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FUNCTIONING OF MOLE DRAINS IN A CLAY SOIL

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ABSTRACT

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Observations of water-table fluctuation and drainflow are reported from a field experiment on a heavy clay soil with replicated "mole-drained" and undrained plots. Results from rainfall events indicated that in both treatments the dominant water movement was through the topsoil which in the drained plots was directly linked to the mole channels probably by fissures.

INTRODUCTION

Mole channels have been extensively used for draining clay soils and Childs (1943) and Trafford and Rycroft (1973) have attributed their effectiveness to the close spacing. However, the mode of action of mole drains during rainfall events has received little critical attention. Nicholson (1946) states that drainage is effected by water flow from the surface layer to the mole channel via the slit made by the standard (leg) of the mole plough. Recently Leeds-Harrison et al. (1982) have confirmed that drain flow was much more rapid after rainfall when mole channels were formed using a conventional mole plough than when they were created by hydraulically jacking an expander horizontally through the soil. The mole channels created by the conventional way had extensive fissuring to the surface, but there was little or no fissuring in the second treatment.

The objective of this work was to establish the importance of the macropore connections between the surface soil and the mole channel for the functioning of mole drains.

EXPERIMENTAL

The soil is a heavy clay soil of the Denchworth series (Jarvis, 1973). The Ap horizon extends from 0—20 cm depth and contains 54% clay (< 2 μm),

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39% silt (2—60 μm), 7% sand (60 μm—2mm). The Bg horizons extend from 20—90 cm and contain 59% clay, 37% silt, 4% sand.

We had four drained and four undrained plots, each 46 m × 41 m. Each plot was hydrologically separated from its neighbours to a depth of about 1 m. Polythene curtains were inserted to 1.1 m down the slope to prevent water from moving laterally from plot to plot. Interception of water moving down the slope was by tile drains arranged across the slope. These were set at 1 m depth with permeable fill to the soil surface. These interceptor drains were located immediately up the slope from the experimental plots and the effective spacing of these drains was 59 m.

At the lower edge of all plots and arranged across the slope were facilities for collection and continuous measurement of the flow of water: (a) over the soil surface (surface run-off); (b) at the juction (20 cm depth) of the cultivated top soil and undisturbed subsoil (interflow); and (c) on the drained plots from deep tile drains at 0.9 m depth which collect water from mole drains at about 60 cm depth and 2 m spacing. The mole channels were drawn down the slope and at right angles to the permeable fill which covered the deep tile drain to a depth of 45 cm; above 45 cm the trench was back-filled with soil. This experiment was carried out 20 months after installation of the drainage system when water flow through the soil above the trench was expected to have little effect on peak flow in the deep tile drain, but would be collected in the adjacent, shallower, interflow drain.

The depth to the water-table below the soil surface was determined for the mid-line between mole drains on drained plots and in an equivalent position on undrained plots using banks of tensiometers (Howse and Goss, 1982) with probes at 7.5, 15, 30, 40, 60, 80, 100, 120, 150 and 200 cm depth. Rainfall was recorded at the site using a tipping bucket raingauge (0.25 mm) that was part of an automatic recording weather station (Wallingford Type).

RESULTS AND DISCUSSION

Detailed observations were made on the fluctuation in the position of the water-table and drain outflow resulting from a rainfall event in the late winter of 1979/80. This comprised two periods of precipitation with a total of 13.5 mm rainfall. Figure 1 shows the changes in the mean position of the water-table together with the mean drainflow rate from the deep drains of drained plots and from the interflow collectors on undrained plots. These were chosen because during this rainfall event the deep drains were the principal collectors yielding 86% of drainage water on the drained plots. Interflow was the most important collector for the undrained plots yielding 76% of drainage water. Furthermore results from these drains enabled a direct comparison of the flow from the mole drains with the flow from the topsoil without interaction. The depth to the water-table below the soil surface was least at the same time for both treatments and more than 1 h later

