

An environmental and economic assessment on the impact of possible reductions in the maximum chemical nitrogen allowances for all grassland stocking rates

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Glossary of Terms

CO ₂	Carbon Dioxide
DM	Dry Matter
FPCM	Fat and protein corrected milk yield
GLEAM	Global Livestock Environmental Assessment Model
MoSt ¹	Moorepark St Gilles Grass Growth Model
N	Nitrogen
P	Phosphorus
PBHDM ²	Pasture Based Herd Dynamic Milk Model
SI	Statutory Instrument

¹MoSt: the Moorepark St Gilles grass growth model is a model developed in C++ in Teagasc Moorepark in conjunction with INRAE St Gilles. The model works on a daily time step and predicts mainly; grass growth, grass N content and N leaching depending on; weather condition, grass management and N application.

²PBHDM: The pasture-based herd dynamic milk model is a dynamic, stochastic agent-based model developed in C++ in Teagasc Moorepark in conjunction with INRAE St Gilles. The model works on a daily time step, comprises of a herd dynamic milk model, and integrates it with a grazing management and a paddock sub-model.

Executive Summary

1. Nationally, chemical nitrogen (N) use has declined by 24%, from 408,495 tonnes in 2018 to 310,411 tonnes in 2024. While this is welcome from an environmental N emissions mitigation perspective, the model simulations in this report suggest that Irish farms have reached a critical point where dairy production systems are entering into forage supply deficits and are becoming less feed self-sufficient.
2. At an organic N stocking rate of 170 kg N/ha (1.85 cows/ha), reducing the maximum chemical N allowance from 206 kg N/ha (SI No 605 of 2017) to 185 kg N/ha (SI No 113 of 2022 and SI No 42 of 2025) reduced farm forage balance by 284 kg dry matter (DM)/ha and reduced N leached to 1 meter by 0.8 kg N/ha. Farm forage balance remained positive at 887 kg DM/ha; however, this positive balance is required to counteract year to year variability in grass dry matter production ensuring system resilience to adverse weather events.
3. At an organic N stocking rate of 210 kg N/ha (2.28 cows/ha), reducing the maximum chemical N allowance from 282 kg N/ha (SI No 605 of 2017) to 241 kg N/ha (SI No 42 of 2025) reduced farm forage balance by 416 kg dry matter (DM)/ha and reduced N leached to 1 meter by 3 kg N/ha. Farm forage balance remained positive at 590 kg DM/ha; however, this positive balance is required to counteract year to year variability in grass dry matter production ensuring system resilience to adverse weather events.
4. At an organic N stocking rate of 220 kg N/ha (2.39 cows/ha), reducing the maximum chemical N allowance from 250 kg N/ha (SI No 605 of 2017) to 214 kg N/ha (SI No 42 of 2025) reduced farm forage balance by 448 kg DM/ha and reduced N leached to 1 meter by 2.6 kg N/ha. Farm forage balance was negative at -198 kg DM/ha.
5. At an organic N stocking rate of 250 kg N/ha (2.72 cows/ha), reducing the maximum chemical N allowance from 250 kg N/ha (SI No 605 of 2017) to 214 kg N/ha (SI No 42 of 2025) reduced farm forage balance by 415 kg DM/ha and reduced N leached to 1 meter by 2.7 kg N/ha. Farm forage balance was negative at -1,317 kg DM/ha.
6. A further reduction of either 5% or 10 % in the maximum chemical N allowances would result in significant forage deficits at organic N stocking rates of 220 kg N/ha or above with only modest reduction in N leached to 1 meter. These reductions in on-farm feed production and declining feed self-sufficiency are likely to result in greater reliance on imported purchased feeds. This shift will lead to the unintended consequence of increased feed N and phosphorus imports onto farms, shorter grazing seasons and increased likelihood of a forage crisis at times of reduced grass production.
7. At an organic N stocking rate of 220 kg N/ha (2.39 cows/ha), reducing the maximum chemical N allowance from 250 kg N/ha (SI No 605 of 2017) to 214 kg N/ha (SI No 42 of 2025) resulted in a reduction in the cost of chemical N application of €43/ha, an increase in feed costs of €194/ha and a reduction in farm profitability of €151/ha. A

further reduction of either 5% or 10 % in the maximum chemical N allowances would exacerbate these reductions in farm profitability. The analysis also demonstrated that for every 1 kg reduction in chemical N/ha, farm profitability reduced on average by €4.14/ha due to the requirement to replace forage not grown with purchased feeds.

8. The inclusion of white clover into perennial ryegrass swards offers a promising mitigation strategy against declining pasture production and forage deficits as chemical N application limits are reduced. Research has shown that well-managed perennial ryegrass white clover pastures (20 - 25 % white clover on average over the whole season) receiving 100 -150 kg/ha of chemical nitrogen (primarily applied in spring) can produce similar herbage yields to perennial ryegrass only pasture receiving 200 - 250 kg/ha of chemical nitrogen (Mayne, 2025). However, consistent and reliable establishment and persistence of perennial ryegrass–white clover swards remain a challenge on many farms. Increasing the proportion of white clover on commercial farms is essential before any further reductions in chemical N allowances can be implemented in a sustainable manner.
9. It is also vital that other technologies such as improved soil fertility and more efficient use organic manures are used to reduce the requirement of chemical nitrogen. Increase in soil pH has been shown to increase nitrogen use efficiency and increase soil P availability for plant uptake. Additionally, the use efficiency of organic manures can be increased by using low emission slurry spreading technology in combination with optimum timing and application rate plus the targeted nutrient distribution across the whole farm.
10. Implementing the ‘adapted silage production allowance’ for farms operating below 85 kg organic N/ha, these farms can contribute an additional 540 kg of DM/ha back into the national forage inventory improving national feed security with minimal environmental impact.

