3.8 Effluent distribution and irrigation systems

The uniformity of land application (or distribution) of effluent depends on the type of system used to transport and deliver dairy effluent to the land and on farmer expertise, capital cost, labour availability, system complexity, climate, weather, landscape, soil type and the crop or pasture being grown. In irrigation areas (particularly flood irrigation areas), the shandying of effluent with other water sources via conventional irrigation systems is typical. Direct application from a yard or pond is also practised using equipment suited to a higher solids content (see also chapter 2.2 'Direct application systems').

Managing effluent for irrigation

Recycling irrigation tailwater

In some dairy production areas, especially in irrigation areas, irrigation tailwater recycling sumps are common. It is usually recommended that where effluent is distributed via flood irrigation, all farm drainage be contained for reuse on the farm to avoid water degradation from runoff from a site receiving applied effluent (DairyCatch 2006, DPI 2004, McDonald 2002). This runoff could arise directly from the effluent application or indirectly from rainfall shortly after application.

Solids

Dairy effluent must undergo mechanical or gravity separation before it is conveyed through conventional irrigation systems. The solids in dairy effluent comprise nutrients, organic matter and inert materials like gravel, sand and clay which can compromise the performance of conduits and nozzles. Effluent with up to 5% solids can generally be handled as a liquid, and effluent with more than 20% solids can generally be handled as a solid (see chapter 1.1 'Physical, biological and chemical components of effluent and manure'). The application of harvested solids to land is discussed in chapter 3.10 'Land application of manure and pond sludge'.

Systems for land application

The types of systems available for the application of effluent and irrigation water are many and varied. They include flood irrigation systems, which encompass border-check irrigation, furrow, contour bank, contour ditch and paddy. Other systems include solid set sprinklers, lateral-move travellers, centre-pivot sprinklers, boom sprinklers, bike moves, pop-up sprinklers, pipe and risers, gated pipes, and drip and micro-sprinkles. All conventional irrigation systems can be used to apply dairy effluent to land. However, although effluent can be transported and applied through dedicated pipe and sprinkler systems, these systems are at strong risk of clogging and corrosion. The utility of any system depends on the concentration of nutrients and salts and on the amount of solids, which dictates downslope surface flow prospects and the clogging potential of pumps, pipes and nozzles.

Flood irrigation

Flood irrigation applies water by gravity to moderately sloping land. Slope is important, as effluent must pass across a paddock in 6–10 h to reduce waterlogging; if the slope is too little, excessive infiltration losses will occur, whereas if it is too great, the soil profile will not be adequately wetted. Flood irrigation systems are commonly used for the application of dairy effluent. Effluent which has undergone primary treatment will distribute more uniformly across the paddock when mixed with water. Soils generally become saturated to the depth of the pasture root zone or below after flood irrigation. As long as evapotranspiration rates are high and profile drainage is possible, the period of saturation is small. These types of systems are not really impeded by solids in the effluent as long as the solids are degradable.

Advantages of flood irrigation:

- low energy use
- minimal land-forming required
- low cost
- low labour.

Disadvantages of flood irrigation:

- unsuitable on undulating or hilly land
- unsuitable on sandy soils
- low application efficiency
- wasteful of water.

The major risks of the more rudimentary flood irrigation systems are the potential for non-uniform distribution of water, nutrients and salt and the exposure to rainfall-induced runoff during and after application. The non-uniformity derives mainly from a poor match between the rate of flow applied at the top of the irrigated area, area slope, area width and soil type. Generally tailwater recycling systems are an essential component. Although these types of systems are often much maligned, they are suited to many soil types and are often the cheapest method of land application both in system establishment and during system operation. Further information on distributing effluent by flood irrigation is documented in McDonald (2002).

Border-check irrigation

Border-check irrigation (BCI) is a form of flood irrigation which allows land with minor slopes to be flood-irrigated by gravity and the tailwater to be captured and reused.

BCI is the most desirable low-energy method for surface-irrigating crops with dairy effluent where topographical and soil conditions are favourable or can be made favourable. Ideal crops for use with BCI systems include lucerne, annual and perennial clover–ryegrass pasture, other deep-rooted pasture types, close-growing timber plantations, forage or cereal crops and orchards.

