Farming on challenging soils – the Teagasc Heavy Soils Programme

Pat Tuohy,
Teagasc Moorepark,
Fermoy, Co. Cork.

The Teagasc Heavy Soils Programme was established in 2011 to look at the limitations associated with farming on poorly drained grassland soils. Ten farms across 8 counties (Limerick, Kerry, Cork, Clare, Tipperary, Mayo, Cavan and Monaghan) are participants in the programme. The aim of the programme is to find the most cost effective and efficient means of increasing profitability on poorly drained soils. The programme has been examining all aspects of the farms involved in terms of system inputs & productivity, management practices and financial performance. Two major issues have been brought to light, namely land drainage design and poor soil fertility status.

Land Drainage

The purpose of land drainage is to remove excess water from the soil as quickly as possible. How best to achieve this will vary with soil type. There is a need therefore for a better understanding of the underlying causes of drainage problems and of the design and implementation of appropriate drainage systems to resolve these problems. We must move away from the short-sighted approach that a broadly similar drainage system can be installed in every wet field regardless of soil and site conditions. An assessment of soil type and its drainage status is a vital first step.

Objectives of land drainage

In poorly drained soils the rate of water infiltration at the soil surface is regularly exceeded by the rainfall rate due to:

- Low permeability in the subsoil (or a layer of the subsoil)
- High watertable due to low lying position and poor/poorly-maintained outfall
- Upward movement of water from seepage and springs

To achieve effective drainage the works will have to solve one or more of these problems. The objective of any form of land drainage is to lower the watertable providing suitable conditions for grass growth and utilization. A controlled watertable promotes deeper rooting which improves productivity and improves load-bearing capacity of the soil.

When planning any drainage programme, the potential of the land to be drained needs to be first assessed to determine if the costs incurred will result in an economic return through additional yield and/or utilisation. Some thought is needed in deciding the most appropriate part of the farm to drain. From a management point of view it is better to drain that land which is nearer to the farmyard and work outwards, however it may be more beneficial to target areas with high potential for improvement. This ensures a better return on the investment.

Drainage investigations

Knowledge of previous drainage schemes in the area, and their effectiveness will often provide an insight. A number (approx. 1 per ha) of test pits (at least 2.5 m deep) should be excavated within the area to be drained to investigate. These are dug in areas that are representative of the area as a whole; consider digging in wet and dry areas for comparison sake.

As the test pits are dug, the faces of the pits are observed, soil type should be established and the rate and depth of water seepage into the test pit (if any) recorded. Visible cracking, areas of looser soil and rooting depth should be noted as these can convey important information regarding the drainage status of the different layers. The depth and type of the drain to be installed will depend on the interpretation of the characteristics revealed by the test pits.

Two principle types of drainage system are distinguished:

- Groundwater drainage system: A network of piped drains exploiting permeable layers
- Shallow drainage system: Where movement of water is impeded at all depths

Groundwater Drainage System

Strong inflow of groundwater or seepage from the faces of test pit walls, indicate that layers of high permeability are present. Under these circumstances the use of a piped drainage system (at the depth of inflow) is advised to capture and remove this water, thereby controlling the watertable.

Shallow Drainage Systems

Where a test pit shows no inflow of groundwater at any depth a shallow drainage system is required. These soils with very low permeability throughout are more difficult to drain. Shallow drainage systems aim to improve the capacity of the soil to transmit water by fracturing and cracking the soil. They rely on soil disruption techniques, namely; mole and gravel mole drainage and sub-soiling.

Collector drains, which are installed across the slope at 0.8 – 1.0 m deep, are required for all shallow drainage systems. Depending on the topography and slope, the collector drains will be at a spacing of 10–40 m. A larger spacing reduces costs but results in a much higher chance of failure. The disruption channels themselves are drawn at right angles to the collectors (up-slope) at spacings of 1.0-1.5 m and a depth of approximately 0.4-0.5 m. Stone backfill for collectors should be filled to within 250 mm of the surface to ensure interconnection with the disruption channels when installed afterwards.