1. Background

The Department of Agriculture, Food and the Marine requested Teagasc to conduct ‘An environmental and economic assessment on the impact of possible reductions in the maximum chemical nitrogen (N) allowances for all grassland stocking rates as well as the main arable crops’. This report looks at the impact on all grassland stocking rates.

The purpose of this request was to inform policy and to support the Nitrates Action Programme. The Base Scenario used was the annual maximum fertilisation rates of N on grassland as outlined by Statutory Instrument No. 605 of 2017. This was compared to:

1. Statutory Instrument No. 113 of 2022 annual maximum fertilisation rates of N on grassland
2. Statutory Instrument No. 42 of 2025 annual maximum fertilisation rates of N on grassland
3. A further 5% reduction in the annual maximum fertilisation rates of N on grassland relative to the maximum chemical N application allowances in Statutory Instrument No. 42 of 2025
4. A further 10% reduction in the annual maximum fertilisation rates of N on grassland relative to the maximum chemical N application allowances in Statutory Instrument No. 42 of 2025

Additionally, the impact of annual maximum fertilisation rates of N on grassland for stocking rates of less than 85 kg of organic N/ha was investigated.

2. Introduction

The global population is projected to peak at nearly 10.3 billion by 2084 (UN, 2024). This population growth, combined with rising standards of living, is driving a dramatic increase in global demand for animal-sourced products (Alexandratos & Bruinsma, 2012). Additionally, recent global disruptions, such as the COVID-19 pandemic, geopolitical uncertainties (e.g., the war in Ukraine and potential trade tariffs) and shifting weather patterns have underscored the urgent need for European food sovereignty. These crucial requirements are reflected in the latest European Commission’s ‘Vision for Agriculture and Food’ (E.C. 2025a). Some of the key objectives outlined in the Vision are to enable;

1. *An attractive and predictable agri-food sector where incomes enable farmers to thrive, attracting future generations that will continue producing food that is affordable for everyone and meets consumer demand*
2. *An agri-food sector that is competitive and resilient in the face of rising global competition and shocks*
3. *A future proof agri-food sector that is functioning within planetary boundaries, where farming and the food sector contribute together to the EU’s climate objectives, while preserving healthy soils, clean water and air, and protecting and restoring Europe’s biodiversity*

The Vision also underscores the pivotal role of Europe in ensuring food production, supporting farm incomes and maintaining the viability of rural communities. It emphasises the importance of the family farm model and the need to support its long-term viability.

Europe currently faces a unique opportunity to be a leader in the production of highly nutritious food. However, this comes with the significant challenge of achieving it in an

environmentally benign manner, that is, increasing total food production while minimising the agricultural sector's overall environmental impact (Godfray et al., 2010; Schulte et al., 2014). The most recent published carbon footprint of Irish milk demonstrates that the average carbon footprint of Irish milk is 0.97 kg CO₂e/kg of fat and protein-corrected milk yield, one of the lowest in the world (Herron et al., 2022). The diet of pasture-based cows can also comprise almost completely of human inedible ingredients resulting in a large to infinite return on human edible resources (Dijkstra et al., 2013; Laisse et al., 2018; Hennessy et al., 2021). High pasture inclusion levels in cow diets can support a resilient business model for the producer and an animal welfare friendly image (Dillon et al., 2008; van Vuuren and Chilibruste, 2013). Additionally, pasture-based systems often feature a high degree of feed circularity, with animals returning the majority of their manure directly to the land where their feed is produced. This process enhances soil health and increases soil organic matter. Such circular systems also support a high degree of feed self-sufficiency, reducing their dependence on purchased/imported feeds. Protecting and promoting such sustainable food production systems is essential.

In Ireland, there is a requirement to reduce nutrient loss to water. During 2024, there was a welcome 10% national reduction in river nitrate concentrations, with reductions observed in all regions (EPA, 2025). However, nitrate concentrations in the southeast, midlands and eastern regions remain too high. It is critical that we identify the pathways through which nutrients are lost and implement effective measures to minimise these losses. Teagasc's 'Better Farming for Water: 8 Actions for Change' initiative outlines strategies in three key areas: nutrient management, farmyard management and land management. A targeted focus on each of these areas will be crucial in reducing nutrient losses. Reducing chemical N application levels can contribute towards reduced nitrate leaching. Since 2018, chemical N usage in Ireland has reduced by 24%, from 408,495 tonnes in 2018 to 310,411 tonnes in 2024. However, it is essential that a scientific, quantitative and methodical approach is pursued to sustainably reduce chemical N application levels while minimising pollution swapping and unintended consequences such as increased supplementary feed N and phosphorus (P) imports onto the farm.

3. Modelling Approach, Scenarios Investigated and Economic Analysis

3.1. MoSt GG–PBHDM Model Description

The Moorepark St Gilles Grass Growth (MoSt GG) model (Ruelle et al., 2018) in combination with the Pasture Based Herd Dynamic Milk (PBHDM) model (Ruelle et al., 2015) were used to conduct the current investigation. Both models have been described in detail by Shalloo et al. (2023). Briefly, MoSt GG is a dynamic model developed in C++ describing the grass growth and the N and water fluxes of a paddock. The model is run with a daily time step simulating soil N mineralisation, immobilisation and water balance, grass growth, N uptake, N leaching and grass N content. The PBHDM model comprises of the herd dynamic milk model and integrates it with a grazing management and a paddock sub-model. Animal intake at grazing is dependent not only on the animal characteristics but also on grass availability and quality. It also depends on the interactions between the animal and the grass during the defoliation process. Management of grass on farm can be regulated through different rules during the

grazing season including the decision to cut some paddocks in the case of a grass surplus and to allocate supplementation in the case of a grass deficit.