Land slopes of more than 0.2% but <1% are most ideal for BCI (Wrigley 2002). Grade changes should be slight, and reverse grades must be avoided. Bays should be formed to provide uniform downslope gradient without cross-fall. If irrigation is required on flat land, it is desirable to establish slopes of more than 0.5% through land-forming. Cross-fall is permissible when confined to differences in elevation of 6 to 9 cm between border strips (Wrigley 2002). The hydraulic application efficiency of BCI is generally quoted as 45% to 60%, excluding tailwater reuse. The inputs and outputs of BCI systems can be controlled and automated.

Dairy effluent can be conveyed through a BCI system by being mixed with irrigation water. Effluent should not be conveyed in channels supplying water for stock or domestic purposes. Shandying of effluent with fresh irrigation water is a common way to lower the levels of salts and nutrients being applied and to achieve as high a flow rate as possible to uniformly wet the root zone to an acceptable depth. Environmental control is highly important, to make effective reuse of nutrients so as to meet soil and plant crop requirements. BCI is most suited to duplex clay soils with low permeability. Sandy and loamy soils are generally unsuitable for BCI owing to their high infiltration rates.

Advantages of BCI:

- low energy requirement due to gravity conveyance of effluent
- simple in design
- suited to broadacre crops
- no problems with clogging
- no aerosols or wind drift
- cheap
- rapid reduction in pathogens through exposure
- easy to maintain
- for the Goulburn Murray Irrigation District and Macalister Irrigation District exploits existing infrastructure.

Disadvantages of BCI:

- weed infestation and sediment clogging of channels and drains
- can only be used with shandied irrigation water during the irrigation season
- pumping costs to extract water from a recycling sump
- low application efficiency; high evapotranspiration and percolation
- high cost of land-forming to set up, and associated soil disturbance
- potential crusting of the surface
- possible odours through overloading and non-uniform application.

Furrow irrigation

Furrow irrigation is a method of irrigating the root zone of a plant without the need for water to penetrate vertically through the soil. It allows water to be flooded between ridges, graded furrows or corrugations. The water application efficiency of furrow irrigation is generally <65%. Although the actual grade in the direction of irrigation is typically 0.5% to 1.5%, no land-forming is required beyond filling gullies and removing abrupt ridges. Flow rates depend on the size of furrows and are typically dictated by siphons or bank cuts. Like other flood irrigation systems, furrow irrigation is most suited to clay soils where the potential for leaching is far less, but it is unsuitable for cracking clays.

Furrow irrigation systems are more suited to row crops and fruit production rather than to pastures. They are discouraged where salt levels in soil or effluent are likely to be elevated, as salts can be concentrated in the root zones. Despite these drawbacks, dairy effluent has been applied successfully by furrow irrigation. Effluent is usually siphoned from an irrigation channel and shifted along a furrow under gravity. The effluent permeates vertically and horizontally through the soil and concentrates at or below the root zone of the crop. By moving laterally it can reach the soil surface through capillary action (Wrigley 2002). Weed control and clogging of furrows are problems, especially if raw effluent is applied without being shandied. The system also has a higher risk of human exposure to effluent owing to the high labour requirement. The advantages and disadvantages of furrow irrigation are similar to those of flood and border check irrigation.

Advantages of furrow irrigation:

- low energy use
- water is in close contact with plant root zone
- easily formed.

Disadvantages of furrow irrigation:

- increased labour required
- greater volumes of water required to pass down and over land
- cost of land-forming
- energy required to shift effluent from lagoons to irrigation channels
- cannot be used on steep land.

Sprinkler irrigation

Sprinkler irrigation emulates rainfall and permits the distribution of solids. It usually competes with flood irrigation for broadacre applications, but allows greater control over the quantity applied. It can suit most types of crops and soil types but, unlike flood irrigation, relies on proprietary systems and the performance claims of component suppliers and manufacturers. There are various types of sprinkler systems, including:

- solid-set sprinklers
- linear-move sprinklers
- centre-pivot systems and lateral booms
- rotating booms
- hydrants and bike-move sprinklers.

Sprinkler irrigation of dairy effluent can be an efficient method of land application as long as clogging of jets is avoided. Sprinklers are suitable only if 5% or less of the effluent is solid material (Wrigley 1994). Research in New Zealand indicates that uneven application can result in adverse effects (Houlbrooke *et al.* 2004). Given the potential for particulate clogging of pressure irrigation systems, the selection of a system must be governed by the type of effluent. For raw dairy effluent, large-orifice emitters must be used, and the sprinklers must be dedicated to effluent. Some products on the market overcome the risk of particulate clogging by using flexible nozzles that enable solids to pass through. Under these conditions nozzles need regular replacement, although all sprinkler system warrant regular sprinkler head maintenance and refurbishment.

