DEPARTMENT OF
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Managing Wet Soils: Mole Drainage

Mole drainage, on the right soil type and installed correctly can help reduce waterlogging problems. This Agnote aims to help farmers construct effective long lasting mole drains.

Introduction

Winter wet soils are a common problem in southern Victoria. While surface drainage can improve the situation by removing excess surface water, in most cases the soil profile itself needs to be drained, so that pastures and crops can reach their potential and stock damage by treading and compaction can be reduced.

Mole drainage is widely used in New Zealand and England on heavy soils to improve productivity of pastures and crops. Mole drainage was popular with dairy farmers in the 1960's but often failed due to reasons now more fully understood. Recent research has resulted in robust guidelines for installing mole drains so that they are more successful and longer lasting, with a greatly reduced failure rate.

What is a mole drain?

Mole drains are unlined channels formed in clay subsoil by pulling a ripper blade (or leg) with a cylindrical foot (or torpedo) on the bottom through the subsoil (Figure 1). A plug (or expander) is often used to help compact the channel wall. The foot is usually chisel pointed and hard faced by welding of the whole point. More frequent hard facing of the underside will increase its effective life.. The beam is the main rail which carries the leg and torpedo.

Figure 1 Mole drainer showing blade, torpedo foot and plug

Mole drains are used in heavy soils where a clay subsoil near moling depth (400 to 600 cm) prevents downward movement of ground water. They are a more sophisticated drainage system than open drains. Mole drains do not drain groundwater but removes water as it enters from the ground surface.

Mole drains over a collector pipe system

In heavy soils where mole drains would have very short life span due to clay type or would need to be very long (greater than 80 m) to reach an outfall, a 'collector pipe system' is recommended (Figure 2). This requires the installation of subsurface pipes at approximately 60 to 100 m apart, across which mole drains are pulled. This system could also be used where soils may contain stones and/or sandy patches in the profile at drainage depth which could collapse when moled. The relatively close spacing of the pipes and shorter mole drain lengths will minimise the area affected by the affected areas.

Permeable backfill such as washed sand, small screenings or small diameter pea gravel is placed (backfilled) on top of the pipe in the trench. Depending on the clay content and its depth this backfill must reach at least 150 mm above the moling depth so that the water moves into the backfill via the mole channel (Figure 2).

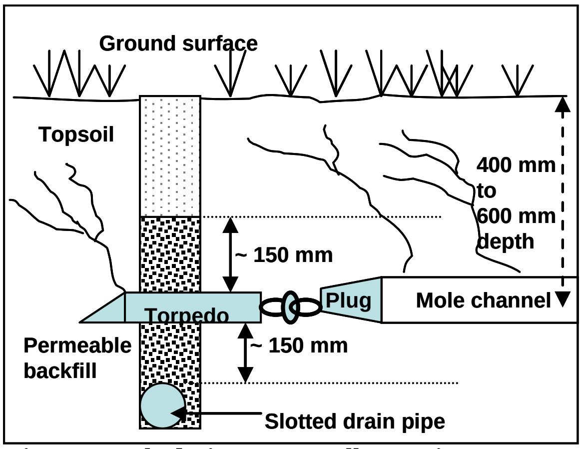

Figure 2 Mole drains over a collector pipe system

Mole drains are then installed at an angle (often 70 to 90^{0}) to the direction of the pipes. Excess ground water flows into and along the mole drains, then drains into the porous backfill above the pipes, and then is quickly removed to outfalls via the subsurface collector pipes.

Types of mole ploughs

Well designed mole draining ploughs allow the torpedo, when properly set, to maintain itself at the set depth almost irrespective of small ground surface irregularities. The front of the mole plough usually has skids to support the front of the beam, but the body of the beam floats clear of the ground. This allows the blade and torpedo some movement to produce a smooth gradient within the limits of the under-beam clearance.

Trailed mole ploughs

These require higher horsepower than other mole ploughs because they scrub the ground when working (Figure 3). However they produce more even grades than three point linkage ploughs because of the longer beam (greater than 1.35 m). They are more difficult to manoeuvre compared to the linkage plough but are now being replaced by semi tractor-mounted designs.

Figure 3. Trailed mole plough

Semi tractor-mounted mole ploughs

Although mounted on the tractor three-point linkage (Figure 4), these act as trailing ploughs when working and even out the mole gradient despite ground variation. The longer beam, coupled to a chain with a floating top link, allows a more even mole channel to be formed.

This plough has been used experimentally in Victorian trials but none are available commercially. They are more expensive to build than the other plough types.

Figure 4. Semi tractor-mounted mole plough

Fully tractor-mounted mole plough

The blade is mounted directly to the three-point linkage, so this type of plough is inexpensive to build and convenient to use. However, this design is one reason for many mole drain failures. This type of mole plough produces more uneven grades than the trailed plo

ughs because of the short beam.