3.2. Core Model Inputs and Assumptions

For all simulations, the MoSt GG model used weather data recorded in the Met Eireann weather station located at Moorepark (52°09'52.3"N 8°15'36.6"W) over a 20 year period (2005-2024). Each of the simulations were completed on a daily time step for those 20 years consecutively meaning that weather or management happening in one year could have consequences (for example N still available for leaching) in the subsequent year. A sandy loam (6% OM, 60% sand and 15% of clay soil to a depth of 100 cm) soil type was selected for the simulations. This is the most at risk soil type to N leaching which is representative of between 4 – 10% of the soils in Ireland (McCarthy et al., 2015).

The PBHDM model simulated good practices in terms of grassland, dairy cow nutrition and slurry management. Concentrate was fed at 480 kg of DM/cow/lactation irrespective of the amount of grass on the farm. Indoors lactating cows were fed grass silage ad libitum (quality 1.1 FV, 0.78 UFL, 75 PDI), while dry cows were allocated 80% of ad libitum intake of a lactating cow to meet energy requirements for maintenance, pregnancy and body condition score change (circa 10 kg silage DM/cow/day). If silage produced on the farm was in deficit relative to herd feed requirements, it was purchased from an external source. During the grazing season, cows were housed when the soil saturation level was over 90%. Grazing management was dictated by both pre- and post-grazing height, while farm grass cover was evaluated daily and was compared with herd requirement.

The PBHDM simulated the number of days at grazing, the number of days at grazing without supplementation, grass intake (kg/cow and kg/ha), silage intake (while cows are grazing, while lactating cows are indoors due to soil saturation and while cows are dry and indoors; kg DM/cow and kg DM/ha), milk, protein and fat produced (kg/cow and per ha), the amount of silage produced (kg/ha) and yearly surplus or deficit of silage (kg/ha). These outputs, as well as grass growth and N leaching from the MoSt GG model, were simulated per day and were then collated over the full period and reported for each of the scenarios outlined below. To compensate for a known limitation of the model which tends to overestimate leaching, the N leaching presented in this report is the leaching due to farming activity namely; cow urine and faeces, slurry application and chemical N application. N leaching due to soil background mineralisation has been discarded.

3.3. Scenarios Simulated

The impacts of progressively reduced maximum chemical N application allowances (described below) were investigated for the organic N stocking rates of 170, 210, 220 and 250 kg N/ha. The cow used within the simulations represented a national average cow (Band 2) with an organic N excretion rate of 92 kg/cow/year. For the adapted silage allowance (described below), an example situation was simulated where 25% of the farm was selected for silage production.

3.3.1. Base Scenario - Statutory Instrument No. 605 of 2017

The maximum chemical N application allowances as specified by the Statutory Instrument No. 605 of 2017 and the application strategy assumed in the modelling scenario are presented in Table 1.

Table 1. Total chemical N application allowances (kg/ha) as specified by the Statutory Instrument No. 605 of 2017 and application strategy assumed in the modelling scenario			
Organic N (kg/ha)	131-170	171-210	>210
Total chemical N applied	206	282	250
February	20.9	28.6	28.7
March	36.4	49.8	43.9
April	36.4	49.8	59.3
May	37.7	51.6	34.1
June	24.9	34.1	34.1
July	-	-	-
August	24.9	34.1	34.1
September	24.9	34.1	25.1

3.3.2. Statutory Instrument No. 113 of 2022

The reduction in maximum chemical N application allowances as specified by the Statutory Instrument No. 113 of 2022 and the application strategy assumed in the modelling scenario are presented in Table 2.

Table 2. Total chemical N application allowances (kg/ha) as specified by the Statutory Instrument No. 113 of 2022 and application strategy assumed in the modelling scenario			
Organic N (kg/ha)	131-170	171-210	>210
Total chemical N applied	185	254	225
February	18.7	25.7	25.8
March	32.6	44.8	39.5
April	32.6	44.8	44.4
May	33.9	46.5	30.6
June	22.4	30.7	30.6
July	-	-	-
August	22.4	30.7	30.6
September	22.4	30.7	22.6

3.3.3. Statutory Instrument No. 42 of 2025

The reduction in maximum chemical N application allowances as specified by the Statutory Instrument No. 42 of 2025 and the application strategy assumed in the modelling scenario are presented in Table 3.

Table 3. Total chemical N application allowances (kg/ha) as specified by the Statutory Instrument No. 42 of 2025 and application strategy assumed in the modelling scenario			
Organic N (kg/ha)	131-170	171-210	>210
Total chemical N applied	185	241	214
February	18.7	24.4	24.5
March	32.6	42.5	37.6
April	32.6	42.5	42.2
May	33.9	44.1	29.1
June	22.4	29.1	29.1
July	-	-	-
August	22.4	29.1	29.1
September	22.4	29.1	21.5

3.3.4. Possible Further 5% and 10% Reductions in the Maximum Chemical Nitrogen Allowances

Possible scenarios of a further 5% and 10% reduction in maximum chemical N application allowances, relative to the maximum chemical N application allowances in Statutory Instrument No. 42 of 2025, and the application strategy assumed in the modelling scenarios are presented in Table 4 and 5.