Flow rates and application rates for sprinkler irrigation need to be lower than soil infiltration rates (see chapter 3.9 'Hydraulic application rate and scheduling'). The range of sprinkler systems in use is many and varied, and unfortunately there is very little research to compare them. In addition, much reliance is placed on manufacturers' claims, which are assessed only in the event of dispute.

Advantages of sprinkler irrigation:

- can be used on rolling terrain (slopes up to 35% depending on equipment and application rate)
- good for high-rainfall areas, where only a small supplementary water supply is needed
- can be used on easily erodible soils with shallow topsoil
- can be used on highly permeable soils, such as sands and loams
- better control of the system allows for more light, frequent applications, even during wet periods, provided the risk of runoff is low
- minimal tailwater
- application efficiency of 60% to 70%, but can be higher with centre pivots
- the rate of application can be adjusted so that surface ponding is avoided

- easy to automate.

Disadvantages of sprinkler irrigation:

- high capital cost
- high operation and maintenance costs
- distribution is subject to wind distortion, although centre pivots are less susceptible
- potential for increases in humidity levels and thus disease
- irrigation with saline effluent can cause damage to plant leaves
- high energy use
- corrosion of components.

Because sprinkler irrigation relies on mechanical devices, these advantages and disadvantages are of a general nature only. Experience indicates that the performance of a new system is incomparable to that of an old, poorly maintained system, and therefore reliance must be placed on experience rather than on documented case studies, which are conspicuous by their absence.

Subsurface irrigation of pastures

There is a significant move towards drip and micro-sprinklers systems, which can provide water to individual plants from a dripper under automatic control. In subsurface irrigation, water is applied beneath the root zone via deep surface channels, pipes or drip tapes. Subsurface irrigation delivers water by capillary action and reduces both evaporation and deep percolation losses. Moisture and nutrients are supplied direct to plants with minimal contact with humans and animals. Subsurface irrigation systems can be used with most soil types and in rolling terrain. The application efficiency is between 80% and 95%.

The application of dairy effluent through subsurface drip irrigation (SSDI) depends on the level of solids in the effluent. Effluent must go through mechanical separation and filtration before being delivered via this system to minimise the likelihood of blocking outlets. Typically a significant volume of irrigation water is necessary for shandying. Unfortunately, the risk of clogging limits prospects for SSDI unless very high standards of filtration are achieved. The size of suspended particulate matter should not exceed 100 µm; clogging is inevitable once particles exceed 300 µm, and filtration is essential. Given this size limitation, SSDI should be used only with highly polished, filtered effluent.

Research is currently under way to determine the potential of SSDI for grazed dairy pastures, but currently drip irrigation is restricted to non-grazed crops and pastures. Research is also being conducted into the use of dairy effluent in drip-irrigated woodlots, amenity horticulture and so-called fodder factories.

Advantages of subsurface drip irrigation*:*

- water is applied to plant root zone
- reduced water losses from evaporation
- minimal contact of humans and stock with effluent
- low percolation losses
- minimal land-forming
- minimal removal of trees.

Disadvantages of subsurface drip irrigation:

- increased risk of clogging; filtration is essential

- pumping costs
- installation cost
- energy use
- high maintenance
- potential for damage by stock
- controls depth of root zone.

Localised irrigation

Localised irrigation systems apply effluent directly to plants. The effluent is not distributed over soil where there are no plant roots. Examples of localised irrigation systems include drip irrigation, bubblers, micro-sprinklers and porous pipes. Perforated pipe or micro-sprinklers on the soil surface drip or spray water at the base of individual plants to adequately wet the root zone. Application rates can be monitored to meet evapotranspiration needs and so minimise percolation losses.

The delivery of dairy effluent via localised irrigation systems is of limited value unless the effluent is highly diluted and filtered. As water is concentrated around a plant root zone, it is important that the salt concentration does not pose a threat to the plants. Dairy effluent may need to be shandied to reduce the likelihood of toxicity to plants and to reduce the clogging potential. Localised irrigation systems have, however, been successfully used with saline effluent and are most suited to row crops and fruit production. An application efficiency of 75% to 85% is commonly achieved by drip and micro-sprinkler irrigation.

Advantages of localised irrigation:

- water applied only to the plant
- less water required
- minimises losses to evaporation
- easy to automate.

Disadvantages of localised irrigation:

- high energy use
- high capital cost
- risk of clogging
- corrosion of components.

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