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Soil Fertility Conference 2018

'Optimising Soil and Fertiliser Management for Sustainable Grassland Production'

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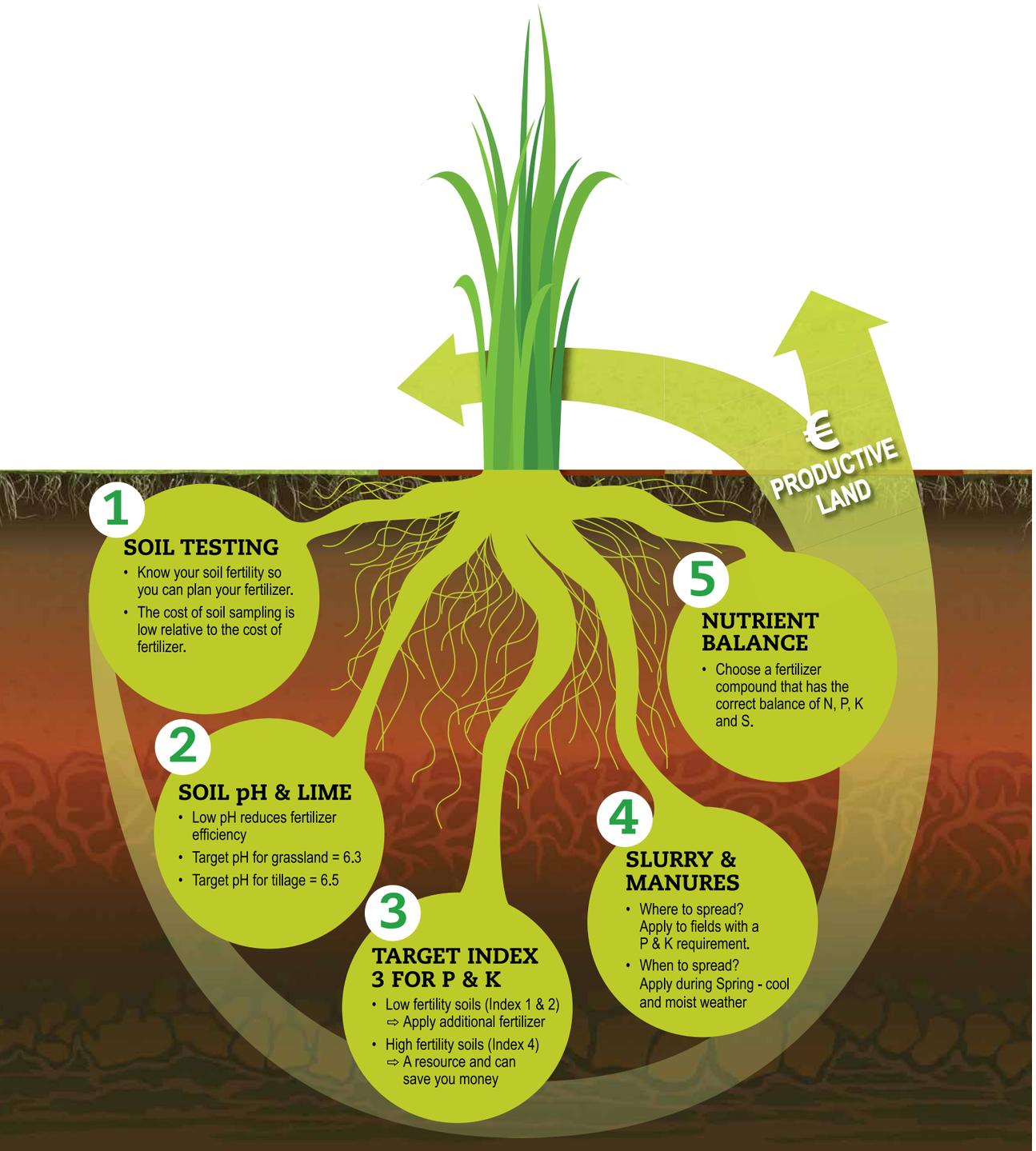
SOIL FERTILITY

THE KEY TO GROWING YOUR PROFIT



Soil Fertility Conference 2018
'Optimising Soil and Fertiliser Management for Sustainable Grassland Production'

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Agriculture and Food Development Authority

Maximising Farm Productivity and Profitability Through Efficient Use of Fertilisers for Sustainable Grass Production

Lyrath Hotel, Kilkenny, Co. Kilkenny
Wednesday, 17th October 2018
10.00 am to 4.00 pm

Edited by David P. Wall and Mark Plunkett
Teagasc, CELUP, Johnstown Castle, Co Wexford

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Soil Fertility Conference 2018
'Optimising Soil and Fertiliser Management for Sustainable Grassland Production'

Introduction

Teagasc welcomes you to the National Soil Fertility Conference 2018, which aims to provide farmers, farm advisors and agri-industry stakeholders with updates on the latest nutrient efficiency and fertiliser research as well as practical nutrient management planning tips and advice. The theme of this event is 'Optimising Soil and Fertiliser Management for Sustainable Grassland Production'.

Grass-based dairy and dry-stock systems hold certain advantages over confined and high concentrate feeding systems in terms of lower cost structure; increased farmer control over feed supply, high quality of the milk and meat produced and increased levels of environmental sustainability. As many Irish dairy farms strive to increase their milk output per ha post milk quota, it is critical that Irish dairy maintains its 'green' image in order to compete in a fiercely competitive world dairy market. Good productive soils are the foundation of any successful farming system and key for growing sufficient high quality grass to feed the herd. Irish farmers are in a position to maximise the potential milk and meat output from their farms and to achieve this high grass growth rates over an extended season is needed. This places an increasing demand on soil nutrient supply. The ability of soils to supply nutrients at a time and in appropriate quantities for grass growth is a key determining factor of how productive a field or farm can be. Therefore, the management of soil fertility levels should be a primary objective of every farm.

Soil Fertility Management

Now is the time for farmers to make decisions regarding fertiliser and manure management strategies for their farms. High fertiliser prices and strict limits under the Nitrates Action Plan have led to decreasing trends in national soil fertility. A recent review of soils tested at Teagasc indicates that the majority of soils in Ireland are below the target levels for pH (i.e.6.3) or P and K (i.e. Index 3) and will be very responsive to application of lime P & K. On many farms sub-optimal soil fertility will lead to a drop in output and income if allowed to continue. It is important to complete a farm fertiliser plan to guide lime, manure and fertiliser decisions in 2019 and to avoid further decline in soil fertility levels.

During this Soil Fertility Conference Teagasc is highlighting 5 steps for effective soil fertility management:

1) Have soil analysis results for the whole farm.
2) Apply lime as required to increase soil pH up to target pH for the crop.
3) Aim to have soil test P and K in the target Index 3 in all fields.
4) Use organic fertilisers as efficiently as possible.
5) Make sure the fertilisers used are properly balanced.

The main focus of this event is to highlight and discuss issues related to good soil fertility management for maximising the productivity of our soils in an environmentally sustainable manner. For those farmers aiming to improve soil fertility on their farms, following these 5 steps provides a solid basis for success.

Programme Soil Fertility Conference 2018

9.15: Coffee on arrival

10.00: **Opening & Welcome**
John Spink, Head of CELUP, Teagasc

Session I. **Soil Fertility Research**
Chair: *John Spink, Head of CELUP, Teagasc*

Session II. **Soil Fertility Research into Practice**
Chair: *John Carroll, Glanbia, Kilkenny*

Programme Soil Fertility Conference 2018

12.30 – 13.30: Lunch

Session III. **Soil Fertility Advice**
Chair: *Aidan Brennan, Irish Farmers Journal*

15.40: **Conference Closing**
Professor Gerry Boyle, Teagasc Director

Response to potassium and implications for grass silage production

Mark Plunkett and David Wall
Teagasc, Crops Environment and Land Use Programme, Johnstown Castle, Wexford.

Summary

- Silage swards have higher potassium (K) requirements than grazed swards
- Aim to apply recommended levels of K for silage and grazing over the growing season
- Select a fertiliser type with the correct P:K balance (1:6) for silage crops
- Recycle nutrients in cattle slurry back to silage fields
- Check slurry dry matter & adjust application rates for correct P & K supply

Introduction

Grass silage is one of the largest crops grown in Ireland with a current requirement of ~ 10 million tonnes of dry matter annually. Making sufficient quality grass silage is an essential component of sustainable grass based livestock production systems for over winter fodder. Correct fertilisation of the grass silage crop is required for both yield and quality at harvest time. Potassium (K) plays a key role as it is necessary for the formation of sugar, starch and protein. Sufficient plant available K is required during peak growth to drive nitrogen (N) efficiency for yield and reduce possible N losses through leaching or de-nitrification. Potassium deficiency will reduce grass yield rapidly in a silage sward compared to a grazing situation where K in recycled during dung and urine deposition. Nationally, the application of fertilisers K on grassland farms is below the levels needed to replace K offtake by the silage crops and for maintenance of soil K levels (K index 3).