The torpedo is influenced by the draught control of the tractor and not free to find its own level. Also being mounted so close to the rear wheels, the torpedo forms a mole channel as dictated by the ground surface undulations.

Ideally the torpedo should be allowed to float with no pressure control used to make it go deeper. The fully tractor-mounted mole ploughs are better suited for smaller tractors and areas and only suitable on even ground surfaces. Since automatic draught control is used to improve traction (lifts the mole plough to reduce downward pressure and allows traction to be regained), this plough type should be used in soils where draught control is not needed.

Gravel mole ploughs

Gravel mole ploughs (Figure 5) incorporate a hopper to allow finely graded gravel to fall into the mole channel. These ploughs have been successful in England and Ireland in heavy soils that can't hold normal moles. Experimental results from north east Victoria and Gippsland show they have promise on unstable clay soils, but are expensive because of the amount of gravel needed. Unfortunately very few of these machines exist in southern Australia.

Figure 5. Gravel mole plough

Tractor power requirements for installing mole drains

Four-wheel drive tractors of approximately 60 to 80 kw minimum power are recommended for pulling in moles. Crawler tractors of lesser power (above 45 kw) are also suitable. The deeper the mole drain to be installed, and drier the soil, the greater the tractor power required.

Speed of mole ploughing

Recommended speed is 2 to 4 km/hr. If pulled too fast, say 5 to 6 km/hr, the plug can disrupt or tear the walls of the channel resulting in failure within two years.

Soil suitability for mole drainage

Soils should have a clay content in the range of 30 to 35 % to ensure long lasting mole channels. A soil with a clay content above this range is likely to collapse quickly due to swelling or shrinking as they "wet up" and "dry down".

Clay gives the soil the ability to hold together and reduces the chances of it collapsing after the mole is pulled. Sand content should be less than 30 %. Ideally, the soil should be free of stones at the mole drain depth. If not, ensure the soil at moling depth is fairly wet so that stones are more easily pushed aside by the plough torpedo/plug.

Testing of suitability for mole draining

Although not always foolproof, two simple tests can indicate a soil's suitability for mole drainage:

1. Test the soil at mole draining depth by rolling out a pencil thick rod and try to form a 40 to 50 mm diameter circle. If this can be done without crumbling or cracking then it may be suitable for mole draining. If the soil sample has dried out before conducting the test, mix in some water until the soil is of plasticine or soft putty consistency.

2. Another test is to find out if the soil at mole drain depth will slake or disperse. Small golf ball size balls of the soil are placed in distilled or rain water and observed over a day or two. If the water becomes cloudy and the ball soften or slumps, then this indicates a dispersive soil. These soils are prone to tunnel erosion and should not be mole drained. If these ball falls apart quickly it is has a tendency to slake.

Soils which tend to slake may be successfully gravel mole drained (actually a gravel slot), albeit expensively. Gypsum may be useful in dispersive soils to suppress clay dispersal, but is difficult to get the gypsum into the subsoil.

It is wise to tap into the experience of a subsurface drainage expert and, failing that, only mole drain a small area initially to gauge the likelihood of success in the long term. Agriculture Note AG1355: *Managing wet soils: determining which subsurface drainage system to use* contains more details on which subsurface drainage system to use, and which soils are most suited to mole drainage.

When to mole drain

To achieve satisfactory results, the soil in the vicinity of the mole channel needs to be moist enough to form a channel. The soil must not be dry enough to crack and break up, and not soft enough to slough off and form a slurry. These conditions usually occur on the drying cycle in late spring or early summer.

The action of the mole plough is to form a channel in the area of the profile with a specific clay content, yet produce upward cracking of the soil profile immediately above the mole channel (Figure 6). These cracks allow water flow to the mole channel.

The upper section of the soil profile needs to be dry enough to form cracks at the time of mole draining and the ground surface dry enough to allow traction. If too moist then the cracks can 'heal' over and reduce water intake. It is preferable to have a warm drying period with no rain to allow the cracks to dry and the mole channel to harden.

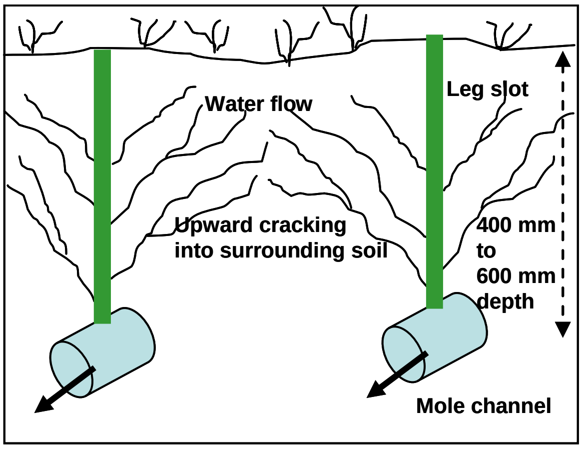

Figure 6 Cross section of mole plough effect in soil

Usually when the clay at mole draining depth has a moisture content of 20 to 25 %, conditions are satisfactory. Test the soil by kneading between the fingers. If a ribbon can be rolled out without it sticking to the fingers the moisture content is right.

