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Mole Drains

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1. What are mole drains?

Mole drains are unlined tunnels (mole channels) in the clay subsoil formed by a mole plow (Figure 1). A mole plow is composed of a shank (leg) attached to a cylindrical bullet followed by a cylindrical expander (Figure 2). The expander strengthens the channel by compacting the wall. The process of pulling the mole plow results in soil cracks. The effectiveness of mole drains depends on the amount of soil cracks that facilitate water movement toward the mole channel.

2. Why install mole drains?

The following are the reasons why you may need to install mole drains:

- In soil where surface drainage is insufficient for addressing excess water problems and installing subsurface (tile) drainage is uneconomical due to low crop income, mole drains are an inexpensive means to drain excess water from the soil profile. An example location is the Upper Peninsula of Michigan.

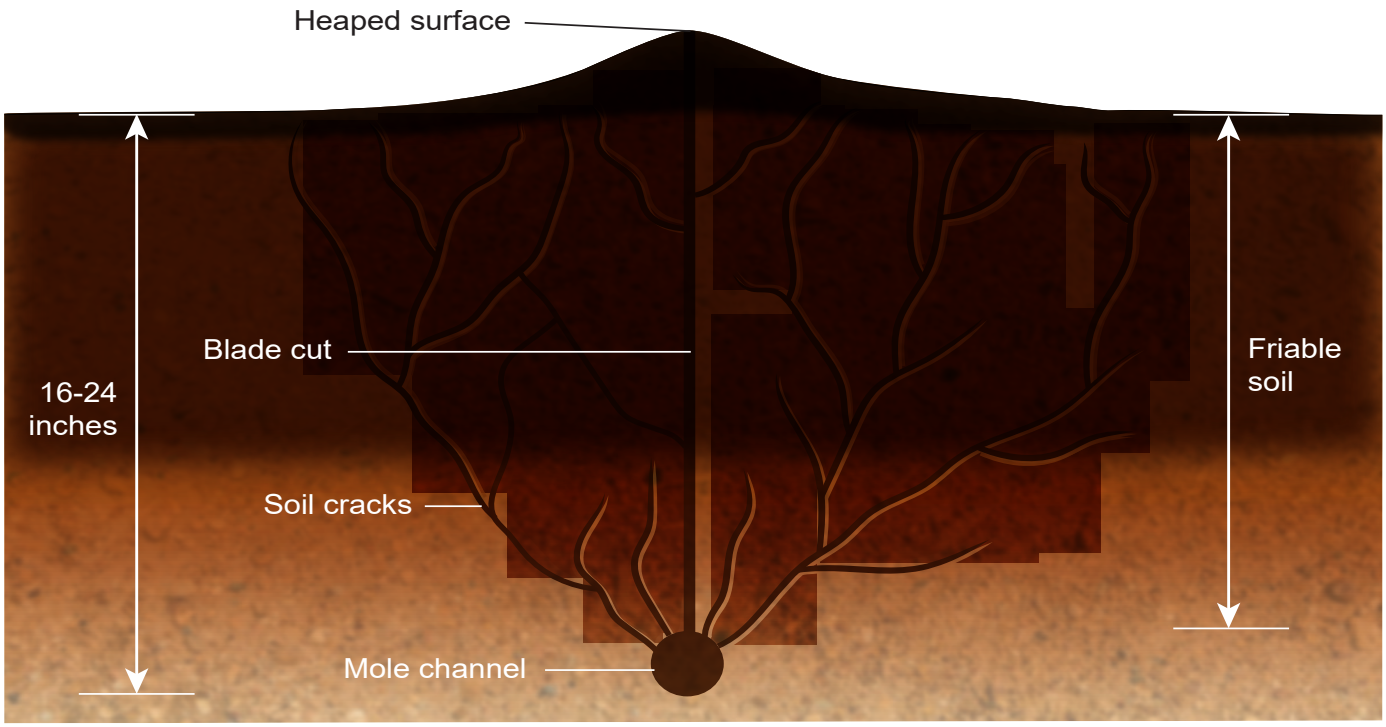

Figure 1- The process of pulling the mole plow results in soil cracks. Soil cracks facilitate water movement toward the mole channel.

