

Project number: 6683
Funding source: Teagasc

Date: January 2021
Project dates: Jan 2015-Dec 2020

Technologies to increase the productivity of dairy farming on heavy soils



Key external stakeholders:

Farmers on Heavy Soils, Drainage contractors, Farm advisors- both Teagasc and commercial advisers, Dairy Co-operatives (especially Kerry, Tipperary Co-op, Dairygold Co-Op & Aurivo)

Practical implications for stakeholders:

- The Heavy Soils Programme (HSP) promoted technologies and management practices that can be implemented to improve the efficiency and performance of farms dominated by heavy soils. Given the prevalence of poorly drained soils and the potential benefits of land improvement, the HSP has had and continues to have a significant impact nationally and is a key element in fostering progression in the industry.
- A focus on maximising grass utilisation on heavy soils requires investment in a number of complementary technologies namely; land drainage, grazing infrastructure, soil fertility and grassland management
- It has been shown that increasing both grass production and utilization on these farms will result in reduced seasonal volatility and increased farm profitability.

Main results:

- Performance analysis of drainage systems installed on HSP farms has shown how drainage system type, soil type and seasonal variations in soil moisture affect drainage system performance. All systems reduce the overall period of waterlogging and improve the conditions for both the production and utilization of the grasslands they drain.
- Drained sites increased grass production by between 4 and 7 tDM/Ha/year with a payback on capital invested of approximately 5 years
- Targeted nutrient improvement measures across the HSP farms has seen them move from a position where only 2% of paddocks sampled in 2013 were optimum for pH, P and K to the current position where 21% of paddocks achieve this status.
- Optimum soil fertility is difficult to achieve with many technical challenges preventing rapid improvements.
- Higher average farm incomes and comparatively high returns on assets can be achieved on challenging soil types in locations of high rainfall, through high levels of technical management efficiency focusing on a grass-based system of milk production. This requires best grazing management practices, adequate drainage, soil fertility and grazing infrastructure combined with strong technical management ability.

Opportunity / Benefit:

- HSP farms have seen increases in milk solids produced per hectare of 57% (1,338 vs. 850 kg/Ha).
- The HSP has demonstrated methods to improve grassland productivity and utilization, thereby sustaining viable farm enterprises on poorly-drained soils. Recommendations from the programme are benefitting farmers working on similar soils, which amount to approximately 1.2 million Ha or 37.5% of grassland nationally.

Collaborating Institutions:
UCD

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1. Project background:

It is estimated that approximately 30% of the milk produced in Ireland is from poorly drained soils. Meteorological records show that excess rainfall and small moisture deficits are a dominant factor of Irish agriculture; therefore poorly drained soils in the wetter regions, where annual rainfall ranges from 1,200 to 2,000 mm, have significant difficulties in achieving high grass utilisation per hectare. The programme aimed to demonstrate methods to improve grassland productivity and utilization, decrease volatility in these parameters and sustain viable farm enterprises on poorly-drained soils. Of the 3.18 million Ha of managed grassland nationally, it is estimated that 0.96 million Ha (30%) are imperfectly or poorly drained, and a further 0.24 million Ha (7.5%) is peat (O' Sullivan et al. 2015). The Heavy Soils Programme acts as a test bed for technologies and management practices that can be implemented to improve the efficiency and performance of farms dominated by such soils. This project was focused on the skills and technologies which facilitate increased profitability on farms with Heavy Soils. This necessitated the adoption of key technologies including land drainage improvement strategies, optimization of soil fertility, quality pasture management, compact calving, increased stocking rates, risk management and low cost labour efficient farm infrastructures. Increasing both grass production and utilization on Heavy Soil farms results in increased farm profitability. The programme has a wide geographical spread with 10 commercial farms participating; representing Counties Limerick, Kerry, Cork, Tipperary, Clare, Mayo, Cavan and Monaghan. The monitoring and data collection from these farms has allowed for production levels to be monitored and weaknesses in each farm system to be identified. The key to the programme is the commitment to understanding the true nature of the limitations exposed by the intensive measurement and monitoring campaign. The data being generated allows for legitimate and detailed analysis of the farm systems to be carried out and over time, the development of solutions to common restrictions to productivity on poorly drained soils.