When a drainage scheme has been completed, the layout should be drawn and noted on a farm map. This map can then be used as a guide when maintaining the works, as well as a record of the works. Land drain outlets should be regularly cleaned and maintained especially if open drains are cleaned/upgraded as this will result in blockages at the drain outlets. The use of a concrete or un-perforated plastic pipe over the end of the drain pipe, minimum 1 m in length, will protect the outlet from damage and will make locating and maintaining it easier.

Drainage design on Sean O'Riordan's farm

As is standard procedure, a site investigation in association with the farmer and local advisor was carried out as the first step in the design process. This involved walking the site and noting outfall conditions, field slope as well as existing drains (in-field and open) and natural water-courses. The next step involved digging soil test pits on the site. The profile uncovered (Figure 6 below) contained a high clay content subsoil. There was increased stone content with depth and bedrock (shale) at depths of 2.5 to 3.0 m. There was some inflow of groundwater at depths of 1.0 – 1.2 m but this was not consistent in all soil test pits. This water movement indicated that a groundwater drainage system at this depth could be beneficial. However, as it was not consistent throughout the site, other means of drainage would need to be employed to ensure a successful outcome. The layer at 0.3 – 1.0 m depth is a heavy clay with no apparent natural cracking. It was classed

Figure 1. Test pit excavation

Figure 2. Drainage trench excavation

Figure 3. Mole plough showing cylindrical foot and expander

Figure 4. Gravel Mole plough showing hopper

Figure 5. Single leg winged sub-soiler

as poorly permeable and would require the intensity of drainage provided by a disruption technique (mole or gravel mole drains or sub-soiling) being supplemented by a network of collector drains. Mole drainage was not feasible on this site due to the large amount of stones present. Given the high cost associated with gravel mole drainage and the level of groundwater discharge naturally facilitated by suitably deep collector drains, it was decided that sub-soiling the site would be an adequate method of subsoil disruption.

The final phase of the site investigation involved measurement and mapping of the site. This would allow for field levels and geometry to be established. A laser-level survey was used to assess falls and provide guidance on the most appropriate positions of field drains.

It was decided to install a series of collector drains across the main field gradient at a spacing of 15 m (see Figure 7). While the drains act predominantly as conduits for surface water being collected, the in-flow of groundwater at 1.0 – 1.2 m depth in certain areas of the site allows for groundwater drawdown. For this reason all collector drains were installed to a minimum depth of 1.1 m. The existing open drain at the eastern side of the site was cleaned and deepened to a depth of 1.5 m to act as an outfall for the new field drains. The drains consisted of an 80 mm corrugated perforated PVC, with a gravel aggregate envelope (10 - 40 mm grade) backfilled to within 0.3 m of the soil surface (to ensure maximum connection to the disturbed (sub-soiled) soil and topsoil) and thereafter backfilled with soil.

Sub-soiling was carried out with a single leg winged sub-soiler to improve permeability of the upper layers and increase the level of infiltration of surface water into the soil profile and ultimately into the collector drains. The collector drains were installed first. Sub-soiling was carried out at a depth of 0.6 m and a spacing of 1.5 m when good weather ensured dry soil conditions and allowed for the maximum level of soil disturbance. The depth and spacing of sub-soiling was set to ensure maximum fracturing and disturbance of the soil.