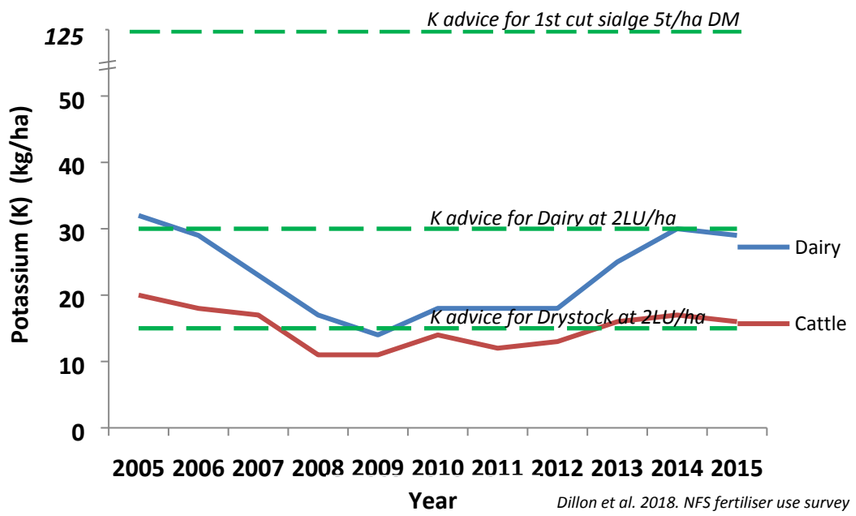


Figure 1. Average potassium (K) fertiliser use on grassland farms nationally and K application advice for drystock, dairy and silage production systems.

Factors affecting soil K status

Over the last decade Teagasc soil test results show that the proportion of grassland soils at K index 1 and 2 levels have increased by 50%. This has the potential to compromise grass productivity and fertiliser N efficiency.

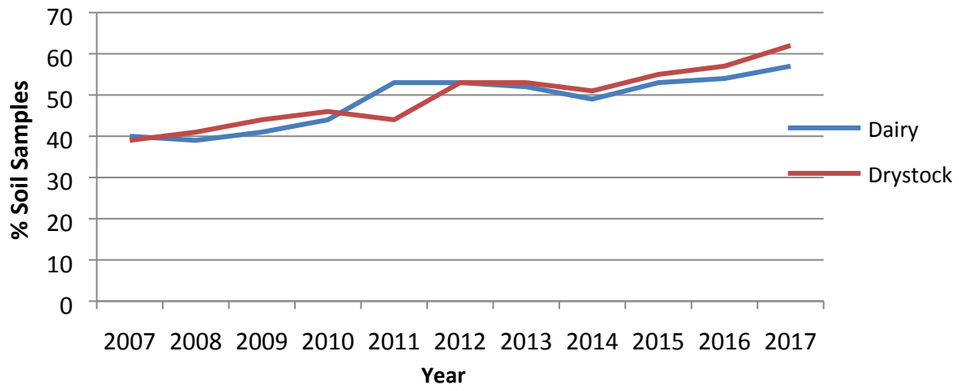


Figure 2. Percentage of grassland dairy and drystock soil samples at K Index 1 & 2.

- **Fertiliser K use**

Fertiliser K use on farms declined dramatically between 1989 and 2009 with a 300% decrease in fertiliser K imports nationally. Since 2009 fertiliser K use has doubled (52,000 to 108,000 t). Figure 1 shows average fertiliser K applications for dairy and drystock farms. Over the 10 year period the average use on dairy and drystock farms has been 23 and 15kg K /ha/year, respectively. This level of K fertiliser use was well below the recommended K rates required for maintenance (Index 3) on silage crops. It is assumed that cattle slurry produced on farms is recycled back to silage fields helping to fulfil most of the K requirements; however, these data indicate that little or no additional K is being applied for soil fertility improvement on the majority of farms.

- **Fertiliser Type**

Selecting a suitable compound fertiliser with the correct P: K ratio is critical for supplying the K requirements for grass production during the growing season. A fertiliser programme should comprise of a 0-7-30 (N-P-K) type fertiliser blend in the absence of cattle slurry. However, where cattle slurry is applied at a rate of 33m^3/ha a fertiliser blend such as 27-2.5-5 is adequate to meet crop requirements with additional K required for low index soils (Index 1 & 2) which is best applied at the end of the grass growing season (autumn).

- **Cattle Slurry**

Recycle the nutrients in cattle slurry back to silage fields to ensure that soil P and K levels are replenished. The nutrient value (P & K) in cattle slurry will be variable depending on dilution with water. More dilute slurry will have lower nutrient value and will result in under fertilising the silage crop. For example 33m^3/ha of cattle slurry at 7% dry matter (DM) will supply the majority of P and K required for a grass silage crop compared to slurry at 4% DM will only supply ~50 and 60% of crop P & K requirements, respectively. This practice will result in a nutrient deficit if fertiliser is not adjusted accordingly.

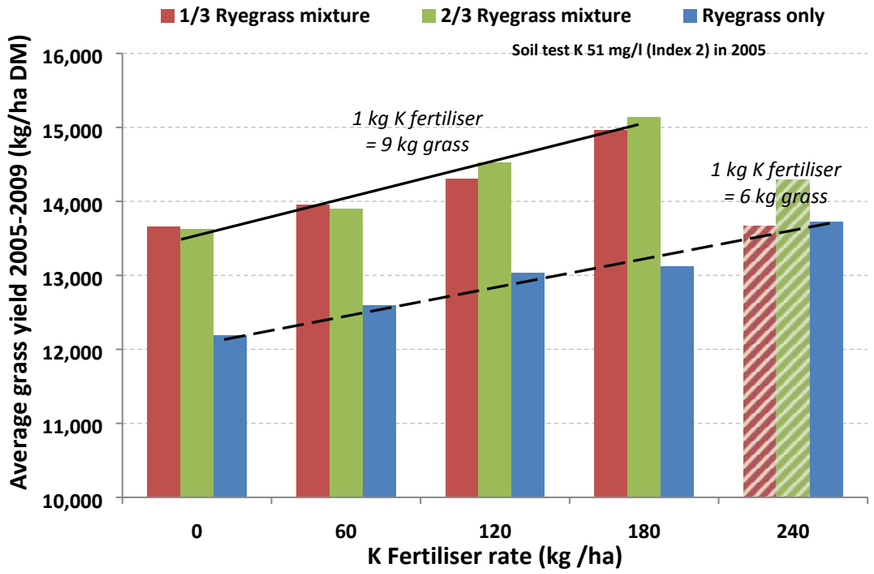


Figure 3. Relationships between average annual grass yield (kg/ha) and potassium (K) fertiliser rate (kg/ha) for a 4 cut silage experiment at Johnstown Castle between 2005 and 2009. Three sward types with varying perennial ryegrass levels were evaluated.

Silage sward response to K fertiliser

A study of silage response to K fertiliser application was conducted from 2005 to 2009 at Teagasc Johnstown Castle. Swards with ryegrass mixed with other grass species had higher grass yield response to K fertiliser (up to 180 kg K/ha per annum) than the ryegrass only sward (up to 240 kg K/ha per annum) as shown in (figure 3).

Potassium advice for silage swards

Intensively cut grass silage has a large demand for K with every 1 ton DM removing 25kg K. For example a 2/3 cut silage system will remove 10t/ha DM and up to 250 kg K/ha. Table 1 shows the recommended levels of K for silage crops based on soil K levels and the typical DM yields. Additional K is required at soil K index 1 and 2 to build soil K levels over time. Build up rates of K should be applied in the autumn time to reduce the risk of grass tetany in the spring time. Potassium rates recommended at soil K index 3 show the levels of K removed by the crop at harvest time. To maintain soil K levels these amounts need to be applied through the application of cattle slurry and, or, chemical K fertilisers.

Table 1 Recommended rates of K for 1st, 2nd & 3rd cut grass silage.

Soil Index	1st Cut *5 t/ha DM*	2nd Cut *3 t/ha DM*	3rd Cut *2 t/ha DM*	Total K *(kg/ha)*
1	185	75	50	**310**
2	155	75	50	**280**
3	125	75	50	**250**
4	0	0	0	**0**

On Index 4 soils omit K for one year and revert back to Index 3 advice until next soil test. Adjust K advice by +/- 25kg K/ha per tonne of grass DM.

