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DRAINAGE TO CONTROL
waterlogging

By D. J. McFarlane¹, T. R. Negus² and J. W. Cox³

Drains can be classified in several ways. Drains on flat land have similar drainage effects on either side of the drain and are called relief drains. Drains on sloping land intercept seepage water moving down hillsides and therefore have most effect on the downslope side. They are called interceptor drains.

Drains can also be classified as being open drains (that is, open at the ground surface) or buried drains (for example, tube drains).

Some advantages of open drains:
• They collect surface as well as some sub-surface water.
• The condition of the drain (for example, amount of silt) can be easily seen.
• They are relatively cheap to install.
• Interceptor drains ensure cultivation on the contour, thus minimising potential soil erosion problems.

On the other hand, buried drains:
• Do not reduce the cropped area.
• Do not hinder field operations.
• If installed correctly, they are less likely to silt up, but may clog as a result of chemical deposits.

Soil conditions are important in deciding what type of drain to install. Open drains in sandy soils may collapse or erode, while buried drains may be costly and not as effective if installed in less permeable clay soils.

It is also important to determine where, and how, drainage waters are to be discharged safely. Most drainage waters contain dissolved salts which might have detrimental effects on downstream land and water supplies.

There are insufficient data on the effectiveness of different drains installed in Western Australian wheatbelt soils. Several projects are underway evaluating different drainage systems. Only preliminary conclusions can be given for two situations—heavy textured flat land and sand over clay—'duplex'—soils on hill slopes.

Heavy textured flat land

The major problems of draining heavy textured flat land are the lack of fall in the land for the removal of drainage waters and the low permeability of the clay soils. Water often ponds on the surface and salt encroachment may be a problem. Gypsum may be needed to improve the infiltration of water.

If the main source of water in the problem area is flood waters from further up the valley, a levee bank system will be needed to contain these waters. If most of the water comes from runoff and shallow seepage from surrounding hill slopes, diversion or interceptor drains will be needed. However, in many flat land situations, rain on the site is sufficient to cause waterlogging.

Open drainage

Several possible open drainage methods can be used on heavy textured flat land (Figure 1). Open drains are usually used to remove ponded surface waters which have not infiltrated the soil profile.

All types of open drainage are improved by land-forming or smoothing to remove small depressions. However, land-forming is expensive and is most suited to deep soils such as sands where the removal of some topsoil does not lead to a long-term fall in soil fertility. The cost of land-forming depends on the volume of earth that must be moved, the distance it must be moved and the precision required.
• Random ditches
Random ditches can usually be installed where surface depressions are too large for filling in by land-forming or smoothing techniques. These ditches interconnect the depressions and drain them to a natural drainage line or to a collector drain. The elevation and distribution of the depressions should be carefully assessed in mid-winter so that the most efficient system of ditches is constructed which will least interfere with field operations.

The ditches are usually V- or W-shaped and collect water from both sides. V-shaped ditches are sometimes called spoon drains (see Farmnote No. 120/84—Spoon and W-draws). They are about 40 to 60 centimetres deep, three to four metres wide and can be constructed using a grader or spinner ditcher. Care must be taken to spread the spoil away from the ditch of V-shaped drains so that surface waters can flow easily into the ditch. The spoil can be used to fill in depressions not large enough to be part of the ditch system.

Where soils are moderately permeable and waterlogging is caused or worsened by a high watertable, deep open drains may be necessary. They can be constructed with a backhoe or excavator. Surface waters must be excluded from these drains to minimise silting. Before construction, sample pits should be dug to determine whether the soil is permeable enough to allow water to drain into the pits. In addition, the natural grade should be sufficient to discharge water safely from the drains.

• Bedding
Bedding involves the construction of long raised or 'crowned' beds from which surface waters drain into adjacent furrows. The beds are aligned in the direction of maximum fall and can be constructed using a grader or disc plough to move the soil away from the furrows.

