Mole drainage for increased productivity in the south west irrigation area

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Mole Drainage

For Increased Productivity in the South West Irrigation Area
An owner or occupier of land must give at least 90 days notice to the Commissioner of Soil and Land Conservation of an intent to drain water where:

- the water to be drained is subsurface water;
- the purpose of the proposal is to control salinity; and
- it discharges onto other land, into other water or into a watercourse.

The notice must be in writing and comply with Form 2 of the Soil and Land Conservation Regulations 1992. This form is available from the Department of Agriculture District Offices, or by contacting the Commissioner’s Office. For proposals to drain land within the Peel-Harvey Catchment Area, proponents must give 90 days written notice (Form 3) to the Commissioner of an intention to drain surface or subsurface water onto other land, into other water or into a watercourse. This form is available from the Commissioner’s Office. Proceeding with a drainage proposal without complying with the notice of intent provisions is an offence, and can lead to prosecution. Maximum penalty is $2,000 for an individual and $10,000 for a body corporate. The person may also face fines of up to $500,000 for an individual and $1 million for a body corporate where the drainage works are not notified and cause serious environmental harm. Other laws may also be relevant, further information on notices of intention to drain is available from local Department of Agriculture Offices.
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WHY MOLE DRAINAGE?

Heavy soils, with low rates of soil-water movement, such as those found in the South-West Irrigation Area (SWIA), require closely spaced (2-6 m apart) subsoil drainage systems to provide sufficient water movement to control the effects of salt-waterlogging on pastures. Such close spacing using traditional buried pipe or tile drainage systems is impractical. As a result, mole drainage systems, used in other parts of the world for over 50 years, have gained popularity in the SWIA in recent years.

This Bulletin Farmnote reports the current 'best-bet' mole draining technique for SWIA conditions gathered from observations over a number of years from several mole drainage systems installed by Agriculture WA and members of the Dardanup and Wellesley LCDCs.

PRINCIPLES OF MOLE DRAINAGE

Mole drainage requires the construction of a series of stable, unlined soil 'pipes' or moles of even and low grade down the paddock. Creating the mole channel results in the formation of a series of fine fissures or cracks in the soil which provide the major flow paths for soil-water to move into the mole channels and then out into the drainage system.

Mole drainage is a completely different operation to deep ripping. Deep ripping is aimed at loosening, fissuring and rearranging compacted soils to allow better infiltration of water and improved root growth. Soil surface 'heave' is often a desirable feature of deep ripping (as it indicates good subsurface disruption), but when mole draining it indicates poor technique and results in poor performance of the system.

Moling is a technique best suited to laser-levelled paddocks with consistent paddock surface gradients of less than 2 per cent. Most lasered paddocks have a gradient of less than 0.5 per cent which is suitable for mole drainage.

Several factors will influence the success of a mole drainage system and the longevity of the mole channels. Correct management of these factors is critical to the success of mole drainage. When installed correctly, a mole drain in the SWIA may last up to five years before remoling is required.
Soils

Good moling soils must have a high clay content (30 per cent or more) at 200-700 mm depth. These soils texture as clays, silty clay loams or clay loams. Most irrigation soils in the SWIA meet this requirement, however, high clay content is not the only soil factor affecting mole stability. Soil chemical factors such as salinity, sodicity and clay type are also important in determining soil stability.

Soils with high levels of salinity and sodicity (an excess of sodium ions relative to chlorine ions) are unstable when mole drained and moles are likely to fail due to dispersion and slaking. This happens when fresh water (from winter rainfall or summer irrigation) comes into contact with highly saline or sodic soil in the mole channel. Because salinity and sodicity generally increase with soil depth, it is often best to keep the mole drainage system as shallow as possible on saline soils (see below; mole leg, foot and expander design).

Work is continuing to determine a laboratory soil test for mole stability. However, in the mean time, a reliable and practical indication of soil stability can be achieved by observing the stability of open drains near the area to be moleled. If the drains have maintained the same shape over a number of years since their construction, and have retained their vertical sides, then it is likely that the soil is stable. However, if the drains slumped badly after installation or need regular cleaning, then the soil is unstable and mole drainage is unlikely to be practical on that paddock.

Our observations indicate that the yellow, orange and light brown clays and clay loams of the SWIA are stable and suitable for mole drainage. The heavy blue, grey and dark brown ‘Bungham’ clays are often unstable and hence unsuitable for mole drainage. Gravel-filled mole drains are a more expensive option for these areas, although their use to date has not been well documented.

Iron and silica-rich clay hardpans are widespread within soils of the SWIA. These hardpans occur in broad ‘waves’ underground at depths of between 400 and 2000 mm and can seriously affect the moling operation. These hardpans vary in texture and hardness from being rocky to a very hard, dense clay.