Fertiliser K Timing Advice

The fertiliser K application strategy should be carefully planned especially where high levels of K are required. For example in springtime K applications should not exceed 90 kg K/ha in a single application. Where higher rates are required it is advised to apply the balance to the aftermath or in late autumn. On fast growing swards which have received high levels of nitrogenous and potassic fertilisers grass tetany (grass staggers) can become more prevalent. High soil K levels can induce grass tetany as it antagonises magnesium uptake by the grass crop. In areas where the disease is known to be problematic it's advisable to feed cal mag 3 weeks before and after susceptible periods.

Conclusions

As animal numbers increase on intensive livestock farms there is an increasing demand for conserved winter feed. Potassium has a major role to play in the production of quality grass silage. Over the last decade the levels of K fertiliser applications on grassland farms have been insufficient to meet K offtakes from grazing and silage systems annually. These low levels of K application have been reflected in soil test results from grassland farms where the percentage of soils at index 1 continues to increase. To produce annual grass silage requirements it is essential that recommended rates of K are applied at key times during the growing season. This can be achieved by recycling the nutrients in cattle slurry back to silage fields and by selecting suitable compound fertilisers to top to crop K requirements.

Spring Nutrient Advice for Grassland Farms

David Wall
Teagasc, Crops Environment and Land Use Programme, Johnstown Castle, Wexford.

Summary

- Soil testing and fertiliser planning are key requirements for any successful farm and should be conducted during autumn in advance of fertiliser purchase.
- Low soil fertility (e.g. soil P and K Index 1 or 2) equates to reductions in grass growth potential in excess of 3t grass DM/ha per year, which is worth at least €540 per ha on a dairy farm and €315 on a drystock farm, per year.
- Soil test results indicate that 88% of grassland fields have sub-optimal soil fertility which is seriously limiting grass growth potential on farms.
- Approximately 47% of soil samples from grassland farms still have below target soil pH of 6.3 indicating that lime applications are required.
- Higher yielding swards and highly stocked farms require higher nutrient application rates to replace nutrients removed during grazing and silage cutting.
- Slurry is valuable resource and should be targeted towards fields with highest requirement for P & K (i.e. Index 1 & 2 or silage fields) to help offset expensive fertiliser costs.

Introduction

Of the dairy farm soil samples analysed by Teagasc in 2017 just 15% had optimal soil fertility levels as indicated by soil pH, P and K. Only $^1/_3$ of dairy farms are applying lime on a regular basis which indicates that more emphasis on lime application is needed to reduce soil acidity. Implementing the correct fertiliser programme in spring to deliver the nutrients required is critical for early grass growth and turnout and sets the farm up for the growing season ahead.

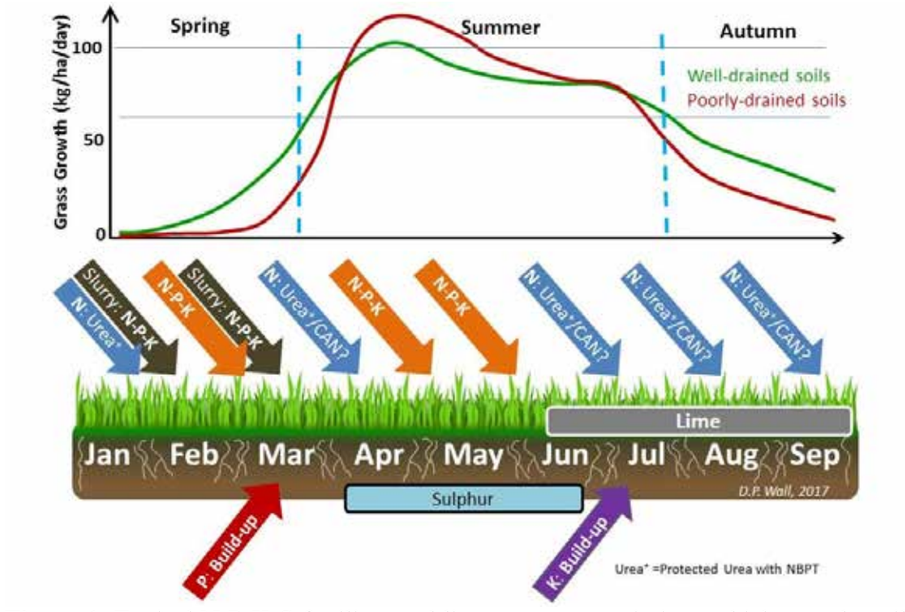


Figure 1. Typical N-P-K-S fertiliser and lime programme timings which must be tailored to seasonal grass growth and soil types on the farm.

Lime & Fertiliser Advice

The starting point when building soil fertility is to apply lime according to the soil test recommendations. In spring soil and weather conditions can be very variable, so selecting a stable N fertiliser source, such as protected urea, can help to maximise the recovery of N by the grass. In very early spring, where soils are wet and cold, delaying N application until conditions improve can be prudent in terms of increased N uptake by the grass and minimising N leaching losses. The nutrient application advice for P and K for dairy grassland is shown in Tables 1 and 2. The advice for both P and K applications shown includes P and K from both chemical fertiliser and slurry sources. In addition, the P application rates should also be adjusted to account for the P coming onto the farm in concentrate feeds.

Table 1. Simplified P fertiliser requirements (kg/ha) of grazed and cut swards for dairy farms *(These total P requirements should be adjusted for concentrate feeds or where organic manure is applied)*

	Grazed Swards				Silage Swards	
Soil P	Farm Stocking Rate (LU/ha)					
Index	<1.5	1.5-2.0	2.0-2.5	>2.5	Cut Once	Cut Twice
1	30	33	36	39	+20	+30
2	20	23	26	29	+20	+30
3	10	13	16	19	+20	+30
4	0	0	0	0	0	0

** Note: Farms stocked at ≥130 kg Org N /ha can avail of additional P build-up allowances on index 1&2 soils. Contact your advisor or consultant for more details.*

Table 2. Simplified K fertiliser requirements (kg/ha) of grazed and cut swards for dairy farms *(These total K requirements should be adjusted for organic manures applied)*

	Grazed Swards				Silage Swards	
Soil K	Farm Stocking Rate (LU/ha)					Subsequent
Index	<1.5	1.5-2.0	2.0-2.5	>2.5	Cut Once*	cuts
1	85	90	95	100	+185	+75
2	55	60	65	70	+155	+75
3	25	30	35	40	+125	+75
4	0	0	0	0	0	0

** Typically no more than 90 kg/ha K should be applied at closing for silage*

Conclusions

Fertiliser is an important investment on dairy and drystock farms and represents >25% of total variable production costs. Trying to plan fertiliser application strategies without field-by-field information on soil fertility levels is impossible and leads to poor return on investment and higher potential for nutrient losses to the environment. Soil testing costs less than 1 kg of fertiliser P per ha per year (€2) and having up to date soil test results for the whole farm is essential when selecting the right fertiliser type, and deciding the right fertiliser application rate and right fertiliser application timing.

Although it costs money to increase fertility levels, the returns in terms of increased grass production from low fertility soils can be considerable (>3.0 tonnes grass dry matter per ha), and can increase the livestock carrying capacity (i.e. stocking rate) of the farm, provide additional winter feed stocks (silage), improve animal health (nutrition value of the grass), increase milk and meat outputs and ultimately whole farm profitability.

Phosphorus Management & Soil P Trends in Agricultural Catchments

Noeleen McDonald[1, 2], Edward Burgess[1], Per-Erik Mellander[2, 3] & David Wall[3]
[1]Department of Agriculture Food and Marine, Agricultural House, Kildare St, Dublin 2.
[2]Agricultural Catchments Programme, Teagasc, Crops, Environment and Land Use Programme, Johnstown Castle, Wexford.
[3] Teagasc, Crops Environment and Land Use Programme, Johnstown Castle, Wexford.

Summary

- The Agricultural Catchments Programme (ACP) has been evaluating the effectiveness of Nitrates Directive regulations for minimising nutrient loss to water since 2009.
- Grassland fields with excessive soil P levels (P Index 4) have generally declined, however, the area with low soil P (P Index 1 and 2) has increased (up to 85%).
- Phosphorus fertiliser inputs varied between years and catchments (24 to 36 kg P/ha).
- Grassland management (grazing vs. silage) and stocking rate at field scale have a large influence on soil P change over time.
- Soil fertility advice and management at field scale is most appropriate for maintaining production levels and also achieving environmental targets.