The width of each bed is a multiple of the width of machinery used in the area and usually ranges from 10 to 30 metres. The distance between the furrows is limited by the drainage characteristics of the site (that is, slope and soil permeability) and the amount of grading or ploughing needed to move the soil. The flatter the site and less permeable the soil, the narrower the beds should be. Moving too much soil can expose sub-soils and lower plant yields near the furrows.

Bedding is one of the oldest drainage practices and used extensively overseas. It has hardly been tried in Western Australia's dryland farming areas. Bedding is now under test at several sites in the wheatbelt. Narrow bedding systems are sometimes used in association with controlled traffic zones which limit soil compaction. Bedding is most effective where waterlogging is caused by poor infiltration and where there is insufficient natural grade for the ponded water to drain away.
Parallel ditches are similar in form to bedding but are used on a much larger scale. Earth-moving equipment is used to create a fall towards parallel, but irregularly spaced, ditches. While crowns or ridges may be formed between the ditches, it is possible to create a continuous fall from one ditch to another, if the natural surface makes this the most sensible thing to do.

Parallel drains are much deeper and more widely-spaced than bedding and are better suited to more permeable soils. The parallel ditch system is common in the USA because large farm machinery can be easily used.

Because cultivation is parallel to bedding furrows and parallel ditches, cultivation ridges may inhibit surface water movement towards the drains. In the USA, small furrow drains are made across the cultivation to allow water to drain towards the furrows and ditches. Ponding caused by cultivation ridges is not a problem when the site is under pasture and in areas with a deep permeable topsoil. Both bedding furrows and parallel ditches discharge in natural drainage lines or open main drains.

Buried drainage

The following are possible buried drainage techniques that can be used on heavy textured flat land (Figure 2).

- **Tube drains**
  
  Tube drains are buried, perforated plastic pipes which discharge into natural drainage lines or open collector drains. The low permeability of clay soils often results in these drains not affecting a large area. Therefore the drains may have to be closely spaced, which is costly. The drains' performance can be improved by laying a sand, gravel or aggregate envelope around the pipe, but this further adds to costs. More details on tube drainage are found in the previous articles on saltland drainage in this Journal.

  In some Western Australian trials, iron deposits have periodically blocked tube drains.

  The performance of tube drains overseas has been greatly improved by the installation of open surface drains to remove surface water, allowing the tube drains to begin removing excess soil water.

- **Mole drains**
  
  Mole drains are unlined tunnels formed in the soil by a mole plough. The mole also produces cracks and fissures in the clay through which water moves more easily. Flooding of mole drains, particularly on clay flats, has usually caused them to collapse in trials in the Western Australian wheatbelt.

  Mole drains have been used successfully in suitable soils in irrigation areas.
Duplex soils on hill slopes

The two main methods used to drain duplex soils on hill slopes are interceptor drains and tube drains (Figure 3).

Interceptor drains

Interceptor drains are open drains, similar in form to grade banks used for soil erosion control, but with the channel of the bank cut deeply enough to intersect the clay sub-soil. Where the clay sub-soil is within 50 cm of the surface, these drains can be constructed by a grader at a cost of about twice that of normal grade banks. As with grade banks, interceptor drains discharge their water into natural or man-made waterways.

Because the channel of an interceptor drain is cut deeply into the soil, the upslope batter could erode if surface runoff is allowed to enter the channel. Such erosion causes silting of the drain and the need for frequent maintenance.

To overcome this problem, reverse bank interceptor drains have been developed which allow surface waters to be carried by a grassed strip above the drain (Negus 1983a,b). This division of surface and sub-surface water also allows the drains to be placed on slopes with a reasonably high grade (for example 0.6 to 0.8 per cent) which minimises the likelihood of ponding (and therefore leakage) and silting in the channels.

