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Phosphorus management on Irish dairy farms post controls introduced under the EU Nitrates Directive

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ABSTRACT

The Republic of Ireland was one of a minority of EU member states to include direct controls on chemical phosphorus (P) fertilisers in its EU Nitrates Directive National Action Plan, first introduced in 2006. This study estimates farm gate phosphorus balances and use efficiencies across 150 specialist dairy farms over the seven year period since these controls were introduced (2006–2012) using nationally representative data. Results indicate that P balances declined by 50% over the study period from 11.9 in 2006 to 6.0 kg ha^{-1} in 2012. This decline was driven by a reduction in chemical fertiliser imports of 6.5 kg ha^{-1}. This is equivalent to a reduction of 281 kg of P and represents a cost saving of €812 per annum across the average farm. Phosphorus use efficiency also improved over the period from 60% in 2006 to 78% in 2012, peaking in 2011 at 88.3%. This was achieved while increasing milk solids output per hectare and per cow. Results of a random effects panel data model indicated that P balance and use efficiency are significantly influenced by factors such as fertiliser prices, stocking rates, land use potential, use of milk recording technology, contact with extension services and rainfall patterns.

1. Introduction

In Ireland, phosphorus (P) is the major limiting element for eutrophication of surface freshwaters (McGarrigle, 2009) while also being a vital element in agricultural production. The sustainable use of phosphorus has gained increased attention not only from an environmental risk perspective but from a long term food security perspective due to finite reserves (Cordell et al., 2011; Huhtanen et al., 2011; Simpson et al., 2011; Amery and Schoumans, 2014). Phosphorus is an essential element for plant growth, however over-use of chemical fertiliser P in agricultural production over time has sometimes lead to the build-up of soil P to excessive levels and losses of P to the aquatic environment with a detrimental effect on water quality (Kronvang et al., 2005). Despite progress it is estimated by the European Environment Agency (2012) that diffuse pollution from agriculture is still significant in more than 40% of Europe's water bodies in rivers and coastal waters, and in one third of the water bodies in lakes and transitional waters. Eutrophication in Irish watercourses emerged as an issue in the 1970s (Flanagan and Toner, 1972). More recently 29% of monitored river channel length was estimated to be polluted to some extent across the Republic of Ireland with agricultural sources suspected in 47% of suboptimal outcomes (Environmental Protection Agency, 2012). Due to the declining global reserves of P, it's now acknowledged that the sustainable use of P based fertilisers has repercussions for food security as well as economic returns to agricultural production (Science Communication Unit, University of the West of England, Bristol, 2013).

Phosphorus can be lost from the soil through a number of pathways namely; erosion and surface runoff, leaching and tile drainage (Amery and Schoumans, 2014). Farm and field level nutrient management is consistently found to be an optimal strategy for P management (Schulte et al., 2009) and is predicated on matching fertiliser P applications to crop demand by maintaining adequate levels of plant-available soil P, thereby minimising excess P available for loss to the environment. This can be achieved voluntarily, where farmers follow appropriate nutrient management advice or through pricing or regulatory instruments (Scott, 2004). Amery and Schoumans (2014) note that, in contrast to nitrates, there is no overarching EU regulation directly governing P applications and losses from agricultural land. Some EU Member States address agricultural P loss through voluntary agri-environment schemes or through national or regional legislation under the auspices of the Nitrates Directive (91/676/EEC), Water Framework Directive (2000/60/IEC) or Industrial Emissions Directive (2010/75/EU). However, other member states (or regions therein) do not have direct P application restrictions outside of indirect controls applicable under the Nitrates Directive (N and P often being managed together, such as in organic fertilisers, so that restrictions on N use will often affect P also).

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The Nitrates Directive (ND) is one of the earliest pieces of EU legislation aimed at water quality improvement. The ND, now under the umbrella of the EU Water Framework Directive, was introduced in 1991 and limits the application of N to agricultural land with a view to reducing the associated nitrogen losses to water bodies. The Republic of Ireland implemented EU Nitrates Directive based regulations ubiquitously on a whole country basis in 2006 and the first National Action Programme (NAP) covered the period from 2006 to 2010. The Republic of Ireland is in a minority of EU countries that included direct controls on P fertiliser use in its National Action Plans 2006–2010 and 2010–2014.

The ND, as implemented in the Republic of Ireland, aims to minimise surplus N and P losses from agriculture to the aquatic environment by restricting use to agronomic optima and constraining applications to periods where mobilisation risk is minimised. Since 2006, the Directive has been implemented in the Republic of Ireland through Statutory Instruments (Government of Ireland, SI 378 of 2006; SI 101 of 2009, SI 610 of 2010; SI 31 of 2014) commonly referred to as the Good Agricultural Practice (GAP) regulations. These gave statutory effect to Ireland's ND National Action Programmes. The GAP regulations mandate a minimum slurry storage requirement for the housing of livestock over the winter period and closed periods for spreading organic and chemical fertilisers during autumn and winter months. The regulations restrict the amount of livestock manure applied to land, together with that deposited by livestock, to 170 kg ha^{-1} of N or up to 250 kg N ha^{-1} where derogation[1] has been granted (Government of Ireland, 2014). Based on national excretion rates applicable in the Republic of Ireland this indirectly limits stocking densities (except where organic manures are exported) to 2 dairy cows ha^{-1} (170 kg organic N) or up to 2.9 dairy cows ha^{-1} (250 kg organic N) in a derogation scenario. Limits on annual P spreading rates are established based on a soil P index system using the measured concentration of available P in soil as determined by the Morgan's P test (Morgan, 1941; Schulte et al., 2010a, 2010b), crop type and P demand (Coulter and Lalor, 2008). Total allowable chemical P fertiliser application limits are, hence based on soil P status and crop demand with reductions for any organic manure P or concentrate animal feed P imported.