Attempting to mole too deeply (intersecting these hardpans) may result in either the mole plough riding along the top of the layers (causing uneven grades and unstable moles), or require a far greater horsepower and traction (e.g. a bulldozer) requirement to pull the implement. To avoid these problems in most areas, aim to mole at less than 500 mm depth.

Soil moisture and timing

Sufficient soil moisture is critical for mole drainage. Moling should be done when the soil, at mole depth, is as close to its upper plastic limit as possible. That is, it is easy to shape or mould by hand but it is not so wet that it loses...
its shape easily. There is often a trade-off between soil surface moisture and traction and soil moisture at depth. Ideally, the soil needs to be moist at moling depth and quite dry and friable near the surface. This is also important for the development of the soil cracks and fissures above the mole channel.

The best time to mole is in late autumn and early winter, after 25-50 mm of opening rain, but before the full onset of winter. Alternatively, early to mid-spring moling (just after hay season) is suitable. After installation, the moles should be left for as long as possible (1-2 weeks is ideal) to settle and ‘cure’ before they receive large flows of either rainfall or irrigation water. Do not mole when the soil is waterlogged.

**Mole plough design**

Mole channels must have an even, gentle grade, with minimal grade changes that create areas in the channel where water ponds. Such areas lead to premature collapse and failure of the channel. With a three point linkage machine, any surface undulations or loss of traction, causing the tractor to pitch are directly transferred to the mole bullet, causing sudden grade changes in the channel and variations in vertical soil pressure at the mole point. This results in very unstable mole channels that will collapse soon after installation.

The two types of machine that have the best application in the SWIA are floating beam and scrubbing beam machines. With both these machines, the mole point is buffered from ground surface imperfections.
The floating beam machine relies on a combination of tow-hitch geometry and depth wheels to control the moling depth. It requires less draught than the scrubbing beam machine but experience has shown it has the major disadvantage of not maintaining depth in hard or variable soil conditions. This is particularly important under SWIA conditions where hardpan clay layers are prevalent.

The scrubbing beam machine uses the full length of the beam, sliding on the ground surface, as both the depth and grade control mechanism. Its major advantage is that this geometry prevents any depth variation due to soil conditions and is usually unaffected by hardpans. It requires more draught than the floating beam and will usually require a coulter mounted at the front of the beam to slice heavy grass thatch (e.g. kikuyu). It is generally the best machine for SWIA conditions.

**MOLE LEG, FOOT AND EXPANDER DESIGN**

The configuration of the moling tool is crucial in achieving stable mole channels.

The size of the mole bullet and expander required is governed by the depth of moling. A moling depth of 400-500 mm is optimum for most conditions. The depth of moling must be at least 6 times the diameter of the mole otherwise poor channel compression will result as evidenced by excessive surface ‘heave’. This is the ‘critical depth’ for moling.

The ideal configuration for moling at 400-500 mm depth is a mole bullet of 65 mm diameter with a 75 mm diameter expander. The function of the expander is to smooth and gently compress the mole channel. The expander only needs to be 10 mm larger in diameter than the mole bullet.

It is important to note that a larger diameter, deeper mole does not mean a better drainage effect or a longer lasting mole and can often mean a less stable mole is produced after a more expensive installation.

The function of the leg is to support the bullet without flexing and to create the required network of soil fissures. The leg should be 200 mm wide and a maximum of 20 mm thick. Any thicker and the leg slot created will be too large, allowing erosion in the leg slot and filling and collapse of the mole channel.

Where ploughing or reseeding will not be undertaken after moling, a leg slot closing wedge is required to prevent access of surface water directly into the mole channel. The ‘wedge’ destroys the vertical continuity of the leg slot and leaves the surface soil in a better condition for compaction.
It is crucial that the wedge is mounted behind the expander at 150-200 mm depth below the surface. Surface compaction over the mole using the tractor wheels is recommended (Note: this can be done on the trip back if the paddock is being moled in one direction).

**Collector Drains**

For most of the laser levelled paddocks in the SWIA, the mole drain should be no more than 50-60 m before it has an outfall. Longer mole lengths may cause instability and poor drainage because of irregular gradients (including possible back grades), poor soils and presence of sand or silt lenses. Collector drains installed across the paddock at 50-60 m intervals provide an effective network to collect and discharge mole drain water.