Introduction

The agricultural catchments programme (ACP) was established in 2008 to evaluate the Nitrates Directive Good Agricultural Practice (GAP) measures for improving water quality in six agricultural river catchments in Ireland. These catchment areas vary in soil type, drainage characteristics, and nutrient loss risk and include both drystock and dairy farming systems. Better nutrient management on farms is recognised as being important for productive and profitable farming and also for minimising the risk of nutrient loss to streams, rivers and lakes. Phosphorus (P) is recognised as a key plant nutrient but is also as a potential pollutant of surface waters when it is lost from the landscape. Nutrient management performance was evaluated in three catchments representing (1) well-drained soils (WD) in Timoleague south-west Cork, (2) moderately-drained soils (MD) in Dunleer, Co. Louth, and (3) poorly-drained soils (PD) in Ballycanew North Wexford over a nine year period. Each field in each catchment were soil sampled every 3-4 years over this period and the soil test results; pH, P and potassium (K), while utilised for research were also provided to the farmers through a dedicated advisory service. Records of fertiliser and manure applications to fields, as well as silage, milk and meat off takes were collected on a number of the ACP farms throughout these years. This enabled farm and field scale P balances to be calculated in order to assess the effectiveness of the fertiliser and manure management on these farms.

Catchment Soil Phosphorus Trends

Across this period soil P levels changed in all the three catchment types (Fig 1). The percentage of grass fields in the PD catchment with sub-optimum P levels (i.e. Index 1 and Index 2) were highest and increased (67% in 2009 to 85% in 2017) over time. Fields with optimum levels of soil P (Index 3) declined across all catchments, while fields with excessive soil P levels (Index 4) declined in two catchments while they increased in the MD catchment. The PD and MD catchments are identified as been the most risky for P loss from the landscape to surface waters. In the PD catchment with the greatest P loss risk due to overland water flow, the area of fields at P Index 4 were lowest out of all the catchments and continued to decline across the sampling periods. Whereas in the MD catchment, fields at P Index 4 peaked in 2014 when 36% of the catchment grass fields had high P source potentially contributing to increased P loss.

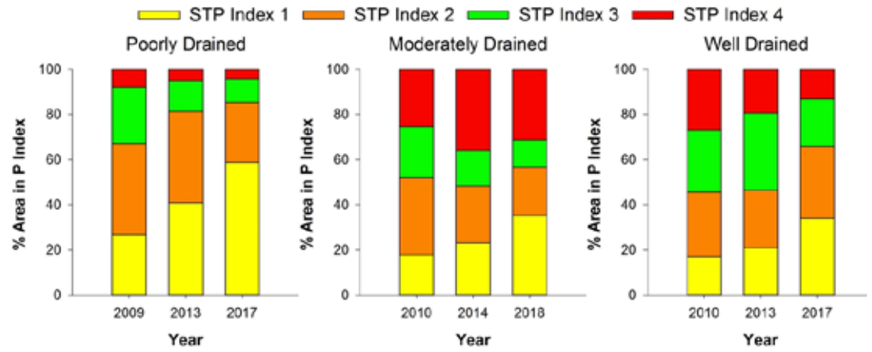


Figure 1 Trend of the soil available P levels in the poorly-drained (PD-Ballycanew) moderately-drained (MD-Dunleer) and well-drained (WD-Timoleague) catchment grassland soils sampled between 2009 and 2018.

Phosphorus Management

The average P inputs, as fertiliser P or manure P ,varied from year to year in each catchment (Table 1). The PD catchment received the lower average P application rates (24 kg/ha) compared to the MD and WD catchments, which received 30kg P/ha and 37 kg P/ha, respectively (Table 1). Of the total P applied to grassland fields, manure P made up the largest proportion of P inputs in these catchments (PD, 51%, MD, 82% and WD 81%). The efficiency of P recovery by the plant varies by soil properties and the type of grassland management (i.e. silage vs. grazing and stocking rate). Silage fields that are cut with no stock grazing have the highest P removal leading to a P deficit of -14 kg P/ha/year on average. In contrast, grassland fields that were grazed and thus recycle P via dung and urine back to the soil, can have lowest P removal, resulting with an average P surplus of +10 kg P/ha/year.

Table 1: The mean P input in kg/ha (chemical and organic manures) to the grassland fields in each study catchment between 2010 and 2015.

Catchment	2010	2011	2012	2013	2014	2015	Six year Average
			P input kg/ha				
Poorly Drained *Ballycanew, Wexford*	18	22	23	22	30	28	24
Moderately Drained *Dunleer, Louth*	23	28	39	35	28	29	30
Well Drained *Timoleague, Cork*	34	26	47	43	39	36	37

Conclusions

Monitoring soil P levels and calculating P input-output balance at field scale has helped to identify the effectiveness of nutrient management strategies on catchment farms. Better distribution of nutrients applied in slurry is necessary to optimise soil fertility and to minimise the risks of nutrient loss to water. Increased farmer awareness and advice is required to address field-by-field soil fertility issues and to develop a suitable fertiliser plan specific to their farm. This will help to achieve sustained grass and crop production levels, improve farm profitability and protect water quality and the surrounding environment.

Managing Grass-Clover Swards in an Intensive Grass Based System

Michael Egan and Deirdre Hennessy
Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland

Summary

- Grass-clover swards can increase grass DM production by 2.9 t DM/ha.
- White clover can fix up to 185 kg N/ha./yr. under optimal grazing management.
- Nitrogen fixation decreased as N fertiliser application increases and sward white clover content decreases.
- Frequent tight grazing (4 – 4.5 cm above ground level) of grass-clover swards will encourage white clover persistence in grazed swards.
- Grass-clover swards, offer the potential to increase grass DM and potential to reduce levels of nitrogen fertiliser applied.

Introduction

Research investigating the benefit of incorporating white clover (clover) into perennial ryegrass (PRG) pastures for high stocking rate systems of milk production over the last number of years has shown the potential to increase pasture production, reduce costs (lower nitrogen (N) input), increase animal performance (increase milk production per cow) and improve environmental sustainability (reduced nitrous oxide emissions). Therefore, clover has huge potential to benefit Irish dairy farmers at farm level. However, the use of clover on Irish farms is low with little or no swards reliant on nitrogen (N) from clover.

Nitrogen Fixation of Grass-Clover Swards

As a legume, clover develops root nodules that house symbiotic N-fixing bacteria rhizobium, which can convert atmospheric dinitrogen (N_2) gas is converted into ammonia (NH_3), a plant-usable N form, through biological nitrogen fixation (BFN). The relationship between the rhizobia and the host plant is symbiotic; in return for fixed N from the bacteria, the host plant provides the bacteria with carbon (C) from photosynthesis. The cost to the host plant in terms of C is approximately 6 g C per 1 g of N fixed. This effectively means that BNF is a very energy demanding process on the clover plant. This higher metabolic cost to the clover plant has previously been used to explain the observation that swards solely reliant on BNF had 40% less growth than that of mineral N fertilised swards. The quantity of N fixed by clover through biological nitrogen fixation (BNF) varies from 10 to 185 kg N/ha/yr. depending on management factors that affect sward clover content, with an average sward clover content of ≥ 20% required before a significant benefit in herbage production is observed through BNF.

Nitrogen Fertiliser and White Clover

It is generally accepted that the application of N fertiliser results in a reduction in sward clover content. However, strategic use of N fertiliser on grass-clover swards can compensate for low clover growth, particularly in the spring period. A reduction in sward clover content is mainly due to an increase in competition with PRG for light, water and nutrients. White clover can utilise N fertiliser similar to PRG, although the uptake of N fertiliser is faster by PRG than by clover. The uneven uptake of N fertiliser between the PRG and clover results in a faster growth rate of PRG. As a result the application of N fertiliser, overall herbage production is often increased, and this can often result in a decrease in sward clover content compared to swards solely reliant on N from clover.

Good grazing management, that is tight grazing in spring and in the last rotation (~ 3.5 cm if possible), 18 to 21 day rotation length in mid-season (April to August), pre-grazing herbage mass of 1300 to 1500 kg DM/ha and post-grazing sward height of 4 cm in mid-season, will benefit clover persistence as it negates the increased competition for light, space and nutrients with increased N fertiliser. A four year grazed plot experiment (2010 – 2013) investigated the effect of N fertiliser application rate on grass DM production and sward clover content. There were five N fertiliser application rates 0, 60, 120, 196 and 240 kg N/ha per year applied to grass-only and grass-clover swards. Regardless of N fertiliser application rate, herbage DM production increased by 2.9 t DM/ha when clover was included in the sward (Table 1). However, as fertiliser N application rate increased, average annual sward clover content decreased from 33.3% when 0 kg N/ha was applied to 19.6% when 240 kg N/ha were applied, and as N fertiliser levels increased the level of BNF reduced (Table 1).