Table 4. Total chemical N application allowances (kg/ha) under a possible further 5% reduction and application strategy assumed in the modelling scenario		
Organic N (kg/ha)	171-210	>210
Total chemical N applied	229	203
February	23.2	23.3
March	40.4	35.7
April	40.4	40.0
May	41.9	27.6
June	27.7	27.6
July	-	-
August	27.7	27.6
September	27.7	20.4

Table 5. Total chemical N application allowances (kg/ha) under a possible further 10% reduction and application strategy assumed in the modelling scenario

Organic N (kg/ha)	171-210	>210
Total chemical N applied	217	193
February	22.0	22.1
March	38.3	33.9
April	38.3	38.0
May	39.7	26.3
June	26.2	26.3
July	-	-
August	26.2	26.3
September	26.2	19.4



3.3.5. Statutory Instrument No. 42 of 2025 < 85 kg Organic N/ha Maximum Chemical N Application Allowance and Proposed Adapted Silage Production Allowance

Within Statutory Instrument No. 113 of 2022, the organic N stocking rate of < 85 kg of N/ha had a maximum chemical N application allowance of 114 kg of chemical N/ha. Within Statutory Instrument No. 42 of 2025, this allowance was reduced to 90 kg of chemical N/ha. While 90 kg of chemical N/ha should be adequate to sustain the grassland stocking rate of < 85 kg of organic N/ha, the farms operating within these stocking rates have reduced ability to produce surplus silage for sale. This surplus silage inventory is crucial to ensure national fodder security in times of adverse weather events (e.g. summer 2018 and spring 2024). Therefore, a possible adapted silage allowance scenario was simulated for the organic N stocking rate of < 85 kg of N/ha. Within the adapted silage production allowance scenario, farmers would dedicate an area of their farm for silage production. Farmers would then receive a greater maximum chemical N application allowance on this farm area (i.e. 185 kg of chemical N/ha) relative to the remaining area which would remain at a maximum chemical N application allowance of 90 kg of chemical N/ha. The application strategy of 185 kg of

chemical N/ha was assumed to be 85 kg N/ha in April (first-cut), 70 kg N/ha in June (second-cut) and 30 kg N/ha in August (third-cut).

Table 6. Total chemical N application allowances (kg/ha) for the organic N stocking rate of < 85 kg of N/ha as specified by the Statutory Instrument No. 113 of 2022, Statutory Instrument No. 42 of 2025 and possible adapted silage allowance scenario, as well as the application strategy assumed in the modelling scenario

	S.I. No. 113 of 2022	S.I. No. 42 of 2025	Adapted Silage Production Allowance	
	Whole farm	Whole farm	Grazing area	Silage sale area
Land area				
Total chemical N applied	114	90	90	185
January	-	-	-	-
February	-	-	-	-
March	29.0	22.7	22.7	-
April	36.0	28.4	28.4	85.0
May	26.0	20.3	20.3	-
June	-	-	-	70.0
July	23.0	18.6	18.6	-
August	-	-	-	30.0
September	-	-	-	-

3.4. Economic Analysis

A simple analysis was completed to quantify the economic impact of progressively reducing the maximum chemical N application allowances on grassland. The analysis was based on the assumptions that pasture utilisation was 80% and that of the forage not grown 70% would have been utilised as grazed grass and 30% would have been utilised as grass silage. It was assumed that the UFL values of grazed grass and grass silage were 1.02 UFL/kg DM and 0.80 UFL/kg DM, respectively. The analysis also assumed that there was a requirement to replace the forage not grown with purchased concentrate and that the cost of concentrate was €350/tonne. The cost savings associated with reduced chemical N were also included, with the cost of chemical N assumed to be €1.20/kg (i.e. €560/tonne of protected-urea).

4. Results of the Modelled Scenarios

4.1. Impact of Statutory Instrument No. 113 of 2022

At an organic N stocking rate of 170 kg N/ha (1.85 cows/ha), reducing the maximum chemical N allowance from 206 kg N/ha (2017) to 185 kg N/ha (2022 and 2025) resulted in a 4.1% decrease in modelled N leaching at a 1-meter depth (from 19.7 to 18.9 kg N/ha; Table 7). This reduction in maximum chemical N allowance also led to a 3.0% decline in modelled grass growth (12,874 vs. 12,491 kg DM/ha) and a decline in forage balance (from 1,171 to 887 kg DM/ha).

At an organic N stocking rate of 210 kg N/ha (2.28 cows/ha), reducing the maximum chemical N allowance from 282 kg N/ha (2017) to 254 kg N/ha (2022) resulted in a 6.9% decrease in modelled N leaching at a 1-meter depth (from 30.6 to 28.5 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 3.1% decline in modelled grass growth (14,180 vs. 13,735 kg DM/ha) and a decline in forage balance (from 1,006 to 745 kg DM/ha).

At an organic N stocking rate of 220 kg N/ha (2.39 cows/ha), reducing the maximum chemical N allowance from 250 kg N/ha (2017) to 225 kg N/ha (2022) resulted in a 6.5% decrease in modelled N leaching at a 1-meter depth (from 29.4 to 27.5 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 2.9% decline in modelled grass growth (13,708 vs. 13,304 kg DM/ha) and a decline in forage balance (from 250 to -46 kg DM/ha), with the forage balance becoming negative.

At an organic N stocking rate of 250 kg N/ha (2.72 cows/ha), reducing the maximum chemical N allowance from 250 kg N/ha (2017) to 225 kg N/ha (2022) resulted in a 6.1% decrease in modelled N leaching at a 1-meter depth (from 31.4 to 29.5 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 2.9% decline in modelled grass growth (13,883 vs. 13,480 kg DM/ha) and a decline in forage balance (from -902 to -1,177 kg DM/ha), exacerbating the forage deficit.

4.2. Impact of Statutory Instrument No. 42 of 2025

At an organic N stocking rate of 210 kg N/ha (2.28 cows/ha), reducing the maximum chemical N allowance from 254 kg N/ha (2022) to 241 kg N/ha (2025) resulted in a 3.2% decrease in modelled N leaching at a 1-meter depth (from 28.5 to 27.6 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 1.6% decline in modelled grass growth (13,735 vs. 13,522 kg DM/ha) and a decline in forage balance (from 745 to 590 kg DM/ha).

