Draining the rain

TEAGASC research has looked at different drainage system types to measure their response to extreme rainfall events.

Escalations in rainfall intensity, in terms of both volume and frequency, are increasing the variability in pasture growth and utilisation on poorly drained soils. The principal mechanism of reducing this volatility is by means of land drainage; however, the efficacy of drainage systems is widely variable, and has not been accurately quantified. Two major drainage system types exist: groundwater; and, shallow drainage designs. In a recent study, we examined the performance of nine site-specific drainage systems (five groundwater and four shallow drainage designs) during a high rainfall period. The key outcomes of interest were response times (start, peak and lag times); discharge characteristics (peak flow rate, total discharge, flashiness index, discharge hydrographs); and, water table control capacity.

Monitoring system performance

The efficiency of a drainage system is a measure of its ability to respond to rainfall events and discharge appropriate volumes of water. A review of the performance of a range of recently installed land drainage systems (on Teagasc Heavy Soil Programme farms) during a high rainfall period is required to add to the understanding of the capabilities and limitations of these systems, to generate new knowledge with respect to the efficiency of various drainage designs, and to assess their potential usefulness to improve the agronomic value of poorly drained soils. The study involved nine drainage systems across seven farms in Munster. End-of-pipe flow meters record water flow rates, while a number of in-field wells (2 m deep) with water level sensors record water table fluctuations. There is also a weather station on each farm.

The drainage system response was quantified by assessing the flow events related to a number of rainfall events. At each site, rainfall events with at least 5 mm of rainfall were selected for use in this study. Rainfall events were categorised into event types A-D depending on total rainfall amount: A = 5.0-9.9 mm; B = 10.0-19.9 mm; C = 20.0-39.9 mm; and, D = > 40.0 mm. Response was quantified according to a number of parameters such as start, peak and lag times, cumulative rain at start and peak times, flashiness index, peak flow rate, and total discharge. Across the sites rainfall was, on average, 27 % higher than the long-term average during the study period.

Drainage system response

The drainage systems were able to control the water table below the surface during the study period. Groundwater drainage designs generally maintained a deeper mean water table than shallow designs (0.82 m vs 0.53 m below ground level, respectively; **Figure 1**). Start time, peak time and lag time were not significantly affected by drainage system or drainage design type. Peak flow rate ranged from 5.5-90.2 m^3/ha per hour, and was significantly affected by drainage system and drainage design type. The average total discharge during rainfall events ranged from 100-1,722 m^3/ha.

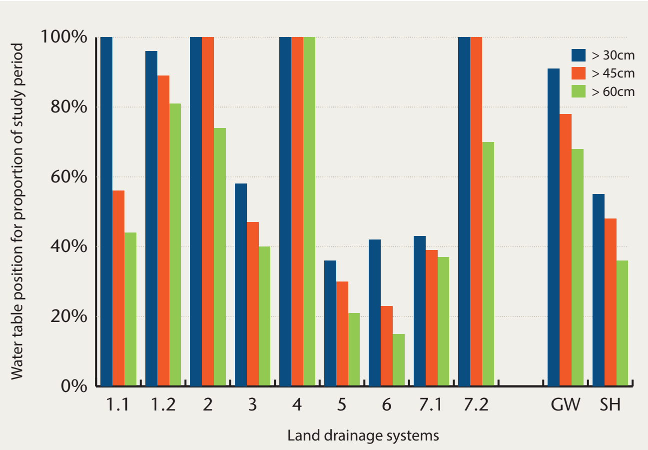

FIGURE 1: Number of days, as a percentage of total days during the study period, at which water table was below particular depths for drainage systems 1.1 to 7.2, and mean values for groundwater drainage designs (GW; 1.1-4) and shallow drainage designs (SH; 5-7.2).

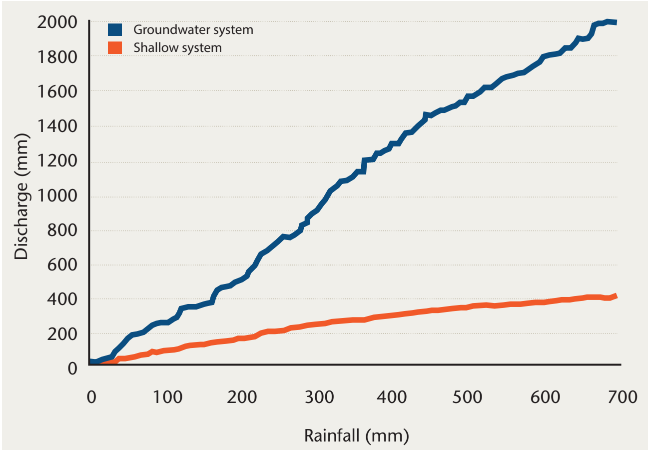

FIGURE 2: Cumulative drain discharge relative to cumulative rainfall during the study period for a groundwater drainage system and a shallow drainage system.

Groundwater drainage designs discharged significantly more water than shallow drainage designs (1,098 m^3/ha vs 189.6 m^3/ha, respectively; **Figure 2**). Start time was affected by event type, and ranged from 3.5 h (A events) to 10.8 h (C events). Peak and lag times were also affected by event type. Peak flow rate and total discharge grew with increasing magnitude of rainfall. Regression analysis identified 30-day antecedent rainfall, event rainfall and mean rainfall intensity as the principal factors affecting response times and drain discharge. Greater 30-day antecedent rainfall before the event start resulted in shorter peak times and increased peak flow rates. Greater mean rainfall intensity resulted in shorter start and peak times, and greater peak flow rates.

Factors affecting performance

All drainage systems were responsive to rainfall events. The mean start time was 6.1 h and the mean lag time was 10.4 h, and neither variable was affected by drainage system or drainage design type. Hence, similar responses were observed despite variation in soil types where appropriate drainage systems were installed. The intensity of discharge was greater in groundwater designs, as evidenced by higher peak flow rates and total discharge relative to shallow designs. This was largely due to the contribution of groundwater, which combines with infiltrating water to increase discharge levels. The location of groundwater designs in a permeable horizon relatively deep in the profile allows for direct interaction with groundwater and a larger zone of influence, and therefore base-flow is a major component of flow due to the nature of these designs. For shallow designs, flow events are almost entirely derived from the influx of surface water such that base-flow is non existent (Tuohy *et al.*, 2018). Discharge from shallow designs may also have been compromised during a rainfall event due to a reduction in the level of structural fissures and macropores that were established during installation, especially for systems reliant on mole drainage or sub-soiling. The integrity of cracks and fissures created when these systems are installed is known to reduce over time, and varies with the natural wetting/drying cycles of the soil. An increase in the efficiency of these techniques is required to maximise their performance and lifespan, and improve their potential usefulness in a more intense rainfall environment.

References

Tuohy, P., O'Loughlin, J., Peyton, D. and Fenton, O. (2018). 'The performance and behavior of land drainage systems and their impact on field scale hydrology in an increasingly volatile climate'. *Agricultural Water Management*, 210: 96-107.

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