Table 1: Average annual grass production and average sward clover content in grass-only & grass-clover swards receiving 0, 60, 120, 196 and 240 kg N/ha per year between 2009 & '13

	Nitrogen fertiliser application rate (kg N/ha/year)				
	0	60	120	196	240
Grass only (t DM/ha/year)	9.1	9.2	11.0	11.3	12.6
Grass-clover (t DM/ha/year)	13.3	13.1	13.1	13.8	14.4
Sward clover content (%)	31.6	29.2	26.4	20.3	18.5
Nitrogen fixation (kg N/ha/year)	219	205	148	122	112

A recent systems grazing experiment undertaken in Teagasc Moorepark (2013 – 2016) investigating the use of clover in an intensive grazing system (stocking rate – 2.74 cows/ha), with three grazing treatments, a grass only sward receiving 250 kg N/ha (Gr250), a grass-clover sward receiving 250 kg N/ha (Cl250) and a grass-clover sward receiving 150 kg N/ha (Cl150), all stocked at 2.74 cows/ha. Over the course of the 4 years, there was no difference in grass DM production between the three treatments (14.5 t DM/ha). It is interesting to note that, at Moorepark, the Cl150 treatment had the same herbage DM production as the Gr250 and Cl250 treatments despite receiving 100 kg N/ha less than the other two treatments. This shows that under high levels of N fertiliser (250 kg N/ha and 150 kg N/ha), good grazing management practices (as mentioned above) can maintain significant levels of clover (23% and 27% on grass-clover swards receiving 250 and 150 kg N/ha, respectively) in the sward five years post sowing (swards were sown in summer 2012) and maintained similar levels of DM production compared to grass-only swards. As well as the positive effects in terms of herbage production, incorporating clover in the swards increased milk solids yield by 33 kg/cow/year compared to Gr250.

Strategic use if Nitrogen Fertiliser on Mixed Grass-Clover Swards

Nitrogen derived from clover alone may not be sufficient to maintain high levels of DM production; however, including clover in swards where high levels of N fertiliser are applied reduces the impact of clover in terms of BNF. We must reach a compromise between including clover into grazed swards and the level of N fertiliser applied. The experiments outlined above indicate that applying 120 to 150 kg N/ha/yr to mixed grass-clover swards produced similar levels of herbage compared to grass-only sward receiving 250 kg N/ha/yr. Seventy per cent of the N fertiliser in those studies was applied by May, with reduced quantities applied thereafter. This coincides with the period of increasing sward clover content, usually April/May onwards, and the potential for that clover to fix N.

Conclusions

White clover can significantly impact on Irish dairy productions systems through increased herbage production. Clover can also offer the opportunity to strategically reduce inorganic N input to high stocking rate grass-based systems, particularly in the second half of the year as sward clover content increases and BNF occurs.

Increasing the Efficiency of Soil Nutrient Management in Northern Ireland

Suzanne Higgins and John S. Bailey
Agri-Food and Biosciences Institute, Belfast

Summary

- A soil sampling and analysis scheme was carried out across Northern Ireland in 2017, and open to all eligible livestock farmers.
- Almost 20,000 fields were soil sampled during the winter of 2017 / 18.
- The aim of the scheme was to improve the productivity of livestock farms while also benefitting the environment.
- Soil nutrient surpluses as well as soil nutrient deficiencies were identified across all sectors.
- Tens of £ millions worth of additional grass dry matter could potentially be realised through correcting these nutrient imbalances.

Introduction

In 2016, The Sustainable Agricultural Land Management Strategy for Northern Ireland, reported that grass utilisation in Northern Ireland was significantly below optimal levels, less than 10% of farmland had an up-to-date soil analysis, and 64% of our soils were not at the optimum soil pH. By enhancing soil health and increasing the efficiency of soil nutrient management we can help to optimise grass yields and grass quality, improve grass utilisation and minimise the loss of excess nutrients to the environment.

Soil Sampling and Analysis Scheme

An EU-funded soil sampling scheme supported by the Department of Agriculture in Northern Ireland, the Ulster Farmers Union, the College of Agriculture, Food and Rural Enterprise, and the University of Ulster was launched in Northern Ireland in 2017. The scheme was designed to provide farmers with detailed information about their soils, with the aim of improving profitability and benefiting the environment (Table 1).

Table 1: Objectives of the 2017 Soil Sampling and Analysis Scheme in Northern Ireland

Improving PROFITABILITY
- Increase grass and forage yields
- Improve soil fertility (pH, P, K, Mg, Ca, OM)
- Improve the distribution of manure, preventing over- or under-supply of nutrients

Benefiting the ENVIRONMENT
- Reducing the risk of nutrient loss to water-bodies

The scheme comprised two components; an Open Scheme and a Catchment Scheme.

The Open Scheme

The Open Scheme was open to all eligible livestock farmers. In total, 3,030 farms (98,000 fields) registered and from this 522 farms were randomly selected (12,218 fields).

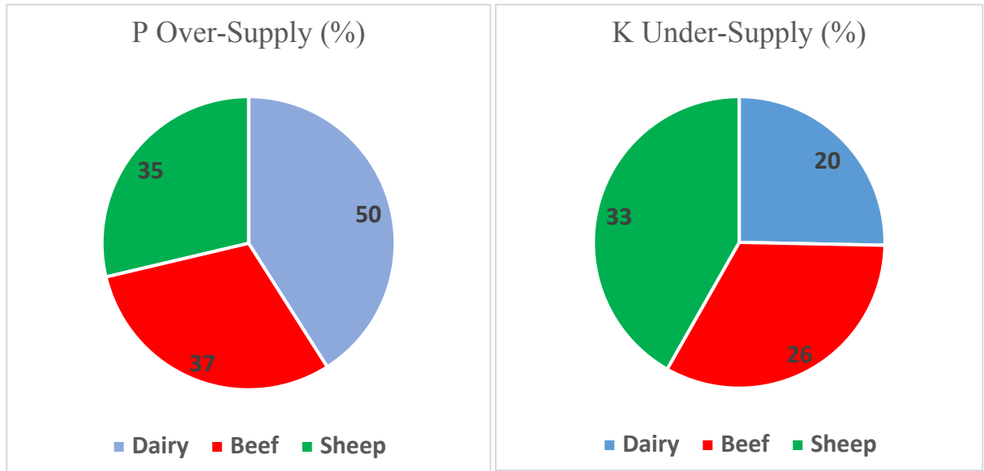
The Catchment Scheme

The Catchment Scheme focussed on the Upper Bann River Catchment with 11 sub-catchments soil tested. 78% of the eligible farms (513 farms out of 654) within the Upper Bann Catchment registered for the scheme and received soil testing.

Soil sampling took place during the winter of 2017/18 and all farmers received their own independent soil analysis report along with nutrient recommendation maps and training on the interpretation of their data. The catchment area was also flown by LiDAR technology and all farmers in the catchment scheme received P run-off risk maps in addition to their soil nutrient maps.

Results

Almost half (42%) of all fields sampled (50% of dairy farm fields) within the Open Scheme recorded soil P indices > Index 2 (Olsen P soil test) (Figure 1). 15% of dairy farms recorded an under-supply of P. A quarter of all fields sampled in the Open Scheme displayed sub-optimum K levels. Additional slurry and / or potash fertiliser on these fields could result in 400 kt/yr extra grass dry matter worth £40 million (gross)/yr.



(a) (b)

Figure 1: Precentage of fields on dairy, beef and sheep farms displaying (a) an over-supply of soil P and (b) an under-supply of soil K

Overall, 43% of grassland in Northern Ireland was shown to require lime. Sub-optimal soil pH can lead to on avarage 2t reduction in grass dry matter/ha/yr. The extra grass potentially achievable through correcting soil pH can represent a 5 fold return on the lime investment.

Conclusions

The 2017 soil sampling scheme in NI highlighted large inefficiencies in soil nutrient management within the three main grass-based livestock sectors (dairy, beef and sheep). P over-loading of land was a problem and needs to be addressed. Nutrient deficiencies were also identified, particularly K deficiency and soil acidity. Farmers were undoubtedly attracted to the scheme by the free soil sampling and analysis provided. However, for the relatively modest cost of soil analysis, which is required only once every 3-5 years, tens of millions worth of additional grass DM could be realised through the correction of nutrient imbalances.

Manure and its Management

Patrick Forrestal
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Summary:

- Soil test this autumn to decide where to apply slurry and to maximise yield potential.
- Target slurry to first cut silage ground or low P and K index soils
- Slurry nutrients can vary widely across farms, just like bagged fertiliser you need to know your slurry "N-P-K label"
- Nitrogen (N): up to two thirds of available N in slurry may be lost during housing and storage
- Maximise the remaining N by applying in spring with a trailing hose or dribble bar
- Phosphorous (P) & potassium (K): applying slurry can save you money, offsetting the need for compound fertiliser purchases.