At an organic N stocking rate of 220 kg N/ha (2.39 cows/ha), reducing the maximum chemical N allowance from 225 kg N/ha (2022) to 214 kg N/ha (2025) resulted in a 2.5% decrease in modelled N leaching at a 1-meter depth (from 27.5 to 26.8 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 1.6% decline in modelled grass growth (13,304 vs. 13,092 kg DM/ha) and a decline in forage balance (-46 to -198 kg DM/ha), exacerbating the forage deficit.

At an organic N stocking rate of 250 kg N/ha (2.72 cows/ha), reducing the maximum chemical N allowance from 225 kg N/ha (2022) to 214 kg N/ha (2025) resulted in a 2.7% decrease in modelled N leaching at a 1-meter depth (from 29.5 to 28.7 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 1.5% decline in modelled grass growth (13,480 vs. 13,278 kg DM/ha) and a decline in forage balance (from -1,177 to -1,317 kg DM/ha), exacerbating the forage deficit.

4.3. Impact of Possible Further 5% and 10% Reductions in the Maximum Chemical Nitrogen Allowances

4.3.1. Further 5% Reduction

Further reducing by 5% the maximum chemical N allowance for the 210 kg organic N/ha (2.28 cows/ha) stocking rate from 241 kg N/ha (2025) to 229 kg N/ha (-5%) resulted in a 3.3% decrease in modelled N leaching at a 1-meter depth (from 27.6 to 26.7 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 1.5% decline in modelled grass growth (13,522 vs. 13,324 kg DM/ha) and a decline in forage balance (from 590 to 450 kg DM/ha).

Further reducing by 5% the maximum chemical N allowance for the 220 kg organic N/ha (2.39 cows/ha) stocking rate from 214 kg N/ha (2025) to 203 kg N/ha (-5%) resulted in a 2.6% decrease in modelled N leaching at a 1-meter depth (from 26.8 to 26.1 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 1.5% decline in modelled grass growth (13,092 vs. 12,892 kg DM/ha) and a decline in forage balance (-198 to -323 kg DM/ha), exacerbating the forage deficit.

Further reducing by 5% the maximum chemical N allowance for the 250 kg organic N/ha (2.72 cows/ha) stocking rate from 214 kg N/ha (2025) to 203 kg N/ha (-5%) resulted in a 2.4% decrease in modelled N leaching at a 1-meter depth (from 28.7 to 28.0 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 1.4% decline in modelled grass growth (13,278 vs. 13,094 kg DM/ha) and a decline in forage balance (from -1,317 to -1,456 kg DM/ha), exacerbating the forage deficit.

4.3.2. Further 10% Reduction

Further reducing by 10% the maximum chemical N allowance for the 210 kg organic N/ha (2.28 cows/ha) stocking rate from 241 kg N/ha (2025) to 217 kg N/ha (-10%) resulted in a 5.4% decrease in modelled N leaching at a 1-meter depth (from 27.6 to 26.1 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 3.0% decline in modelled grass growth (13,522 vs. 13,117 kg DM/ha) and a decline in forage balance (from 590 to 301 kg DM/ha).

Further reducing by 10% the maximum chemical N allowance for the 220 kg organic N/ha (2.39 cows/ha) stocking rate from 214 kg N/ha (2025) to 193 kg N/ha (-10%) resulted in a 5.2% decrease in modelled N leaching at a 1-meter depth (from 26.8 to 25.4 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 2.8% decline in modelled grass growth (13,092 vs. 12,725 kg DM/ha) and a decline in forage balance (-198 to -449 kg DM/ha), exacerbating the forage deficit.

Further reducing by 10% the maximum chemical N allowance for the 250 kg organic N/ha (2.72 cows/ha) stocking rate from 214 kg N/ha (2025) to 193 kg N/ha (-10%) resulted in a 4.9% decrease in modelled N leaching at a 1-meter depth (from 28.7 to 27.3 kg N/ha; Table 8). This reduction in maximum chemical N allowance also led to a 2.7% decline in modelled grass growth (13,278 vs. 12,916 kg DM/ha) and a decline in forage balance (from -1,456 to -1,587 kg DM/ha), exacerbating the forage deficit.

Table 7. Impact of maximum chemical nitrogen allowance on grass growth, forage balance and nitrogen leaching to 1 meter depth from pasture grazed by dairy cows, at a stocking rate of 170 kg of organic N per hectare on a free draining soil

Scenario ¹	Organic N (kg/ha)	Chemical N (kg/ha)	Grass Growth (kg DM/ha)	Grass Intake (kg DM/cow)	Silage Intake (kg DM/cow)	Con. Intake (kg DM/cow)	Milk Solids (kg/cow)	Forage Balance (kg DM/ha)	N leaching (1 m; kg/ha)
2017	170	206	12,874	3,438	1,339	480	459	1,171	19.7
2022 and 2025	170	185	12,491	3,438	1,340	480	459	887	18.9

¹2017 = Statutory Instrument No. 605 of 2017; 2022 = Statutory Instrument No. 113 of 2022; 2025 = Statutory Instrument No. 42 of 2025.