Figure 2- A mole plow is composed of a shank (leg) attached to a cylindrical bullet followed by a cylindrical expander (photo credit: Patrick Tuohy).

- In heavy clay soil with low permeability, mole drains can drain excess water from the soil profile. Alternatively, mole drains can be combined with subsurface drainage to improve drainage performance in heavy clay soil (Section 6).
- When iron ochre is a temporary issue, mole drains can leach the soluble iron over the initial few years after installation. After the iron leaching has declined, install subsurface drains. For more information about iron ochre, see Ghane (2022a).
- When impeded infiltration or percolation is a problem, the shank (leg) creates a blade-cut to break up the clay-pan and compacted layer (figures 2 and 3) (Ghane 2022b). Also, soil cracks increase infiltration and water movement by providing a water pathway to reach the mole channel, thereby improving soil aeration (Figure 4).

Figure 3- A tractor pulling a mole plow. The shank (leg) creates a blade-cut to break up the clay-pan or compacted layer to improve infiltration (Photo credit: Patrick Tuohy).

Figure 4- After the tractor pulls the mole plow, a soil crack forms to improve infiltration (Photo credit: Patrick Tuohy).

3. Specification of mole drains

The expander diameter is 3 to 4 inches, with the larger size generally used at deeper depths (Eggelsmann, 1978; Schwab, 1947). Mole drains are typically installed with 3-ft to 6-ft spacing (Figure 5). Since some of the channels will fail following installation, the final spacing will be wider. For example, installing at 6-ft spacing may result in a 12-ft final spacing, assuming some mole channels will fail. As a result, plan on installing narrower spacings to achieve your final wider spacing. The larger spacings are used in cultivated fields, and the smaller spacings are used for grasslands with very wet climates (Schwab, 1947).

The depth of the mole channel is usually between 16 to 24 inches. If tractor capacity or surface traction limits mole depth in heavy clay soil, start with a shallow mole depth, no shallower than 16 inches. As the soil structure improves over the years with better infiltration and root development, increase mole depth to around 24 inches in the following installation (Vlotman et al., 2020). Generally, mole depth should be as deep as possible for the channel to be placed in the plastic subsoil. If moling is combined with subsurface (tile) drainage, care should be taken to avoid cutting the plastic drains (Section 6). Deep moles last longer than shallow ones because they are less prone to damage by traffic, roots, animals, and shrinking and swelling of the soil.

Mole length depends on soil type and land grade, with the shorter lengths lasting longer (Hopkins, 2002). Relatively flat fields require shorter mole lengths than steeper slopes. Generally, the maximum length of a mole drain should be about 200 ft to ensure it lasts longer.

If the mole channel flows into a ditch, make sure the mole outlet is far away enough from the bottom of the ditch to provide a continuous free flow (Hopkins, 2002). The mole outlet can be protected by inserting a 3- to 6-ft long piece of rigid pipe into the outlet to stabilize the channel and allow rat-guard installation (Vlotman et al., 2020) (Figure 6). The outlet must be regularly maintained, so the mole drains work as designed.

Figure 5- A mole drain with 4-ft spacing. Note that the 4-ft spacing may result in the desired spacing of 8 ft or wider assuming some of the mole channels will fail (Photo credit: Patrick Tuohy)

Figure 6- A rigid pipe at the outlet of a mole channel. Notice the soil cracks visible above the outlet (photo credit: Patrick Tuohy).

4. Suitability of mole drains

Moling is very suitable in heavy clay soil with a minimum of 45% clay content and less than 20% sand at the mole depth (Tuohy et al., 2015). Soil with a minimum of 35% clay and less than 45% sand at mole depth may be suitable (Tuohy, 2013). Soil with stones and clay content less than 35% are unsuitable for mole drains due to low mole channel stability.