Interceptor drains are small structures constructed on a grade. They should not be confused with interceptor banks which are large, level, bulldozer-built structures designed to store intercepted water in the bank channel. Although interceptor banks do not need a waterway, their building costs are about four to ten times that of grader-built interceptor drains and they occupy about two to three times the area of interceptor drains. About 75 per cent of interceptor banks are known to leak (Negus 1983c). There is also concern that level banks may be diverting fresh surface water through saline sub-soils into the deeper groundwater, thereby raising saline water tables.

- Tube drains
Tube drains may not work well in heavy textured soils, but they have worked when installed in soils with a permeable topsoil at least 60 cm deep. Tube drains can be used instead of interceptor drains if farmers want to work over drains. Placing coarse-grained material around the drain can minimise bridging or leakage across the drain.

Tube drains however do not control surface runoff and erosion and they do not ensure control of seepage into the deeper groundwater. Tube drains can be used instead of interceptor drains if farmers want to work over drains. There is also concern that level banks may be diverting fresh surface water through saline sub-soils into the deeper groundwater, thereby raising saline water tables.

Costs and benefits of drainage

The relative costs and benefits of different drainage systems are difficult to estimate as some systems have hardly been tried in the wheatbelt. Also, the distance between the drains depends on the climate and the site.

A comparison of open and buried drains in non-saline, heavy textured soils in the USA showed that open drains gave the best cost-benefit ratio for a particular investment. Open drains should be the first to be installed as they will be needed if a buried system is installed later. Buried drains alone do not remove surface water quickly enough as the water first must infiltrate the soil before it encounters the drain.

Negus (1983d) examined the yield reductions of cereal crops at four sites in the Upper Great Southern as a result of severe waterlogging. Average yield reductions were 73 per cent for wheat, 59 per cent for oats and 64 per cent for barley. Negus (1983c) has estimated that a crop yield increase of 1.015 kilograms per hectare (range 265 to 2,072 kg/ha) can be expected on an average of 50 m downslope of an effective interceptor drain in a cropping year when severe waterlogging occurs.

Few data are available on the effective drainage distance and yield effects of other drainage methods, but it is possible to compare the cost of installing different drains and the area of land disturbed (see table).

When to drain

The costs and benefits of draining non-saline heavy textured flat land are yet to be adequately estimated. Surface drainage techniques seem to be more appropriate than buried drainage for controlling waterlogging in these areas.

Seepage interceptor drains will probably be worthwhile for draining deep (more than 40 cm of topsoil) duplex soils on hill slopes when waterlogging during a cropping year can be expected at least one year in ten. Waterlogging control is essential above mildly salt-affected areas to prevent the combined effects of excess salinity and waterlogging reducing crop yields.

References


Spook and W-drains. Farmnote No. 120/84.

Drainage costs and land disturbed

<table>
<thead>
<tr>
<th>Drainage technique</th>
<th>Assumed drain spacing (m)</th>
<th>Approximate capital cost ($/m)</th>
<th>Hectares of land disturbed per drained hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random ditches</td>
<td>50</td>
<td>0.10</td>
<td>0.06–0.08</td>
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<tr>
<td>Bedding</td>
<td>10–30</td>
<td>0.20</td>
<td>0.07–0.20</td>
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<tr>
<td>Parallel ditches</td>
<td>100–150</td>
<td>0.20</td>
<td>0.10–0.15</td>
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<tr>
<td>Tube drains—heavy soil</td>
<td>25</td>
<td>2.50–3.50</td>
<td>1000–500–700</td>
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<tr>
<td>—duplex soil</td>
<td>50</td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>Mole drains</td>
<td>2</td>
<td>0.015</td>
<td>none</td>
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<tr>
<td>Seepage interceptors</td>
<td>60–100</td>
<td>0.25</td>
<td>0.05–0.08</td>
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<tr>
<td>(grader-built)</td>
<td></td>
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<tr>
<td>Seepage interceptors</td>
<td>60–100</td>
<td>1.00–1.50</td>
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<td>(dozer-built)</td>
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- Ignores cost of land-forming which may be considerable if the land surface is very uneven.