How to Maximise the Efficiency of Slurry Nutrients for Production & Profitability

1. Do you have a recent soil test?

If not soil test all fields this autumn to determine your slurry and fertiliser plan to grow the most grass at the least cost next year.

Figure 1. Soil P & K index system and associated P & K plan.

2. What is the target crop?

Slurry contains P and K in a suitable balance for silage. Note that slurry is mainly produced from animals eating silage during winter housing. Therefore slurry is best suited for application to silage ground and less suited to grazing ground due to high K levels.

Table 1. Maintenance N-P-K requirements for silage production (Index 3 soils)

Crop	Target Yield t/ha (D.M.)	N	P kg/ha	K
1st cut silage	5	125	20	125
2nd cut silage	3	100	10	75

3. What is the nutrient content of your slurry?

Slurry nutrient content is very variable across farms (Figure 2). A recipe for leaving crops short of nutrients or for costly over application of purchased fertiliser.

Slurry dry matter content is a reasonable indicator of N and P content and also gives an indication of K content. Dry matter content can be measured using a slurry hydrometer (figure 2), talk to your advisor. Also consider sending a slurry sample for lab analysis to check the nutrient level of slurry produced on your farm.

Figure 2. Large nutrient variability in slurry, a 17 fold difference in available N, a 11 fold in P and a 15 fold in K between high and low samples.

4. How do you get the most out of slurry N and balance correctly?

Get the most out of the available N not lost in housing and storage by:
(a) using a trailing shoe or dribble bar and **(b)** apply slurry during spring.
Balance with fertiliser N to crop requirements as per figure 3 & download your free copy of the Teagasc Green Book of nutrient advice produced at Johnstown Castle.

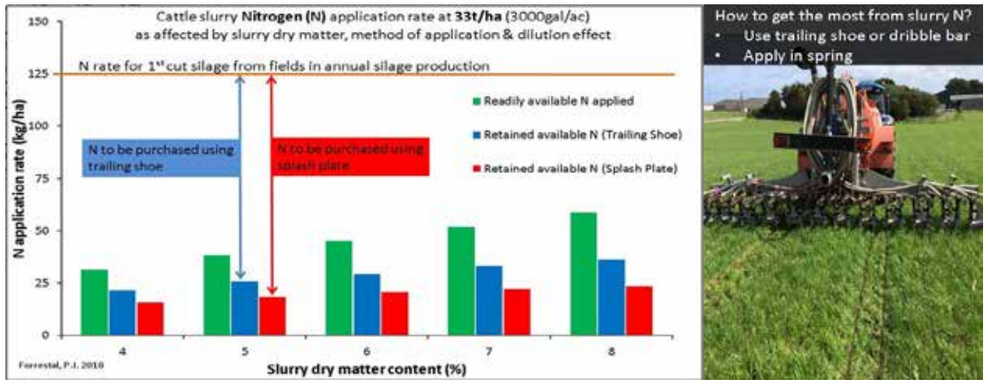

Figure 3. Effect of slurry dry matter and application method on available N retained.

5. Purchase P and K fertiliser required for maintenance & soil build-up requirements?

Unlike nitrogen P and K are not lost as gases during housing, storage or application so the majority of maintenance requirements can often be met from slurry. Top up P and K with fertilisers as required (see figure 4) and apply build-up P and K as indicated by soil test.

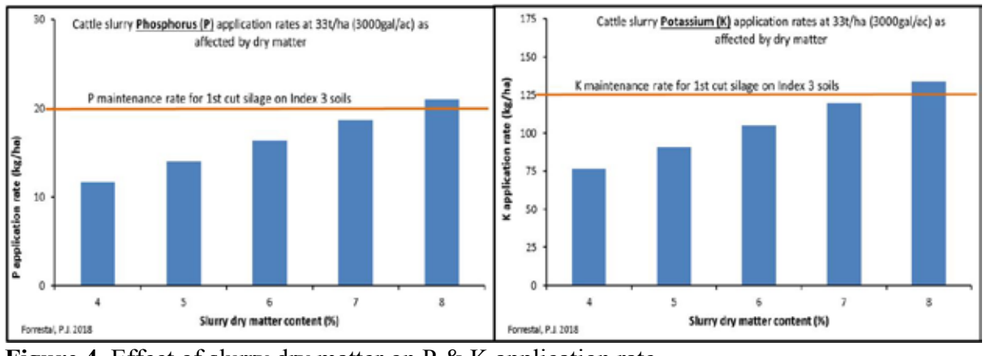

Figure 4. Effect of slurry dry matter on P & K application rate.

Long Term Fertiliser use Trends in Ireland and Implications for Sustainability

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Summary

- This research looks at fertiliser use on Irish farms based on data collected by the Teagasc National Farm Survey between 2005 to 2015.
- Nitrogen (N), phosphorus (P) and potassium (K) fertiliser application rates on farms declined by approximately 11-16% between 2005 and 2015, with more dramatic declines in (23-52%) fertiliser use in the mid-study period.
- Fertiliser use on land used for cereal production generally increased over this period.
- Fertiliser application rates on grassland were on average 36% lower for farms participating in Agri-environment schemes.
- On average just over 20% of farms used lime year-on-year over the study period.

Introduction

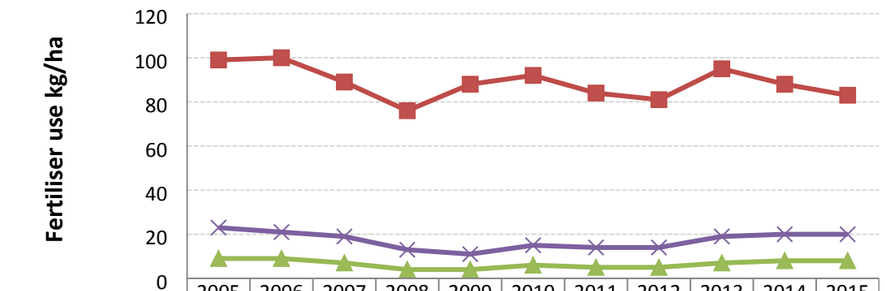
This research examines long term developments in farm and crop scale fertiliser use across the Republic of Ireland. The analysis is based on data collected by the Teagasc National Farm Survey covering the years 2005 to 2015. This is a period when fertiliser use on farms in the Republic of Ireland has been constrained by the Nitrates Directive regulations. This longer term study provides a better picture of fertiliser use trends at farm level than short term analysis. Data showing short term trends in fertiliser use can be affected by fertiliser price levels and weather variations and are a less reliable indicator of longer term changes

Methodology

The data used for this analysis is taken from the Teagasc National Farm Survey (NFS). The NFS is based on a nationally representative random sample of the farming population. The 2015 results are based on a sample of 898 farms which represents 84,259 farms nationally. Results are presented for average quantities of N, P and K and lime applied at farm level on grassland and arable farms between 2005 and 2015. Trends in fertiliser use by nitrates zone, land use class, farm system, stocking rate and agri-environmental scheme participation are part of overall research project (Teagasc, 2018). These NFS data results closely track annual sales data of N, P and K from the Department of Agriculture, Food and the Marine (DAFM).

Results & Conclusions

Results indicate that average N, P, K, fertiliser application rates on grassland tended to be between 11-16% lower at the end of the study period compared to the start, with more dramatic declines in application rates noticeable in the mid-study period (23-52%). The years of lowest grassland fertiliser use (2008-09) coincided with the period of higher fertiliser prices, while higher than average fertiliser application rates in 2013-2014 were associated with the aftermath of a national fodder shortage. Higher application rates of N, P and K on grassland were generally associated with farms in nitrates zone A, farms of wide land use potential, dairy farms and farms with higher stocking rates.

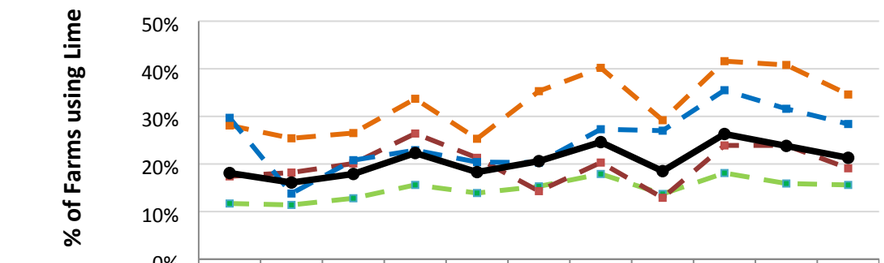


	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nitrogen	99	100	89	76	88	92	84	81	95	88	83
Phosphorus	9	9	7	4	4	6	5	5	7	8	8
Potassium	23	21	19	13	11	15	14	14	19	20	20

Figure 1: Average fertiliser N, P and K applications on grassland from 2005 to 2015.

