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Improving the productivity of heavy wet grassland for delivery of Food Harvest 2020

Key external stakeholders: Farmers, policy makers, research scientists, farming community

Practical implications for stakeholders:
Since the abolition of the milk quota much of the increase in milk production has come from existing dairy farms and drainage is key to increasing the productivity of farms on heavy soils in higher rainfall parts of the country with minimal impact on the environment.

- Improved drainage increased herbage production, the length of the grazing season and milk solids production.
- It shortened the housing period and costs of production.
- It had no impact on greenhouse gas emissions from the soil.
- It lowered P losses to water.
- It increased nitrate losses although nitrate concentrations were low and well below the MAC for nitrate in drinking water.
- Installation of a zeolite interceptor has potential to lower nutrient concentrations in drainage water by up to 90%.

Main results:

Improved drainage increased herbage production, livestock carrying capacity, the length of the grazing season and milk solids production. It shortened the housing period and costs of production. Artificial drainage had no impact of Greenhouse Gas (GHG) emissions from the soil and soil C storage. Modelling indicated that, in the long term, artificial drainage can significantly lower nitrous oxide emissions (an important GHG) from the soil mainly due to drier soil conditions and lower rates of denitrification. Artificial drainage lowered total P loss to water by improving infiltration of surface water, which facilitated the capture (sorption) of P in the soil. Improved drainage increased loss of nitrate-N; increasing concentrations to 0.99 mg/L, which is very low relative to the 11.3 mg/L threshold for drinking water. Drainage also increased ammonium-N losses with concentrations of 0.64 mg/L. The installation of a zeolite interceptor has potential to lower the latter concentrations by up to 90% and below maximum admissible concentrations for surface waters.

Opportunity / Benefit:

Artificial drainage is often associated with negative impacts on the environment. The results of the present study show that, along with productivity gains, artificial land drainage can have positive environmental benefits, i.e. lower P losses to water and no change or lower GHG emissions. It can also have negative impacts, i.e. higher nitrate and ammonium losses in drainage water, although nitrate levels following artificial drainage in this study were 0.99 mg/L, which is very low relative to the 11.3 mg/L threshold for drinking water.

Collaborating Institutions:

Johnstown Castle, UCD, TCD.

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1. Project background:

Producing milk from grazed grass is an important part of the Irish Economy. However, grazing on heavy wet soils can be problematical and farms with heavy wet soil have limited productivity and higher costs of production. Historically, Ireland has a low level of artificial drainage compared with other European countries. Approximately 20% of the utilizable agricultural area in Ireland has undergone artificial drainage compared with 65% in England and 74% in the Netherlands. Since the abolition of the milk quota much of the increase in milk production has come from existing dairy farms, many of which are on heavy soils in traditional dairying areas in higher rainfall parts of the country. Achieving higher productivity from farms on heavy wet soils while minimising environmental impact can make an important contribution to realising the targets set out in Food Harvest 2020.

2. Questions addressed by the project:

- The role of artificial drainage in increasing the productivity and profitability of farms on heavy wet soils.
- The risk that facilitating the discharge of water from soils by artificial drainage could increase nutrient losses to aquatic systems.
- The potential of a zeolite interceptor to lower nutrient concentrations in drainage water.
- The risk that drainage could increase greenhouse gases emissions from the soil.
- The national and global implications of improving land drainage to expand dairy production.

3. The experimental studies:

This study used a combination of field measurements at Solohead Research Farm and modelling, including the DNDC Ecosystem Process Model, Dairy System Simulation Model (Dairy_Sim) and Life Cycle Assessment to examine the impact of artificial drainage of grassland on productivity and on environmental impact in the context of improving drainage to facilitate expansion of dairy production on poorly-drained soils.

4. Main results:

Improved drainage increased herbage production by up to 13%, livestock carrying capacity, the length of the grazing season and milk solids production. It shortened the housing period and, hence, costs of production. Artificial drainage lowered total annual P loss to water (by 114 g/ha) by improving infiltration of surface water, which facilitated the capture (sorption) of P in the soil. On the other hand, improved drainage increased loss of nitrate-N; increasing concentrations to 0.99 mg/L, which is very low relative to the 11.3 mg/L threshold for drinking water. Drainage also increased ammonium-N losses with concentrations of 0.64 mg/L. The installation of a zeolite interceptor has potential to lower the latter concentrations by up to 90% and to below maximum admissible concentrations for surface waters. Artificial drainage *per se* had no impact of Greenhouse Gas (GHG) emissions from the soil and soil C storage. Modelling using the DNDC Ecosystem Process Model indicated that, in the long term, artificial drainage can significantly lower nitrous oxide emissions (an important GHG) from the soil mainly due to drier soil conditions being conducive to lower rates of denitrification. On the other hand, the expansion of milk production onto this land is increasing national GHG emissions (associated with dairy herd expansion rather than artificial drainage *per se*). From the perspective of global emissions expansion of dairy production on artificially drained soils in Ireland can have net global environmental benefits due to displacement of less efficient dairy production in other regions of the world. Mitigating emissions associated with expansion of the national dairy herd *per se* is a challenge for policy makers.