The pipe size used in the collectors (Figure 6) can be either 80 or 100 mm diameter perforated agricultural pipe. Pipe size governs the width of the trench. As a standard, we recommend that the thickness of permeable fill in the trench should be twice the diameter of the pipe. The permeable fill should ideally be crushed rock screenings of around 10 mm size. Currently, bluemetal forms the basis of permeable backfill used in the SWIA. The bluemetal should be brought to within 300 mm of the surface to ensure that the mole drains intersect this layer. The top 300 mm should be backfilled with soil and compacted to minimise irrigation water loss into the drains. The collector trenches should be dug using laser controlled equipment for accuracy as the grades of the collectors (i.e. across the paddock) are often very low (less than 0.1 per cent). Collector depths will generally only be 900-1000 mm in the SWIA.

![Diagram of mole drainage system](Figure 6 Best bet specification for collector drain)
SYSTEM DESIGN CONSIDERATION

The most important design consideration is that the system has sufficient outfall to drain completely. The design should attempt to prevent water ‘backing up’ during storm events. This can often only be achieved by having a complete drainage survey and drainage farm plan undertaken.

There are two main options for the mole outlets at the bottom end of the paddock. The first is to drop the moling tool into the tail drain and mole away from it, effectively using the tail drain as a collector drain. Often the tail drain will need to be deepened to at least 200 mm greater than moling depth. Each mole also needs a length of PVC pipe inserted in the end to prevent erosion and blockage by debris or rodents. A better option is to install a collector pipe 10 m from the end of the bay (as in Figure 8) and mole

![Figure 7 (right) Cross section of a collector drain during construction. In this example, the collector pipe is being installed at 850mm depth and the trench back-filled with bluemetal to within 300mm of the surface.](image)

![Figure 8 Plan of a typical collector/mole drainage installation in the SWIA](image)
from the soil surface near the tail drain, into the collector and on up the paddock. It means that the moles are likely to be more stable near the end of the bay, and provides additional deep drainage to the wettest part of the paddock.

Where the collector pipes cannot discharge straight into a deep open drain at the side of the paddock, the options are to either dig an open drain or plumb them into a 150 mm pipe and convey this to the main outfall point (as in Figure 8).

Blockage of the collector pipes with iron precipitate from the drainage water is a potential problem in the SWIA because of the high iron concentrations in the shallow groundwater. To date, there has been no evidence of blockages (systems four years old). However, because of this possibility, it is wise to incorporate permanent inspection points at the ends of the lines and make the lines no longer than 300 m. This is to allow for cleaning the pipe using a high pressure air and water scrubbing system (maximum available length 300 m).

Because mole and collector systems are often very efficient, some systems may ‘over drain’ during summer irrigation. If this occurs, installing reducers to the collector outfalls is recommended (e.g. 80 mm to 12 mm) during the irrigation season. It is not recommended that the outfalls be blocked off completely because consistent flooding of the mole channels can reduce their stability and longevity. It is also an advantage to remove salt and waterlogging throughout the whole year.

**SELECTING AREAS TO DRAIN**

Deciding which areas should have priority for drainage can be tricky. There are strong arguments for spending money on draining the potentially more productive (lower salinity) areas before the areas that are more saline, waterlogged and which may take longer to become productive. However, many farmers prefer to tackle the most saline areas first. Salinity/productivity mapping services available from private consultants, using the EM38/GPS system is an excellent way of characterising the farm’s natural resource base and assigning priority to future drainage areas.

**Costs**

The moling operation itself is relatively inexpensive. Rates of 1 ha per hour are common using a 120-150 hp tractor with moles installed at 1.5-2 m spacing. The large expense comes with the installation of the collector pipe system by a contractor using specialist equipment. This will cost over $1500/ha (50 m spacings between collectors).

Partial-paddock mole drainage systems are a way of reducing this cost and testing the effectiveness of mole drainage. Often the most salt-waterlogging affected part of a paddock is the 50-100 m up from the tail drain. For example, mole drain from a deepened tail drain to 50-100 metres up the paddock or install only the bottom 1 or 2 collectors of a system initially. Also, using ground geophysics ($10-20 ha) to find hot spots may reduce the overall project cost.

**Summary Table**

- Mole drainage is a completely different operation to deep ripping.
- Survey and plan the site so it fits into an overall drainage strategy.
- Make sure an adequate discharge point is available.
- Mole drainage should be used in conjunction with a collector pipe drainage system spaced at 50-60 m intervals.
- Mole drainage will only be effective where there are suitable clays.
- Mole drain when soils are moist at moling depth but drier at the surface - usually late autumn or late spring.
- 3 point linkage mole machines are ineffective.
- Scrubbing beam mole machines are the most effective.
- Moling depth should be 400-500 mm. Mole spacing should be about 2 m.
- The best mole tool configuration for 400-500 mm depth is:
  - leg dimensions 200 mm deep by 20 mm wide;
  - mole bullet 65 mm diameter;
  - a 75 mm diameter expander is essential;
  - a closing wedge is essential if the paddock is not being cultivated.