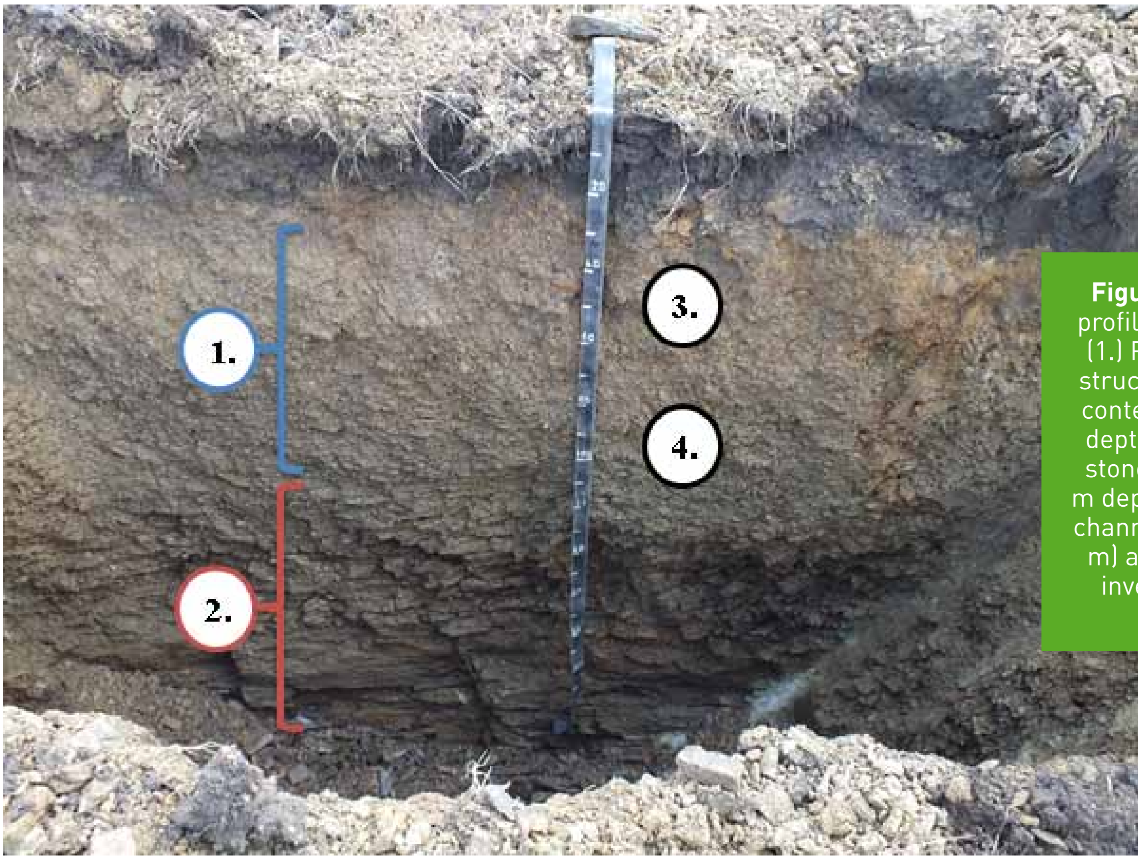


Figure 6. Typical soil profile at Kiskeam site; (1.) Poorly permeable structureless high clay content soil (0.3-1.1 m depth), (2.) increasing stone content (1.1-2.5 m depth), (3.) sub-soiler channel invert level (0.6 m) and (4.) field drain invert level (1.1 m).

A Planned Approach To Improving Soil Fertility

Sean O'Riordan did a comprehensive soil analysis of his 40 ha milking block in Jan 2014. In total 38 soil samples were taken. The results showed an average pH of 5.77 with 29% of samples below a pH of 5. Only 44% were above a pH of 6.

Table 1. Change in pH status on the O'Riordan farm

	Average pH
2014	5.77
2015	5.82
2016	6.17

Sean applied 96 tonnes of ground limestone in 2014 and a further 84 tonnes in 2015. Annual sampling has taken place on the farm and in Jan 2016 average pH had risen to 6.2 with only 11% below pH 5.5. Sean is farming a high clay content soil near Kiskeam, Co Cork with an average annual rainfall of 1.7 m. Lime loss via drainage is one of the key loss pathways on this farm

Analysis of Sean's grass measurements 2014 and 2015 show that those paddocks that had a pH of 5.5 in 2013 and increased to a pH of 6.3 in 2015 produced 2 tonnes DM/ha more grass in 2015. This indicates an immediate economic response of €260/ha payback for each €60 spent on lime. Correcting pH on these clay soils is vital as low pH adds to the problem of a naturally high phosphorus (P) fixation capacity soil type. While progress in correcting phosphorus deficiency is slow, an immediate impact on grass production is achieved by correcting the lime deficiency.