2. Questions addressed by the project:

- How can land drainage design be optimized for a range of poorly drained soils
- What are the key factors that impact on land drainage system performance
- How do the study soils respond to nutrient and lime application
- What is the optimum methodology to increase soil fertility status
- What technologies are key to optimizing grass utilization on heavy soils
- How do study farms compare with national averages in terms of physical and financial performance metrics

3. The experimental studies:

The HSP encapsulated a number of experimental exercises as well as long term monitoring of existing farm systems. Land drainage design was evaluated by assessing designs developed by visually characterizing soil physical properties with regard to their drainage characteristics relative to idealized designs established through laboratory analysis of soils. Land drainage performance was assessed by quantifying the general performance and effectiveness of installed drainage systems over a number of rainfall events of varying magnitude during an extended high rainfall period to quantify behavior characteristics of drainage systems and drainage design types and determine the principal factors which dictate their behavior. Performance was measured in terms of water table control, response and discharge parameters (namely flow start, peak and lag times, peak flow rate, flashiness index and total discharge) and discharge hydrographs.

In terms of soils fertility. The response to lime application at three sites was assessed by comparing two lime products with regards to their ability to counteract soil acidity and increase nutrient availability over time; and secondly, to determine the rate of lime product required to counteract soil acidity and achieve optimum pH

on naturally acidic soils, while further analysis across all sites assessed the response of 25 soils dominated by fine particle size, and/or high organic matter content, in terms of the effects of (1) ground lime on altering soil pH and nutrient availability, (2) the impact of P application rate on increasing STP and (3) the potential impact on nutrient loss vulnerability indicators, given the high buffering capacity of these soils. An incubation study was identified as the best approach of assessing these soils.

4. Main results:

- Performance analysis of drainage systems installed on HSP farms has shown how drainage system type, soil type and seasonal variations in soil moisture affect drainage system performance. All systems reduce the overall period of waterlogging and improve the conditions for both the production and utilization of the grasslands they drain. All drainage systems were capable of discharging excess water and controlling the water table to a certain extent but effectiveness was seen to vary. Response times were not affected by drainage system or drainage design type, showing similar responses despite variation in soil types where appropriate drainage systems are installed. Groundwater drainage designs were seen to discharge greater volumes of water and maintain a deeper water table relative to shallow drainage designs. The direct interaction of GW designs with the groundwater table was noted both in the level of base-flow apparent during flow events and the reactivity of the water table position to rain events.
- The comparison of such systems highlights the contrasting behaviors of individual drainage systems and drainage design types, which is dictated largely by the hydraulic capacity of the soil within their catchment and their connectivity to different water bodies (groundwater versus perched water). Classification of the performance of drainage systems must take account of their inherent differences. Performance metrics will need to allow for the contrasting responses of different drainage design types
- Groundwater drainage designs exploit natural conditions to discharge large volumes of water and can control water table directly by means of their interaction with layers and zones of high permeability. Shallow drainage designs are combatting the natural state of their host soils by relying on shallow disruption techniques which are ultimately destined to revert to their original state, particularly in the case of mole drainage and sub-soiling techniques. They have a smaller zone of influence, no direct connectivity to the water table and displace lower volumes of water which is collected directly from the surface.
- Drained sites increased grass production by between 4 and 7 tDM/Ha/year with a payback on capital invested of approximately 5 years.
- Optimum soil fertility is difficult to achieve with many technical challenges preventing rapid improvements. Targeted nutrient improvement measures across the HSP farms has seen them move from a position where only 2% of paddocks sampled in 2013 were optimum for pH, P and K to the current position where 21% of paddocks achieve this status.
- On average across study sites, one tonne/Ha of each lime product increased soil pH by 0.15 and 0.21 pH units for ground and granulated lime, respectively. Granulated lime was 5.9 times more expensive than ground lime in its ability to reduce soil acidity.
- Large variability in responses of soils to nutrient application are evident. Mineral soils showed significantly stronger responses to lime and Phosphorus application than organic soils which were more likely to pose a major risk in relation to P runoff due to their extremely low P sorption capacity
- Higher average farm incomes and comparatively high returns on assets can be achieved on challenging soil types in locations of high rainfall, through high levels of technical management efficiency focusing on a grass-based system of milk production. This requires best grazing management practices, adequate drainage, soil fertility and grazing infrastructure combined with strong technical management ability.