5. Opportunity/Benefit:

Drainage can increase herbage production and carrying capacity of dairy cows and, hence, facilitate the expansion of dairy production on heavy wet land. Drainage has the potential to improve water quality by

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lowering P loss to water although it also increases the risk of nitrate losses to water from heavy soils. In general P loss to water from heavy soils is a far bigger problem than nitrate losses from such soils and the nitrate levels recorded were very low in this study. Furthermore artificial drainage can significantly lower nitrous oxide emissions (an important GHG) from the soil in the long term. There are many benefits associated with artificial drainage to increase national dairy output in line with Food Harvest 2020 with little or no impact of artificial drainage *per se* on GHG emissions and nutrient losses to water.

6. Dissemination:

Dissemination was through publication in peer-reviewed scientific journals, conference presentations and proceedings (see below). There were also presentations at National and International workshops, in-service training for advisors, technical seminars, technical articles and the farming press. Dissemination was also via Moorepark Opendays and approximately 50 farm walks held at Solohead Research farm since the beginning of the project.

Main publications:

Valbuena-Parralejo N., Fenton O., Tuohy P., Williams M., Lanigan G.J., Burchill W. and Humphreys J. (2019) Greenhouse gas emissions from temperate permanent grassland on clay-loam soil following the installation of artificial drainage. Agriculture, Ecosystems and Environment, 269, 39-50.

Valbuena-Parralejo N., Fenton O., Tuohy P., Williams M., Lanigan G.J. and Humphreys J. (2019) Phosphorus and nitrogen losses from temperate permanent grassland on clay-loam soil after the installation of artificial mole and gravel mole drainage. Science of the Total Environment, https://doi.org/10.1016/j.scitotenv.2018.12.173.

Sharma P, Humphreys J, Holden N.M. (2018) The environmental impact of dairy production on poorly drained soils under future climate scenarios for Ireland. Journal of Environmental Management, 223, 625-632.

Popular publications:

Humphreys J. and Barrett D. (2017) How much poaching is acceptable? Todays Farm, Jan-Feb, 56-58.

Humphreys J. and Barrett D. (2017) Restricting dairy cow access to pasture and milk production on a heavy wet soil. Mooepark Openday 2017; Irish Dairying – Resilient Technologies, 105-106.

Sharma, P., Humphreys, J., Holden, N.M. (2017). The effect of field drainage on productivity and environmental impact of grass based dairy production systems. Paper presentation in the 10th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2016), 19th to 21st October 2016, Dublin, Ireland.

Sharma, P., Humphreys, J., Holden, N.M (2017). The effect of future climate scenario on carbon footprint of milk produced in Ireland. Oral presentation in the European Meteorological Society (EMS) Annual Meeting, 4th to 8th September 2017, Dublin, Ireland.

Sharma, P., Humphreys, J., Holden, N.M. (2017). Intensification or Extensification? Environmental impacts of Irish dairy farms. Biosystems and Food Engineering Research Review 22, 2017.

Valbuena-Parralejo N., Tuohy P., Fenton O., Williams M., Lanigan G.J., Burchill W. and Humphreys J. (2016) Environmental impact of land drainage. Seminar was given to the Dairy Advisors for the Sustainable Dairy Course. Teagasc, AGRIC, Moorepark, Fermoy, Co. Cork on the 14th June 2016.

Valbuena-Parralejo N., Tuohy P., Fenton O., Williams M., Lanigan G.J., Burchill W. and Humphreys J. (2016) Environmental impact of agriculture subsurface artificial drainage. Presentation at the Moorepark Walsh Fellow student's seminar. Teagasc, AGRIC, Moorepark, Fermoy, Co. Cork on the 20th February 2016.

Sharma, P., Humphreys, J., Holden, N.M. (2016). System simulation and environmental impact assessment to define sustainable management practices for dairy farms on poorly drained land. Poster presented in Greenhouse Gas and Animal Agriculture Conference (GGAA, 2016), Melbourne, Australia.

Sharma, P., Humphreys, J., Holden, N.M. (2016). Sensitivity analysis of eutrophication impact of a typical Irish farm. Biosystems and Food Engineering Research Review 21, 2016.

Sharma, P., Humphreys, J., Holden, N.M. (2016). The effect of field drainage on productivity and environmental impact of grass based dairy production system. Paper presented in the 10th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2016), 19 – 21st October 2016, Dublin, Ireland. UCD, Dublin, Ireland.

Valbuena-Parralejo N., Fenton O., Tuohy P., Williams M., Lanigan G.J., Burchill W. and Humphreys J. (2015) The effect of mole drainage on N2O emissions from a clay-loam soil under grassland. Wageningen International Soils Conference 2015, in Wageningen, The Nederland on the 27th August 2015.

Valbuena-Parralejo N., Fenton O., Tuohy P., Williams M., Lanigan G.J., Burchill W. and Humphreys J. (2015) The effect of mole drainage on background N2O emissions from an unfertilised clay-loam soil'. The Agriculture Research Forum 2015, in Tullamore, Co. Offaly, Ireland. The 9th March 2015.

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Sharma, P., Humphreys, J., Holden, N.M. (2015). The influence of regional climate and soil drainage on global warming potential of Irish dairy farms. (Biosystems and Food Engineering Research Review 20, 2015).

Valbuena-Parralejo N., Tuohy P., Fenton O., Williams M., Lanigan G.J., Burchill W. and Humphreys J. (2014) Environmental impact of agriculture subsurface artificial drainage – materials and methods. Postgraduate symposium of the Botany Department at Trinity Collage Dublin, on the 20th February 2014.

Humphreys J., Phelan P., Tuohy P. and Barrett D. (2013) Farming on wet ground at Solohead, Moorepark 2013 - Irish Dairying - Harvesting the Potential, 119-121.

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