Table 8. Impact of maximum chemical nitrogen allowance on grass growth, forage balance and nitrogen leaching to 1 meter depth from pasture grazed by dairy cows, at a stocking rate of 210, 220 and 250 kg of organic N per hectare on a free draining soil

Scenario ¹	Organic N (kg/ha)	Chemical N (kg/ha)	Grass Growth (kg DM/ha)	Grass Intake (kg DM/cow)	Silage Intake (kg DM/cow)	Con. Intake (kg DM/cow)	Milk Solids (kg/cow)	Forage Balance (kg DM/ha)	N leaching (1 m; kg/ha)
2017	210	282	14,180	3,497	1,272	480	460	1,006	30.6
2022	210	254	13,735	3,483	1,286	480	459	745	28.5
2025	210	241	13,522	3,467	1,302	480	459	590	27.6
-5%	210	229	13,324	3,428	1,334	480	458	450	26.7
-10%	210	217	13,117	3,437	1,329	480	459	301	26.1
2017	220	250	13,708	3,456	1,307	480	459	250	29.4
2022	220	225	13,304	3,412	1,349	480	458	-46	27.5
2025	220	214	13,092	3,402	1,359	480	458	-198	26.8
-5%	220	203	12,892	3,404	1,355	480	459	-323	26.1
-10%	220	193	12,725	3,395	1,366	480	458	-449	25.4
2017	250	250	13,883	3,390	1,373	480	458	-902	31.4
2022	250	225	13,480	3,358	1,397	480	457	-1,177	29.5
2025	250	214	13,278	3,358	1,398	480	457	-1,317	28.7
-5%	250	203	13,094	3,354	1,405	480	458	-1,456	28.0
-10%	250	193	12,916	3,333	1,425	480	457	-1,587	27.3

¹2017 = Statutory Instrument No. 605 of 2017; 2022 = Statutory Instrument No. 113 of 2022; 2025 = Statutory Instrument No. 42 of 2025; -5% = possible further 5% reduction in the maximum chemical nitrogen allowances; -10% = possible further 10% reduction in the maximum chemical nitrogen allowances.

4.4. Impact of Statutory Instrument No. 42 of 2025 on the < 85 kg Organic N/ha Stocking rate and Proposed Adapted Silage Production Allowance

Reducing the maximum chemical N allowance for the < 85 kg organic N/ha stocking rate from 114 kg N/ha (2022) to 90 kg N/ha (2025) led to a 5.5% decline in modelled grass growth (9,136 vs. 8,630 kg DM/ha; Table 9). For farms operating at < 85 kg organic N/ha, a decline in forage balance may not be particularly impactful; however, the decline in cumulative annual dry matter production is a concern from a national forage security perspective.

By implementing the ‘adapted silage production allowance’ for the < 85 kg organic N/ha stocking rate, it resulted in a slight increase of 0.4% in modelled grass growth when compared with maximum chemical N allowance of 114 kg N/ha (2022; 9,170 vs. 9,136 kg DM/ha, respectively; Table 9). When compared with the maximum chemical N allowance of 90 kg N/ha (2025), the adaptation increased forage production by an additional 540 kg of DM/ha, which could contribute to the national forage inventory. Reducing the maximum chemical N allowance for the < 85 kg organic N/ha stocking rate from 114 kg N/ha (2022) to 90 kg N/ha (2025) led to a reduction in N leached to 1 meter by 0.7 kg N/ha. Increasing the maximum chemical N allowance for the < 85 kg organic N/ha stocking rate from 90 kg N/ha (2025) to 114 kg N/ha (adaptive silage production) led to a reduction in N leached to 1 meter by 0.3 kg N/ha compared 114 kg N/ha (2022).

Table 9. Impact of maximum chemical nitrogen allowance on grass growth from pasture grazed by livestock at a stocking rate of < 85 kg of organic N per hectare or at < 85 kg of organic N per hectare with an area of the farm dedicated to silage production

Scenario ¹	Organic N (kg/ha)	Chemical N (kg/ha)	Grass Growth (kg DM/ha)
2022	< 85	114	9,136
2025	< 85	90	8,630
Adapted silage production	< 85	114	9,170

¹2022 = Statutory Instrument No. 113 of 2022; 2025 = Statutory Instrument No. 42 of 2025; Adapted silage production = farmers would dedicate an area of the farm for silage production

4.5. Economic Impact of Reducing the Maximum Chemical N Allowances

The economic impact of reducing the maximum chemical N allowances for farms operating at 220 kg organic N/ha are shown in Table 10. Based on the analysis completed in this report, every 1 kg reduction of chemical N resulted in a grass growth reduction on average of 17 kg of DM/ha. While this reduction in chemical N application had associated savings of €30 to €68/ha, there was a €127 to €309/ha cost to replace the reduced grass growth. This ultimately led to a reduced farm profitability of €97 to €241/ha.

Table 10. The economic impact of reducing the maximum chemical N allowance, relative to the maximum chemical N application allowances in Statutory Instrument No. 605 of 2017, for farms operating at 220 kg organic N/ha

Scenario ¹	Chemical N (kg/ha)	Reduced Chemical N (kg/ha)	Chemical N savings (€)	Grass Growth (kg DM/ha)	Reduced Grass Growth (kg DM/ha)	Cost to replace grass growth (€)	Total cost (€)
2017	250	-	-	13,708	-	-	-
2022	225	25	30.0	13,304	404	127.1	97.1
2025	214	36	43.2	13,092	616	193.8	150.6
-5%	203	47	56.4	12,892	816	256.7	200.3
-10%	193	57	68.4	12,725	983	309.3	240.9

¹2017 = Statutory Instrument No. 605 of 2017; 2022 = Statutory Instrument No. 113 of 2022; 2025 = Statutory Instrument No. 42 of 2025; -5% = possible further 5% reduction in the maximum chemical nitrogen allowances; -10% = possible further 10% reduction in the maximum chemical nitrogen allowances.

5. Discussion

In the most recent Eurobarometer survey (E.C. 2025b), an overwhelming majority of respondents replied that securing a stable supply of food in the EU at all times (94% of respondents), ensuring reasonable food prices for consumers (92% of respondents), ensuring sustainable management of natural resources (91% of respondents), and strengthening the farmer's role in the food chain (90% of respondents) are important. This reflects a growing and unprecedented public awareness of, and support for, agriculture and farmers across the EU. It is therefore essential that policy framework enables a sustainable increase in food production to meet rising global demands, while also preventing pollution swapping and minimising unintended environmental and social impacts.