Mole drains are very suitable on uniformly sloped landscapes with slopes ranging from 0.2% to 3.0% because the grade of the mole drains follows the landscape's slope. If the grade is too steep (>3.0%), erosion may occur in the mole drains. If there is not enough grade in the mole channel, water stagnation will weaken the walls and lead to early collapse. Any irregularities in landscape slope will show up in the mole grade (Vlotman et al., 2020).

5. When to install mole drains

Best installation conditions usually occur during summer, when the upper soil layer is as dry as possible (Tuohy, 2013). If the soil at mole depth has too much moisture, it leads to smearing and reduces the effectiveness of the mole drains. As a rule, the soil moisture at the mole depth should be at or just below the plastic limit (Vlotman et al., 2020).

To determine if the soil is below the plastic limit, use a soil auger or shovel to grab a handful of the soil from the mole depth. If the soil sample has gravel, separate those larger than 2 mm as much as possible. Take a small sample of the soil (about the size of a peanut) and immediately roll it between your palm and a smooth surface (glass-like surface) to create a thread. Rolling should be done under the shade to avoid the sun drying the sample. If the larger thread breaks into shorter threads, continue rolling the shorter thread. If the thread crumbles into barrel-shape pieces at a diameter greater than 1/8 inch, the soil is dry enough for moling, that is, the soil is at or below the plastic limit (Figure 7). If the thread reaches 1/8-inch diameter without crumbling into barrel-shape pieces, you have too much moisture for moling (ASTM D4318-17e1).

Figure 7- Barrel-shape soil crumbles made during the rolling process. During the rolling process, if the thread crumbles into barrel-shape pieces before reaching the 1/8" diameter, the soil is dry enough for moling. The item on the left is a bucatini pasta with a 1/8" diameter after soaking in water, which can be used as a reference for the desired 1/8" diameter (photo credit: Zouheir Massri).

6. Combining mole drains with subsurface drainage

Mole drains can be combined with subsurface drainage to improve drainage performance in heavy clay soil. In this system, mole drains are installed perpendicular to the subsurface drain pipes. To avoid cutting through the existing drain pipe, keep at least a 4-inch distance between the bottom of the mole channel and the top of the subsurface drain pipes (Stuyt et al., 2005).
The combined system has two designs. In the first design, mole channels create cracks in the soil that facilitate water movement toward the drain pipes, and the mole channels empty into a ditch (Figure 8).

In the second design, mole channels do not empty into a ditch. Instead, flow in the mole channel is intercepted by a gravel-filled trench with a drain pipe (Figure 8). The trench is installed first, then the mole channel. The mole channels cut through the gravel envelope without cutting through the drain pipe, and water from the mole channel flows through the gravel to reach the drain pipe. To save cost, you may not need trenches for every lateral drain pipe. Install the trenches for select drain pipes at an interval ranging from 100-200 ft. The closer the trenches, the quicker the water removal. In this design, there is no mole outlet, so there is no need for the mole outlet maintenance. This design has been shown to improve the performance of the drainage system in poorly permeable soil (Tuohy et al., 2018).

Both designs can address compaction issues by breaking up the plow-pan or compacted layer. Mole drains result in soil cracks, facilitating water movement toward the drain pipe and increasing infiltration. Caution is advised when moling under wet surface conditions as these can worsen the compaction issue.