Mole draining in autumn is not recommended, as the topsoil is wet and subsoil is too dry. The subsoil is difficult to mole and to dry out and it's difficult to achieve the desirable depth. Mole channels will tend to slough off and fail.

Length and gradient

The length of mole drains varies with the slope (gradient) of the ground (Table 1), surface evenness, soil textural changes in the profile and soil suitability. If mole channels are too long, the channels could remain wet at the lower end for too long, gradually softening over time and collapsing. If outfalls dictate long mole drains, then a collector pipe system is highly recommended.

Table 1 Recommended lengths and gradients for mole drains in pasture soils

Soil profile	Surface gradient (%)	Mole length (m)
Clean	0 - 1	40 - 50
Clean	1 - 2	50 - 60
Clean	3 - 5	80 - 100
Stony	0 - 1	30 - 40
Stony	1 - 2	40 - 50

Many mole drains have been installed at a length of 200 m and some up to 400 m have been pulled at Cooriemungle in south west Victoria. These have performed satisfactorily for a number of years, but would survive much longer if the length was reduced (80 to 100 m) because they would empty out quicker and are not likely to remain saturated.

Steeper gradients

Steeper gradients of greater than 3 % should enable relatively trouble free moles because minor surface undulations won't cause blockages with negative gradients, and the risk from erosion is reduced. On steeper gradients moles should cross the direction of the main slope to help intercept surface runoff and to avoid the possibility of channel scour.

Lower gradients

However, in most situations surface slopes are usually below 3 % and drains should run parallel to the slope fall.

The flatter the gradient, the more even the soil surface has to be and the use of collector pipe drains will be needed to achieve good results.

Depth

Optimum mole depth depends on soil type, and the conditions when moles are installed. Generally moles are pulled at 400 to 600 mm depth. For most pasture situations a torpedo diameter of 65 to 75 mm is recommended, although the channel diameter will be slightly less immediately after moling. A plug or expander attached to the rear of the torpedo will tend to maintain the channel size and smear the channel itself increasing its longevity.

Moles less than 400 mm deep are liable to be damaged by tractors and animals during or immediately after rain. However, if mole drain depth is slightly less than 400 mm, use a smaller diameter torpedo (35 to 45 mm) to reduce ground heave during mole draining. Torpedoes of 100 mm have been used but require substantially higher powered tractors and have not been proven to be an advantage over the smaller sized torpedoes.

A rule of thumb is that the expander to mole draining depth ratio is 1:7 i.e. a 70 mm diameter expander should have mole depth of 490 mm.

Very heavy soils and those with high contents of suitable clay down to moling depth may benefit from its first mole draining at a shallower depth due to tractor limitations. Also as the soil structure improves over time subsequent moles can often be pulled at deeper depth.

Spacing

Spacing is designed to promote an interlacing effect of the fracture pattern from the moling and so encourage maximum water flow opportunity (Figure 6). Spacing between moles is usually about 2 m in dairy pastures. In less intensely grazed areas spacing may be up to 5 m apart, but performance falls off markedly with wider spacing.

Outfall

The drain outfall or outlet is the most important part of the system. If this fails the whole system fails.

Mole drains can discharge to open drains, into interceptor drains filled with gravel, or preferably a collector pipe system. The latter two systems are more expensive, but protect the mole outlets and the only maintenance required is at the tile outlet. (see Agriculture Note AG0948 *Managing wet soils: subsurface pipe drainage*)

Open drain outlets should be fenced off from stock and kept clean so the outfall is above the drain water level. This prevents water backing up into the mole outlets, softening the clay channel and eventually causing them to collapse. Short lengths of plastic pipe inserted in the ends can protect them.

Another advantage of gravel filled interceptor drains is that moles can be pulled both ways, instead of the one way trip from open drains, speeding up the job.

Effective life

The effective life of a mole drain can be from hours (if done in the wrong conditions) to 10 to 15 years (if done in the correct conditions). Moles in some soils have lasted longer. Even some soils that in theory shouldn't support moles are still operating after 5 years.

Other factors.

1. Improved drainage not only takes away surplus water but takes away some nutrients as well. Fertiliser should not be applied immediately before rain events when run off is likely. Good management practices, such as not applying fertiliser within four days of predicted rain should reduce nutrient run-off to a minimum.

2. Consider changing paddock layout to make mole draining easier. Water pipes often have to be re-laid.
3. Drainage trenches can outfall to dams, so that more water can be harvested.

The Water Act

The Water Act (1989) provides guidance for the management of waterways and swamps. Before considering draining a wet area you should contact your local Catchment Management Authority for advice and Regional Water authorities, as a permit may be required.

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