In recent years, Irish agricultural policy has progressively reduced the maximum chemical N application allowances on grasslands in order to reduce environmental N emissions. During this period, the National Fertiliser Database was also enacted and implemented. For farms operating within the 171-210 kg of organic N/ha stocking rate, the maximum chemical N application allowances have reduced from 282 kg of N/ha in 2017 to 241 kg of N/ha in 2025, representing a 14.5% reduction. Our model simulations suggest that these policy changes have contributed to a 10% reduction in N leaching at 1 metre depth, from 30.6 to 27.6 kg N/ha. While this environmental improvement is welcome, it has been accompanied by a decline in grass production, with grass DM production falling by 658 kg DM/ha. This reduction poses challenges for feed security and the self-sufficiency of dairy production systems.

Nationally, chemical N use has declined by 24%, from 408,495 tonnes in 2018 to 310,411 tonnes in 2024. Again, while this is welcome from an environmental N emissions mitigation perspective, our model simulations suggest that Irish farms have reached a critical point where dairy production systems are entering into forage supply deficits and are becoming less feed self-sufficient. It is important to note that these model outcomes are based on 20-year averages, which may mask the severity of forage deficits in specific years, such as 2018, when particularly large forage shortfalls occurred. The downward trend in feed availability observed in the simulations is also evident in national data recorded by PastureBase Ireland

(Figure 1). Further reductions in the maximum chemical N application allowances for grassland will push more dairy systems deeper into forage deficits.

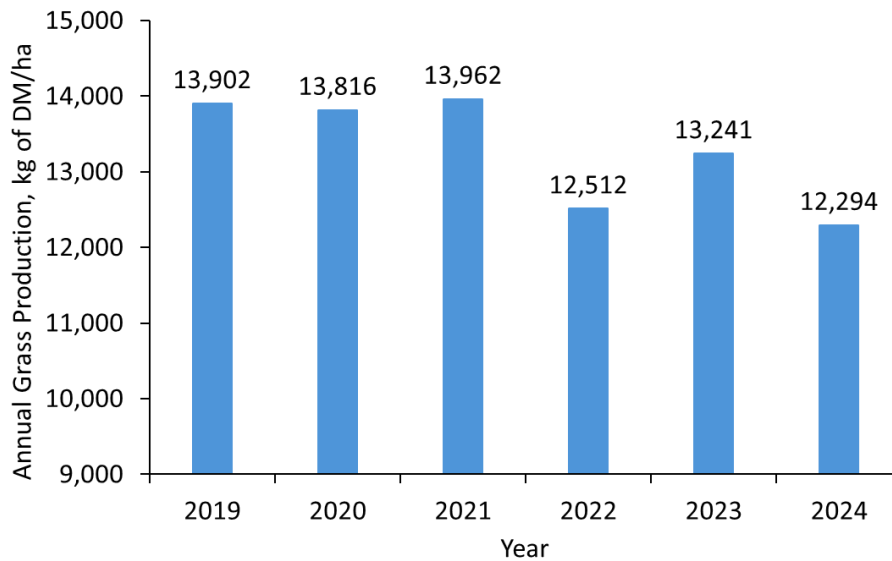


Figure 1. Annual grass dry matter production on a sample of matched farms recording on PastureBase Ireland (2019-2024).

Ultimately, reduced on-farm feed production and declining feed self-sufficiency are likely to result in greater reliance on imported purchased feeds. When 2024 is compared with 2019 within the Teagasc National Farm Survey, chemical N use on dairy farms has reduced by 14%; however, purchased concentrate fed per cow has increased by 18% (Figure 2). Similar trends have also occurred within the Teagasc Clover 150 and Teagasc Signpost farms. Such trends indicate that dairy farms will opt to offset declining annual grass dry matter production by purchasing supplementary feed to maintain herd milk output, albeit at lower financial margin. This is unsurprising given that financial commitments such as labour, depreciation and loan interest are relatively fixed on farms and, therefore, farms will seek to maintain levels of output to dilute these overhead costs. A wider industry shift to greater reliance on supplementary feed could lead to the unintended consequence of increased feed N and P imports onto farms. For example, in Northern Ireland, there has been an upward trend in the P balance of farms from 8.7 kg of P/ha in 2008 to 12.3 kg of P/ha in 2017 (Doody et al., 2020). This has primarily been driven by an increase in concentrate P purchases from 13.4 kg of P/ha in 2008 to 16.8 kg of P/ha in 2017 with a slight increase in chemical fertiliser P purchases from 3.1 to 4.5 kg of P/ha (Doody et al., 2020). Such trends underscore the importance of considering the longitudinal whole-system effects of policy change on nutrient balances and the circularity of dairy production systems. Altogether, it is critical to sustain pasture-based systems with low reliance on imported feeds.

This report also demonstrated that for every 1 kg reduction in chemical N/ha, farm profitability reduced on average by €4.14/ha due to the requirement to replace forage not grown with purchased feeds. This estimation corresponds closely with Shalloo et al. (2023), where a 75 kg reduction in chemical N/ha was associated with a €322/ha reduction in net farm profit. It is clear from this analysis that as farms move from feed surplus to deficit, the impact of reduced chemical N is magnified and that the risks associated with feed deficits and forage crisis are magnified.