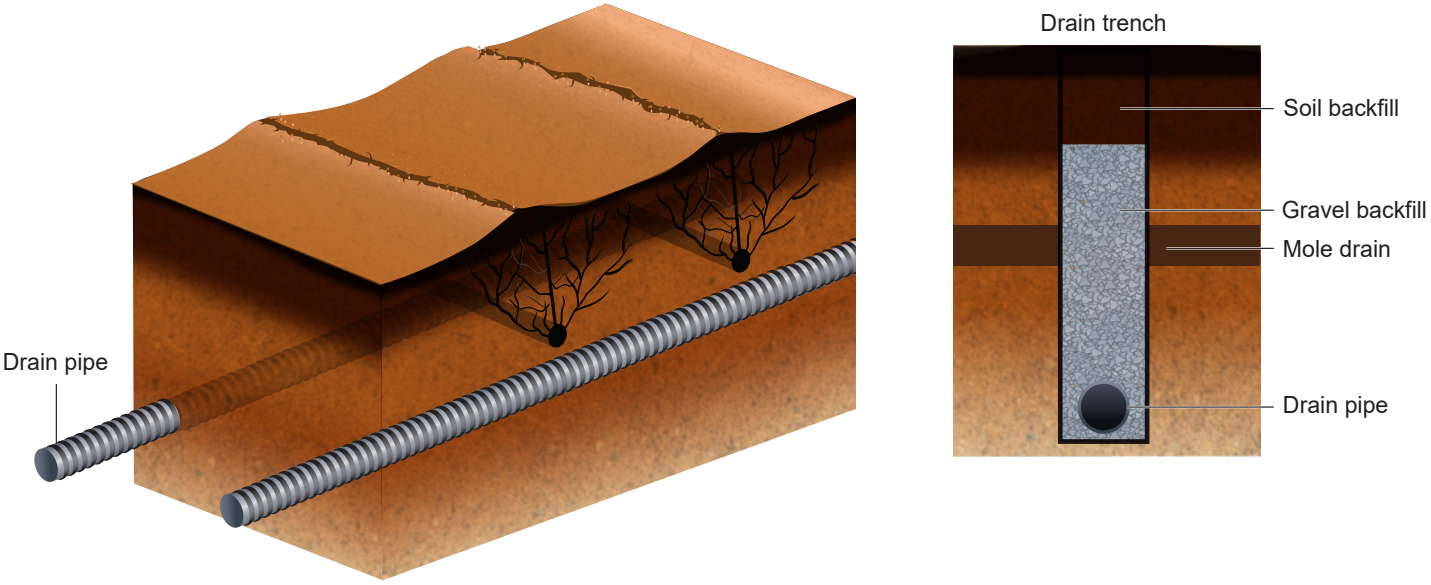

Figure 8- Left: In Design 1, mole channels create cracks in the soil that facilitate water movement toward the drain pipes, and the mole channels empty into a ditch. Right: In Design 2, mole channels do not empty into a ditch. Instead, flow in the mole channels is intercepted by a gravel-filled trench with a drain pipe.

7. Life expectancy of mole drains

The lifetime of a mole drain depends on the soil's stability and the soil moisture at mole depth during installation. However, if mole drains are properly installed in suitable soil and moisture condition, they can last beyond five years (Hopkins, 2002). Since the mole drains' effectiveness decreases over time, re-run the mole drains every 3 to 4 years.

8. Benefits of mole drains

The primary benefit of mole drains is its low cost. Other benefits are improved soil physical properties and increased crop yield in heavy clay soil (Jha & Koga, 1995; Muirhead et al., 1996). When properly installed, mole drains create soil cracks that increase soil aeration, increase infiltration, and facilitate water movement toward the mole channels. The improved drainage under mole drains enhances root development and gradually improves the soil structure (Hopkins, 2002; Vlotman et al., 2020).

Overall, mole drains should not be considered as merely a cheap version of subsurface drainage, but as a soil-and-drainage-improvement practice (Vlotman et al., 2020).

9. Summary and recommendations

Mole drains are a low-cost practice to improve the soil physical property and drainage performance. The effectiveness of mole drains depends on the amount of soil cracks that facilitate water movement toward the mole channels. Moling is very suitable in heavy clay soil with a minimum of 45% clay content and less than 20% sand at the mole depth.

Plan on installing narrower spacings to achieve your final wider spacing because some of the mole channels will fail. Since the mole drains' effectiveness decreases over time, re-run the mole drains every 3 to 4 years.

Mole drains can be combined with subsurface drainage to improve drainage performance in heavy clay soil. In one design, mole channels empty into a ditch. In the other design, mole channels empty into a gravel-filled trench with a drain pipe.

Expert Reviewed

This bulletin has been reviewed by Dr. Patrick Tuohy (Research Officer, Teagasc, Environment Research Centre, Ireland), James Isleib (Crop Production Educator, MSU Extension), and Dr. Timothy M. Harrigan (Associate Professor, Michigan State University).

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