The intensive soil analysis undertaken in Jan. 2015 highlighted the extremely low P status of Sean's milking block. Average P reading was 1.91 mg/l or a low Index 1 P Status. Sean's fertiliser plan indicated that 1,900kg chemical P could be applied in 2014 (45 kg/ha) and Sean set out a plan to apply this P on a little and often basis over the grazing season. This level of P application did increase the P status in the samples taken a year later. However P status fell back to Index 1 P when farm was resampled in Jan 2016 (Table 1).

Table 1. Change in phosphorus status on the O'Riordan farm

	Average P levels (mg/l)
2014	1.91
2015	4.39
2016	2.76

Detailed chemical analysis of the heavy clay soils (David Wall, Teagasc Johnstown Castle) indicated that the phosphorus retention capacity on Sean's farm was 40% higher than other clay soils which have less acidic underlying bedrock material. This high P retention clay soil is typical to the south-west region, particularly North Cork, West Limerick & North Kerry.

In effect the fertiliser P applied, surplus to off take (2015 was a good grass growing year), was being fixed by the soil which had a very poor P reserve. Normally the additional P would be expected to build up P status.

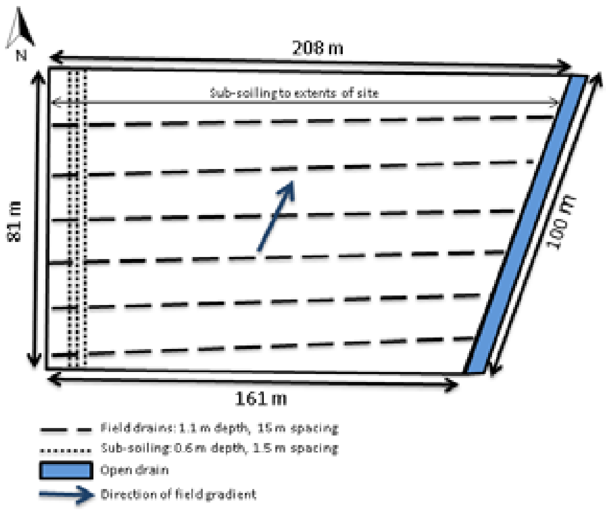
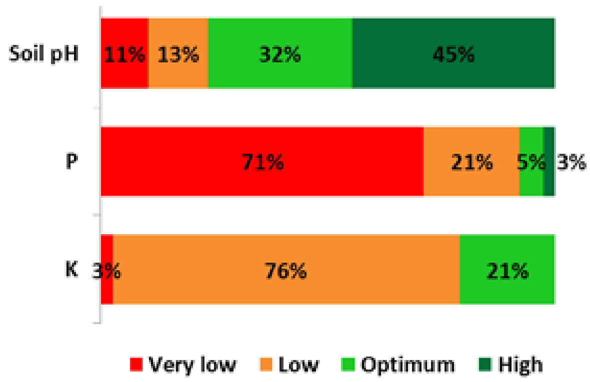


Figure 7. Field map of drainage works on the O'Riordan farm



It is crucial that Sean continues to fully utilise his phosphorus allowance. This requires prioritising spending on fertiliser ahead of other lower return farm costs e.g. excessive concentrate feeding. Otherwise the 5-7 year time frame that Sean has to travel in achieving optimum soil fertility and grass production will be slower and more costly in the long run.

Key messages from Sean's experience

- Do a comprehensive soil test of all paddocks at least every two years.
- Correct lime deficiency based on lime requirement. On heavy soils, limit lime application to two tonnes/acre in any single application.
- As a guide, where average farm pH is below 5.8 apply one tonne of ground limestone per cow in the herd in year 1.
- Use your soil results to set up a fertiliser plan and know the total amount of P fertiliser you are allowed spread.
- Split your P allowance applying 50% in spring and remainder in July. Apply on a little and often basis.
- Prioritise lime/fertiliser spending above other lower return costs.