Agri-environmental scheme membership had a large impact on fertiliser usage. Fertiliser application rates on grassland were on average 34-38% lower on farms participating in an Agri-environment scheme and 3-15% lower for cereal production.

A concern raised by this research is that just over 20% of farms are using lime from year to year. Adequate liming is essential to achieve optimum soil pH levels in order to maximise the effectiveness of fertilisers. Higher rates of liming were associated with dairy farms but also on farms of wide land use potential and farms with higher stocking rates.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Cattle	12%	11%	13%	16%	14%	15%	18%	14%	18%	16%	16%
Dairy	28%	25%	27%	34%	25%	35%	40%	29%	42%	41%	35%
Sheep	17%	18%	20%	26%	21%	14%	20%	13%	24%	24%	19%
Tillage	30%	14%	21%	23%	20%	20%	27%	27%	36%	32%	28%
All Systems	18%	16%	18%	22%	18%	21%	25%	19%	26%	24%	21%

Figure 2: Percentage of farms using Lime by Farm System.

Acknowledgements

Grateful acknowledgement to the research staff involved in the collection and validation of the data and to farmers participating in the Teagasc National Farm Survey.

Teagasc National Farm Survey: Fertiliser Use Survey 2005-2015, 2018. Available: https://www.teagasc.ie/media/website/publications/2018/Fertiliser-Use-Survey 290518.pdf

Getting the Most out of your Stored Slurry

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Summary

- Maximising slurry nutrient value is important for offsetting expensive fertiliser input costs on farms.
- Use of chemical and biological amendments reduced nutrient losses during storage.
- These amendments may have secondary benefits when slurry is applied to field.
- Further investigation needed at field application.

Introduction

As artificial fertilisers represent a large input costs on farms and fertiliser prices remain extremely volatile, the improved slurry utilization has never been more relevant. Slurry is a resource that has the potential not only to improve soil quality and grass growth but also lead to direct savings in the form of reduced artificial fertiliser usage. Typical cattle slurry of 7% dry matter (DM) has a nutrient value of approximately 2.4 kg of nitrogen (N) per tonne. The majority of N in slurry is in the form of ammonium (NH_4) which is readily available for plants, however, it is also susceptible for loss to the air as ammonia (NH_3) gas. The cattle sector (dairy & beef) accounts for 80% of agricultural ammonia emissions in Ireland. Animal housing and manure storage contribute approximately half of these emissions (Figure 1).

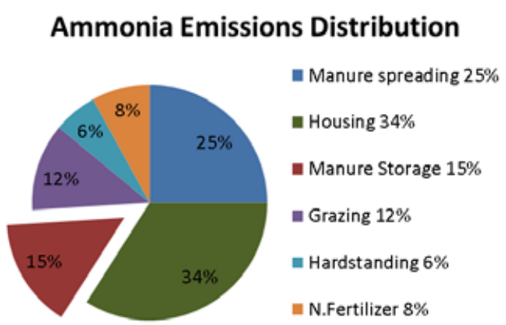

Figure 1: Ammonia emissions distribution from cattle.

What's the problem?

Ammonia emissions during slurry storage equate to large N losses of up to 20 units of N nutrient for every 1000 gallons of slurry or 2.2kg of N/tonne and result in reduced N availability in slurry for land spreading. On top of this agronomic loss, ammonia emissions have detrimental effects on the environment. Ammonia leads to pollution and acidification of waterways and it disrupts the N balance of sensitive ecosystems and also indirectly leads to greenhouse gas pollution in the form of nitrous oxide (N_2O). Ammonia can also lead to other issues such as bovine respiratory problems in poorly ventilated houses and infrastructural damage in the form of rusting and corrosion of ventilation points.

Solution

Recent work carried out at Johnstown Castle evaluated various chemical and biological amendments for reducing ammonical N losses from slurry during the winter storage period. An incubation experiment was carried out investigating ammonia emissions from cattle slurry treated with chemical amendments such as sulphuric acid, acetic acid, ferric chloride and alum, and agricultural waste products such as sugar beet molasses and dairy processing waste under winter storage conditions. The reductions in ammonical N emitted throughout the three month experiment were significant with the greatest reduction of 97% from slurry treated with ferric chloride compared to the untreated slurry (Fig. 2). These amendments also had the added benefit of drastically reducing methane emission from the slurry and reducing crusting, which would suggest potential reduction in slurry agitation costs.

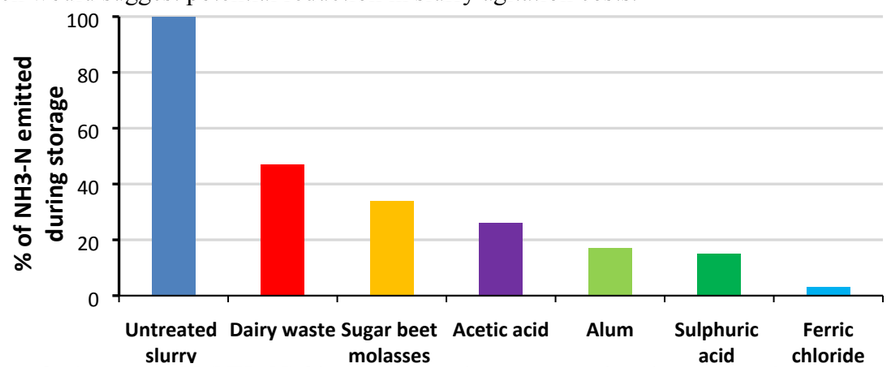

Figure 2: Ammonia-N (NH_3-N) % reductions when compared to the untreated slurry.

The reduction in ammonical N emissions helped preserving the N nutrient content of the slurry during storage. Plant-available N in slurries varied between amendment types and was lowest in the untreated slurry and highest from slurry treated with ferric chloride (Table 1).

Table 1. Available nitrogen (NH_4–N) in untreated and amended cattle slurry post winter storage period

Treatment	Available nitrogen (NH_4-N) in slurry		Nitrogen saving
	kg/t	Units/1000 gallons	kg/t
Untreated slurry	1.16	10 units	0
Dairy waste	1.24	11 units	0.08
Sugar beet molasses	1.68	14 units	0.52
Acetic acid	1.52	13.5 units	0.36
Alum	2.36	21units	1.2
Sulphuric acid	2.22	20 units	1.06
Ferric chloride	3.02	27 units	1.86

Conclusion

The use of selected amendments during winter slurry storage significantly reduced N emissions leading to increased plant available N at slurry spreading time. Following the incubation experiment a pilot-scale study is planned for winter 2019 to further investigate the effects of slurry amendments on gaseous emissions to air, plant availability of slurry nutrients and grass growth response post slurry application. In particular, the use of amendments such as ferric chloride and alum may have an effect on phosphorous availability. Furthermore, different slurry spreading methods, such as low emission slurry spreading techniques, will be used to evaluate the full potential of ammonia savings and improved N use efficiency of slurry. The financial cost-benefit of each amendment will also be evaluated.

NMP-Online; Planning lime & Nutrient Requirements for the Farm

Christy Watson,
Drystock Advisor, Naas, Co. Kildare

Introduction
Irish farmers spent €500m on fertiliser and lime in 2017, a very significant input cost on Irish farms. It is essential that fertiliser inputs are used to maximum effect in driving output while at the same time not adversely affecting the environment. This poses a challenge for advisers to produce fertiliser recommendations that meet crop requirements within the constraints of existing environmental protection legislation. With many factors to be considered it is not a simple procedure to generate fertiliser recommendations for a farmer. Some of the factors that must be taken into account are as follows;

- Soil test results: pH, P & K levels
- Quantity of concentrate feed used on the farm
- Whole farm and grassland stocking rate
- Winter housing period: 16, 18, 20 or 22 weeks
- Crop rotation and grassland use (grazing or silage +/- grazing)
- Use of organic manures-imports and exports
- Farm soil type : mineral vs organic (peaty) soils
- Environmental scheme (GLAS / BPS) or Nitrates derogation participant

So we can see it is no longer as simple as looking at a soil test result and telling the farmer what to apply to any particular crop. An additional complication is the wide variety of fertiliser types used by both livestock and tillage farmers. According to the Teagasc National Farm Survey-Fertiliser Use Survey 2005-2015 thirty nine fertiliser types account for 95% of the applied fertiliser on Irish farms in 2015. So the task of generating a fertiliser recommendation for the average Irish farm is not as simple as we might first believe. It is clear that we need comprehensive and intelligent decision support tools to assist us to develop a fertiliser plan in order to get best outcome for our farmer clients.

