato irrigation is not technically defined as SDI (Source: RMCG)

What about costs?

The capital and operating costs of furrow, centre pivot, temporary and permanent subsurface drip irrigation systems were compared for three crop types – vegetable, lucerne (cut and carry) and a summer crop.

Temporary SDI can generally cost between $5000–$6000/ha and permanent SDI costing between $5700–$6900/ha. To provide some perspective, breakeven production values were calculated to give an indication of the possible increases in income and production that would be required to pay for upgrading an irrigation system from furrow to centre pivot or temporary or permanent subsurface drip irrigation (installed from new). These costs are presented as a guide only, and are based on average costs from the literature and the past experience of the project team.

Individual circumstances vary and this analysis should not be used to conclude one particular system is more suited for a particular situation. There is a need for analysis on a case by case basis.

Is an upgrade worthwhile?

The percentage increase in production needed to pay for alternative irrigation systems compared with furrow irrigation, will vary depending on the value of the crop.

Vegetables

For a vegetable crop changing from furrow to centre pivot irrigation, the percentage increase in production needed will vary from approximately 3% for a crop with a gross return of $5,000/ha to 1% for a crop with a gross return of $12,500/ha.

A higher production increase is needed for the conversion to permanent SDI from furrow for a vegetable crop. For a crop with a gross return of $5,000/ha a 10% approximate increase is needed, while a crop with a $12,500/ha gross return needs a 4% approximate increase. Conversion to temporary SDI from furrow for a vegetable crop requires a 14% increase in production at $5,000/ha down to a 5% increase in production at $12,500/ha.

These figures suggest that converting furrow to SDI is an economically viable option for vegetable crops, given some crop production has been shown to double when converted to SDI. The processing tomato industry has had a shift from furrow to SDI as a result of the improved production.

Lucerne (cut and carry)

Conversion to centre pivot from furrow for lucerne (cut and carry) systems requires an increase in production of approximately 13% at an existing gross return of $2,000/ha to an approximate 5% increase at a gross return of $5,000/ha. Conversion to permanent SDI requires an increase in production of approximately 28% at $2000/ha gross return down to an 11% increase at $5000/ha gross return. Converting to temporary SDI from furrow would need a 36% increase in production at $2,000/ha gross return, ranging to a 14% increase at $5000/ha.

Given previous research has shown a 20–30% increased in productivity can be obtained for lucerne crops under SDI, the above estimates suggest it may be an economically viable option.

Summer crop
For a typical summer crop system, converting to centre-pivot from furrow would require an increase in production ranging from approximately 10% at $2000/ha gross return to approximately 4% at $5000/ha gross return. The increase in production needed for conversion to permanent SDI would range from approximately 25% at $2000/ha to 10% at $5000/ha gross return. For a conversion from furrow to temporary SDI to be viable, an increase in production would be needed between 34% at $5000/ha to 14% at $2000/ha gross return.

A 16% increase in yield was obtained at the Coleambally trial for a maize crop using subsurface drip compared to furrow irrigation. Such results indicate conversion to SDI from furrow irrigation may be a viable option for some summer crops.

Summary

In simple terms SDI is highly likely to be viable when it is used for a high value crop, on the best soils, with a high level of management. Where any one of these factors is missing SDI becomes a more risky proposition.

There appear to be opportunities for adopting SDI technology in the Murray Irrigation region given the soil types and agriculture systems present. It is important to realise that while SDI is suitable for production in several of the above-mentioned crops, it is essential that growers fully investigate the market demand for produce and the associated prices before investing in the irrigation technology. It is also essential that growers be adequately trained in the management requirements of SDI given the risks involved. This includes an understanding of the suitability of their soils (eg accurate soil surveys) and chosen enterprise(s) for SDI.

Overall there is some difference between system costs, however the main advantage is that subsurface drip does enable opportunities for expansion (reducing production costs per hectare) and increased yields. Therefore, where these opportunities are realised, subsurface drip is an attractive option. However, individual cases will vary enormously and should be investigated thoroughly.

The decision to change irrigation systems should not be taken lightly. All irrigators have different circumstances and management practices and these need to be considered when choosing the system.

Further information

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Further reading

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