5. Opportunity/Benefit:

Of the 3.18 million Ha of managed grassland nationally, it is estimated that 0.96 million Ha (30%) are imperfectly or poorly drained, and a further 0.24 million Ha (7.5%) is peat. The Heavy Soils Programme acts as a test bed for technologies and management practices that can be implemented to improve the efficiency and performance of farms dominated by such soils. Given the prevalence of poorly drained soils and the potential benefits of land improvement the Heavy Soils Programme has had and continues to have a significant impact nationally and is a key element in fostering progression in the industry. The longest standing participant farms have seen increases in milk solids produced per hectare of 57% (1,338 vs. 850

kg/Ha). The development of the Heavy Soils Programme has been an important step in satisfying the agenda for managing and improving heavy soils

6. Dissemination:

The HSP has been linked with numerous industry focused events, training courses, publications and engagements at events and lectures. Each of these interactions has allowed detailed dissemination of major research findings to farmers and the farming community, Teagasc and private Advisors/consultants, students and many more stakeholders from the wider Agri-food industry. We have hosted a number of public open days on each programme farm, attracting a total of approximately 3,500 visitors. We have also been involved at every major Teagasc open day in recent years (Dairy-Moorepark, Beef-Grange, Sheep-Athenry) to allow for broader dissemination. Further to this we have participated in numerous heavy soils/land drainage focused farm walks and events in all parts of the country.

Main publications:

Corbett, D., Wall, D.P., Lynch, B. and Tuohy, P. (2021). The influence of lime application on the chemical and physical characteristics of acidic grassland soils with impeded drainage. *The Journal of Agricultural Science* (in Press).

Hanrahan, L., Tuohy, P., McHugh, N., O'Loughlin, J., Moran, B., Dillon, P., Breen, J., Wallace, M. and Shalloo, L. (2019). A description and evaluation of the physical and financial characteristics of dairy farms operating on soil types classified as poorly drained and associated with high rainfall. *Grass and Forage Science*, 74(3), pp.548-558.

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.

Popular publications:

Tuohy, P., Fenton, O. and O'Loughlin, J. (2019). The design of land drainage systems and their performance. *Irish Dairying – Growing Sustainably Moorepark 2019 Open Day 3/7/19*. Teagasc, pages 254-255

Tuohy, P., Fenton, O. and O'Loughlin, J. (2017). Land drainage design and installation. *Irish Dairying – Resilient Technologies Moorepark 2017 Open Day 4/7/17*. Teagasc, pages 198-199

Tuohy, P. and O' Loughlin, J. (2016). Understanding and Improving heavy soils. *Teagasc/Irish Farmers Journal Grazing Guide 2*. p. 79-81

Tuohy, P. (2016). Farming on Challenging Soils-The Teagasc Heavy Soils Programme. *Irish Grassland Association Newsletter*. Issue 33. Autumn 2016 p. 26-29

O' Donoghue, J., Tuohy, P. and McCarron, A. (2016). More Farms Join Teagasc Heavy Soils Programme. *Today's Farm*, May/June 2016, Vol. 27, no. 3, p. 34-36

Tuohy, P., Fenton, O. and O' Loughlin, J. (2016). Land Drainage Guidelines. *Irish Farmers Monthly-Forage & Nutrition Guide 2016*. p. 15-17

Tuohy, P. (2016). Getting the most from land drainage. *PAC News*. Issue 1, Vol. 2. March/April 2016 p. 3

Tuohy, P. and O'Loughlin, J. (2015). Teagasc Heavy Soils Programme. *Moorepark Dairy Levy Research Update Series No. 29*. Teagasc, pages 1 - 40

Tuohy, P. (2015). Drainage unlocks potential of marginal land. *Forager Magazine-Summer 2015* p. 8-9

7. Compiled by: Dr. Pat Tuohy