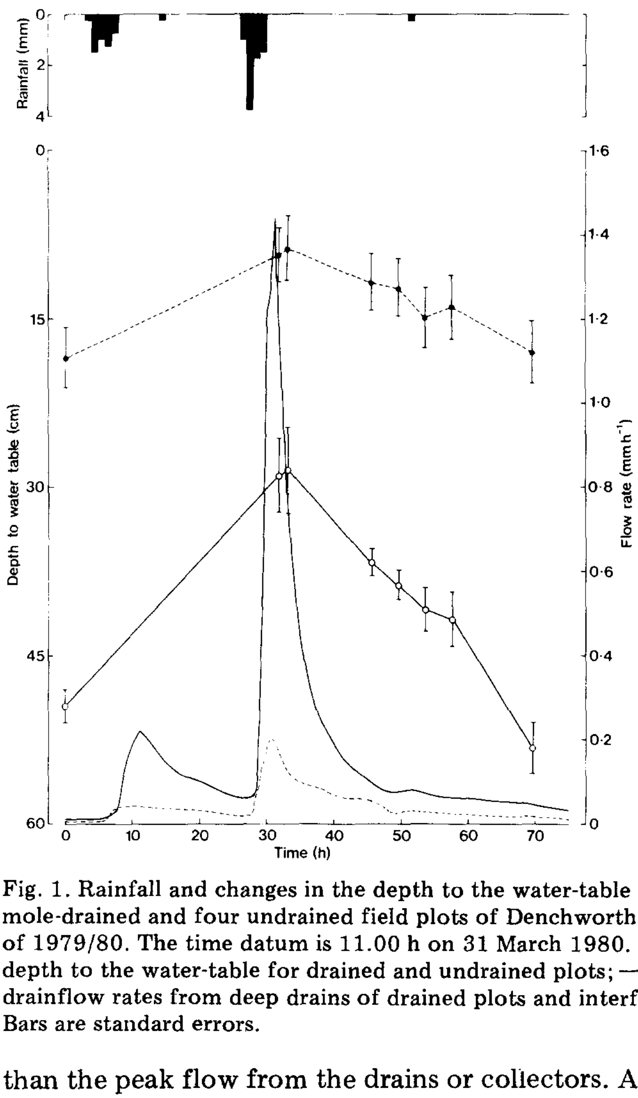

Fig. 1. Rainfall and changes in the depth to the water-table and drain outflow from four mole-drained and four undrained field plots of Denchworth series soil, in the late winter of 1979/80. The time datum is 11.00 h on 31 March 1980. ○- - - -○ and ●- - - -●, the mean depth to the water-table for drained and undrained plots; ——— and - - - - - - - the mean drainflow rates from deep drains of drained plots and interflow drains on undrained plots. Bars are standard errors.

than the peak flow from the drains or collectors. At the start of the storm the water-table in the poorly drained plots was only 18 cm from the soil surface and so within the Ap horizon. In drained plots the water-table was at about 49 cm from the soil surface to start with and rose to 28 cm below the surface but remained within the Bg horizons. The time of peak drainflow was the same time on the drained and undrained plots, suggesting that flow into the drains was largely influenced by movement in the topsoil. Analysis of a number of midwinter storms has given qualitatively similar results, with drain flow-rate reaching a peak in advance of the depth to the water-table reaching a minimum. These observations support the hypothesis that the principal route of water from the soil surface to the mole drains was not uniformly through the subsoil but must have been via large fissures linking the topsoil with the mole channel. The most prominent of these were found by excavation to be those formed by the passage of the standard of the mole plough. This is consistent with the view of Nicholson (1946).

The fall in the water-table continued long after the peak in drain flow and the decline to the initial level was more or less linear with time in both treatments (Fig. 1) however the rate in the drained plots (6.6 mm h^{-1}) was almost double that in the undrained plots (3.6 mm h^{-1}). This reflects the fact that in the drained plots the water-table fluctuated within the subsoil which had only a small volume (4.3%, *v/v*) of drainable pores at each depth. Thus removal by the closely spaced mole drains of only a small volume of water caused a large fall in the water-table. In contrast in the undrained plots the water flowed largely in the more porous Ap horizon (14.4% drainable pores) for most of the recession and so required a much larger volume to be removed for a similar fall in the water-table.

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