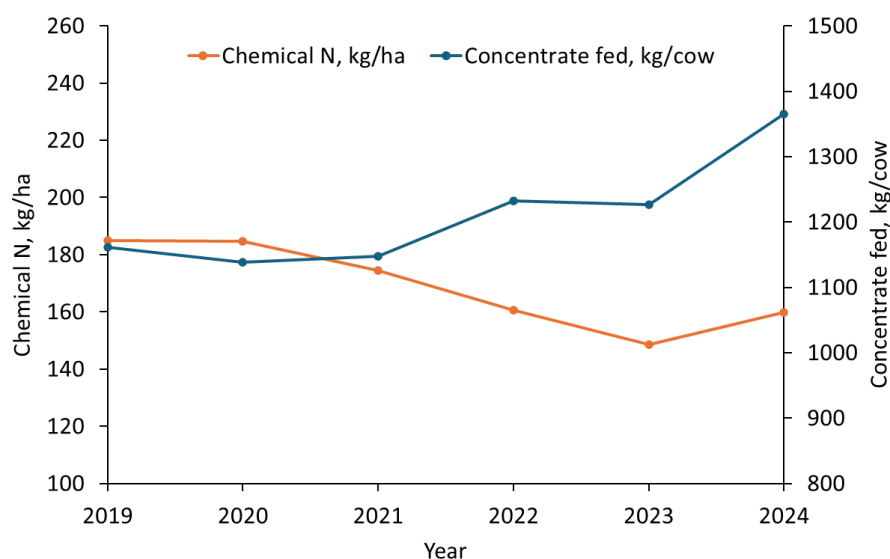


Figure 2. Chemical N use (kg/ha) and concentrate fed (kg/cow) on dairy farms within the Teagasc National Farm Survey (2019-2024).

The inclusion of white clover into perennial ryegrass swards has been demonstrated to increase the milk production efficiency of lactating dairy cows (McClearn et al., 2019) while simultaneously reducing the amount of chemical N fertiliser required (Egan et al., 2018; Murray et al., 2024), when sward clover content is >20%. This technology offers a promising mitigation strategy against declining pasture production as chemical N application limits tighten. However, consistent and reliable establishment of perennial ryegrass–white clover swards remain a challenge on many farms. Ongoing research at Teagasc, spanning a range of soil types, is focused on developing best management practices to maintain optimal and stable white clover content in swards. Key factors under investigation include cultivar selection, N application strategy, grazing management during the establishment phase and the strategic use of over-sowing. On commercial dairy farms, increasing the proportion of white clover is essential before further reductions in chemical N allowances can be sustainably implemented.

In the interim, it is vital that other technologies such as improved soil fertility and more targeted use of organic manures at the optimum time and using the correct quantity. Optimum soil fertility (i.e. soil pH > 6.2 and index 3 and 4 for P and potassium (K)) can increase N use efficiency by 20% and is key to ensuring sward productivity. However, chemical P use has reduced by 33% and chemical K use has reduced by 23% in Ireland when comparing 2024 with 2019. In the Teagasc soil fertility report 2024, dairy soils had significant shortcomings in soil fertility with only 24% of soils optimum in pH, P and K; 39% of soils with a pH <6.2; 37% of soils at P index 1 and 2; and 38% of soils at K index 1 and 2. It is vital that these metrics are improved rapidly. By implementing the ‘adapted silage production allowance’ for farms operating below the 85 kg organic N/ha stocking rate, these farms can contribute an additional 540 kg of DM/ha back into the national forage inventory improving national feed security. Ultimately, a dynamic combination of dietary and management strategies that complement the biological N fixation of white clover will be required to reduce environmental N emissions while maintaining and enhancing pasture-based production systems with low reliance on imported feeds.

Reducing farm stocking rates could help alleviate the forage deficits arising from the progressive reduction in maximum chemical N application allowances on grasslands. However, such a move would conflict with the European Commission's 'Vision for Agriculture and Food', which aims to develop a future-proof agri-food sector operating within planetary boundaries, where farming and the food sector contribute together to the EU's climate objectives, while preserving healthy soils, clean water and air and protecting and restoring Europe's biodiversity. Pasture-based systems of milk production have consistently been shown to outperform more intensive systems in terms of sustainability and efficiency. The FAO's Global Livestock Environmental Assessment Model (GLEAM) provides a fair example of this as it calculates GHG emissions from livestock systems in different world regions using a consistent LCA methodology (Shalloo and Herron, 2024). According to GLEAM, the Irish dairy sector has the lowest carbon footprint across a number of comparisons at 1.02 kg CO₂e/kg of milk, compared with 1.14 in New Zealand/Australia, 1.30 in North America, 1.41 across the EU-27 and a global average of 2.01. While Ireland's dairy sector currently holds a strong position in terms of carbon footprint, the Teagasc Dairy Roadmap 2030 sets a target to reduce this further to 0.63 kg CO₂e/kg of fat- and protein-corrected milk. This reduction is projected to be achieved through the adoption of existing technologies that are already available and currently being implemented on farms. It is clear that Ireland's pasture-based, low-emissions model of food production, where nutrient loss to water is declining at farm level, should play a central role in positioning Europe as a global leader in the production of nutritious and sustainable food, while also contributing to both European and global feed and food security.

6. Conclusion

Irish agriculture has significantly reduced its annual usage of chemical N fertiliser. However, both the model simulations presented in this report and national on-farm data indicate that Irish farms have reached a critical point where dairy production systems are entering into forage supply deficits and are becoming less feed self-sufficient. Further reductions in the maximum allowable chemical N applications on grassland risk exacerbating these deficits, pushing dairy production systems into deeper reliance on external feed sources. This shift toward greater use of imported purchased feeds would have unintended consequences, particularly through increased N and P imports onto farms and will undermine environmental gains.

Improving soil fertility, increasing the efficiency of organic manures, and incorporating white clover into perennial ryegrass swards are effective strategies for reducing the reliance on chemical nitrogen (N) fertilizers. Maintaining an optimum soil pH enhances nitrogen use efficiency (NUE) and improves phosphorus (P) availability for plant uptake. Applying organic manures at the correct time and at appropriate rates further improves their nitrogen efficiency. Introducing white clover into grass swards enables the replacement of chemical nitrogen through biologically fixed nitrogen. However, the successful adoption of these technologies at farm level requires time before further reductions in chemical nitrogen allowances can be realistically achieved.

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