Sub-optimal nutrient use at farm and field level has significant potential economic and environmental implications (Oenema and Pietrzak, 2002; Buckley and Carney, 2013). Policymakers are progressively interested in the environmental efficiency of different farming systems and seek indicators of sustainability (Brouwer, 1998; Halberg et al., 2005).

Farm-gate nutrient accounting systems have been offered as a method of evaluating farm level nutrient use efficiency while also providing an indicator of pressure on environmental quality (Schroder et al., 2004; Elsaesser et al., 2015). Such systems account for nutrient inputs onto a farm, mainly through imported fertilisers and feedstuffs, and subtract nutrients exported from the farm through outputs such as milk, meat, cereals, wool and organic manures (Bach and Frede, 1998; Huhtanen et al., 2011; Gaj and Bellaloui, 2012; Gourley et al., 2012). The farm gate approach restricts analysis to imports and exports of nutrients that cross through the farm gate and over which the farmer has direct control. In the case of P, there are very little imports that the farmer does not control. Typically, P imports exceed exports in a dairy farm system (Van Keulen et al., 2000) and the excess results in surplus P that is either accumulated in the soil or lost from the system (Arriaga et al., 2009; De Vries et al., 2013), principally to water.

A total of 5.65 billion litres of milk was produced in the Republic of Ireland in 2013 (Central Statistics Office, 2014a). Post abolition of the EU milk quota regime a 50% increase in milk production by 2020 has been set by policymakers as a national target (Department of Agriculture, Fisheries and Food, 2010). In contrast to most EU countries milk production across the Republic of Ireland is predicated on a grazed grass, low-cost, low-input, seasonal (compact spring calving). This model of milk production seeks to maximise the utilization of grass grown on-farm and minimise the proportion of imported feed (Dillon and Delaby, 2009). In the Republic of Ireland dairy farms tend to have the highest stocking densities, fertiliser and feed inputs of grassland based systems (Hennessy et al., 2013; Buckley et al., 2015) and are therefore perceived as being of some concern in terms of pressure on the environment. Recent studies, based on relatively small numbers of commercial specialised dairy farms, have suggested that farm-gate P balances and use efficiencies on Irish dairy farms have improved in recent years, with potential agronomic and environmental benefits (Mihailescu et al., 2015a, 2015b; Murphy et al., 2015).

This study explores changes in the use of P on specialist dairy farms since the introduction of controls through the EU Nitrates Directive based GAP regulations in 2006. This assessment is based on deriving farm-gate P balance and use efficiency across 150 specialist dairy farms taking part in a national farm survey over a 7 year period (2006–2012). Additionally, this paper uses a panel data model analysis to explore environmental and managerial factors which influence P use over the study period.

2. Methodology

2.1. Data

This analysis is based on data from the Teagasc National Farm Survey (NFS). The Teagasc NFS is collected annually as part of a requirement to supply farm level data to the EU Farm Accountancy Data Network (FADN) requirements (Farm Accountancy Data Network, 2005). A comprehensive set of farm accounts and enterprise level data are recorded on a random representative sample of farms across the Republic of Ireland. This analysis focuses on a balanced panel of 150 specialist dairy farms that remained in this survey over a 7 year period from 2006 to 2012. Average population weights over the period were employed and the sample is hence representative of 8668 dairy farms nationally over the study period. It's estimated that there were approximately 15,654 specialist dairy farmers in the Republic of Ireland in 2012 (Teagasc National Farm Survey, 2013).

Population weights are based on data provided by the Central Statistics Office of Ireland (Teagasc National Farm Survey, 2013). Statistics presented in this analysis are population weighted unless otherwise stated. Farmers who indicated importing or exporting organic manures were excluded from the analysis as no data were available on the quantities of manures imported or exported. In line with results from Hennessy et al. (2011) a total of 5% of the potential sample were excluded from the analysis due to import/export of organic manures. Additionally, data on whether farmers were importing or exporting organic manures was only available from 2008 to 2012 on a self-reported basis, hence if a farmer was not importing/exporting over these 5 years then it was assumed this held for 2006 and 2007.

A specialist dairy farm is defined as a system where a minimum of two-thirds of farm standard output is derived from grazing livestock and dairy cows are responsible for a minimum of three-quarters of the grazing livestock output. Standard output is an economic based measure where values are assigned to each animal and crop output on the farm and only farms above a threshold of €8000 or more (the equivalent of 6 dairy cows) are eligible for inclusion in the survey. Although labelled specialist dairy farms, these farms tend to have other farm enterprises also. Farm gate balances derived here are for the whole-farm and not just exclusively for the dairy enterprise. Hence, some of the nutrient imports and exports included in the balances will be associated with other non-dairy on-farm enterprises such as livestock rearing or arable crops grown for sale.

[1] This derogation was secured due to length of growing season in the Republic of Ireland. A total of 6323 farmers secured derogation in 2014, 88% were dairy farmers (Nolan, 2015).