The Teagasc Nutrient Management Planning (NMP) Online tool was launched in 2016 and enables agri-professionals to produce high quality nutrient management plans for farmers by combining their expert knowledge of soil fertility with a range of information sources.
The Teagasc NMP Online programme has been designed for agri-professionals to allow them to design a programme of fertiliser management for their clients to optimise production while working within the limits set down for nutrient use under the Nitrates regulations. Some of the key features of the programme are discussed as follows in this paper.

Mapping Tool
The latest aerial imagery and mapping capability is used to map all fields on the farm. All soil characteristics and management factors to be considered are linked to the field unit. This enables maps to be generated for the farmer showing the soil nutrient phosphorus (P), potassium (K), magnesium (Mg) and pH levels for each field with colour coding according to index, to show fields that need particular fertiliser treatment to remedy a significant deficiency, as shown in figure 1.

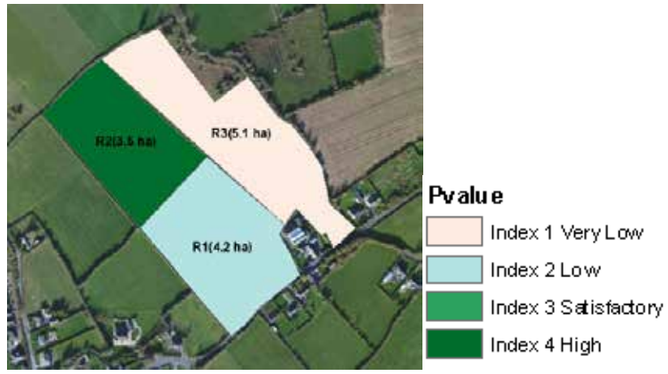

Figure 1. Field map, with field area and soil test P index

Planning
Once the farm is mapped then animal numbers to be held on the farm are entered to generate a stocking rate. Soil sample results for the farm are electronically imported into NMP Online which saves time and eliminates any potential error. Concentrate feed usage is entered for the year preceding the planning year along with details of all animal housing and manure/slurry storage facilities. Using this information the NMP Online programme generates an accurate estimate of the volumes of slurry/soiled water and farmyard manure produced on the farm, giving the farmer and advisor two critical pieces of information. A report showing the quantity of organic manures to be spread or exported and the adequacy of the storage facilities to meet mandatory storage requirements under Nitrates regulations as shown in figure 2. This enables the advisor and farmer to target the valuable nutrient resources in slurry and manures that are available to the fields that have the highest P and K requirements.

Farm Slurry Storage Balance	Total Slurry to be stored on Farm	Volume of Cattle Slurry for Spreading
Slurry Produced (Animals)	514.4 m³	514.4 m³
Cattle Slurry Imported		0.0 m³
Cattle Slurry Exported		0.0 m³
Slurry Produced (Dirty Yards)	0.0 m³	0.0 m³
Slurry Produced (FYM Seepage)	58.1 m³	58.1 m³
Slurry Produced (Dairy Washings)	0.0 m³	0.0 m³
Slurry Produced (Rainfall in open tanks - 16 weeks)		5.1 m³
Total Slurry Produced	572.5 m³	577.6 m³
	125932.3 Gallons	127054.1 Gallons
Dilutes Added to Slurry		63.2 m³
Dilution factor		89.1 %
Total Available Net Storage	622.4 m³	
Surplus Storage Available	49.9 m³	

Figure 2. NMP Online farm manure calculations for slurry storage and slurry produced.

Liming Programme
The first critical aspect of nutrient management planning is to ensure that any fields with low pH are limed adequately. The NMP Online programme generates a lime report which clearly outlines to the farmer where lime is needed and what rate to be applied. An example of the lime application map is shown in figure 3.

Figure 3. Field map with soil pH level and lime application.

Fertiliser Plan - chemical fertiliser
A chemical fertiliser plan can be generated in a map format as well as a tabular version to guide the farmer in a practical way at farm level. Once the nutrient management plan is completed the programme generates a purchase list of the fertilisers recommended for the relevant year as shown in table 1.

Table 1. Annual farm fertiliser shopping list and quantities required

Planned Fertilisers	
Fertiliser	Tonnes
Urea(46%N)	4.7
18-6-12	20.6
CAN(27%N) + S	12.5

NMP Online – farm case study
Good nutrient management planning should increase overall farm profitability by increasing output or helping to reduce existing costs of production, for example leading to a reduction in the need for rented land or a reduction in purchases of forage or concentrates. In 2016 I completed a nutrient management plan using NMP Online for a client who took on an extra 12.5ha block of land on long term lease. The main issues on this land block were old pasture with all soil samples at index 1 for P and 2/3 of samples at index 1 for K, and 1/3 of the farm required 2 tonnes lime per acre.

As this leased farm was to be used for beef production it was decided not to reseed but to address soil fertility and install paddocks, with the aim of maximising grass production. The livestock grazed on the farm and fertiliser use in 2017 are shown in table 2.

Table 2. Livestock type and number and fertiliser use on the farm in 2017

Livestock type	No.	Lime/ Fertiliser Type	Rate (t/ac)
Bulls @ 420kg	40	Lime (autumn 2016)	2 t/acre
Heifers @ 390 kg	28	Urea	½ bag/ac
Suckler Cow + calves	2	18-6-12+S	5 bags/ac
Turnout date: March 13th Weanlings purchased as stock is finished or housed		Total Units/ac N: 113 – P:30 – K:60 – S:20	

The outputs achieved in the first full year of production are shown in table 3, demonstrating the excellent output that can be achieved on old pasture through judicious use of fertiliser nutrients combined with excellent grassland management. The nutrient management plan for this block of land addressed the existing soil fertility issues, and resulted in 13.75 tonnes/ha DM of grass grown.

Table 3. Lime and fertiliser costs and livestock and grass outputs and revenue generated.

Lime & Fertiliser inputs	Cost (€)	Outputs	€
Fertiliser	€2,812 (€225/ha)	240 grazing days	
Lime	€400	9,000 kgs Live Wt	€21,150
Outblock:		60 silage bales	€1,500
20% more fertiliser	(+€37/ha)	Grass grown	13.75 t/ha DM
Total Cost €3,212		Total Revenue €22,650	

Conclusions:
- NMP Online is an essential tool for delivering fertiliser and lime advice to farmers.
- Nutrient recommendations are presented in a very user friendly and practical format.
- The NMP Online maps create a visible link to soil fertility results on a field-by-field basis and for map based fertiliser and lime application programmes to be generated.
- As well as giving guidance on grassland and crop nutrient requirements, NMP Online also provides critical information on regulatory compliance.
- By following good nutrient advice farmers can reduce their costs of production, by increasing grass production expensive rented land can be eliminated.

Growing Lots of Grass!

Mark Heffernan
The Heffernan Family Farm,
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Summary

- Our objective is to grow and utilise as much grass as we can and in turn convert that grass into milk solids.
- Soil testing and fertiliser planning every year are important to ensure the farm can grow lots of grass.
- White boards in our dairy show a map of soil fertility and slurry application strategy for each paddock.
- Soil tests results in January 2017 indicate that about 60% of the soils on the farm have a deficiency in lime and potassium (K).
- We have spread 800 tons of lime in 2017 to help improve the soil pH.
- Muriate of potash (50% K) was the main fertiliser product used to tackle our K deficiency.
- Slurry is targeted towards soils with highest requirement for K.

Introduction

Our farm consists of about 200 ha of land which is in 3 blocks. The home farm is the milking platform of 132 (95 ha owned, 37 ha leased). There are 2 outside blocks; Outside block 1 is 23.5 ha which is all leased and the second Outside block 2 is 37.5 ha which is also all leased. The outside blocks are used for grazing the replacements for the dairy herd and for silage production. For many years the home block of 95 ha was farmed as a mixed farm with typically 40 dairy cows, 300/400 breeding ewes, and a cattle and a tillage enterprise. Now the farm is completely focused on dairy production and is farmed as a family partnership made up of my parents, myself and my brother Liam.

The farm has evolved overtime and has grown in cow numbers over the last decade to become a dairy farm. This is outlined in the table below.

Table 1. Dairy cow numbers between 2008 and 2018 on the farm

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Cows	70	79	102	104	120	144	165	224	295	346	450

Growth in cow numbers has been matched with both an increase in land base but also an increase in the grass grown per ha on the farm. Outlined below is the grass production pattern over the last 10 years. There has been a 50 % increase in grass production on this farm. The length of our grazing season is now about 290 days.

Table 2. Average grass grown (t/ha) between 2008 and 2017 across the farm.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Grass t/ha	12.6	14.3	13.6	15.6	15.9	15	16.5	17.5	16.5	19.0

Grass Management

We began measuring grass in 2008 and have continued to do so ever since. We walk the farm weekly and twice a week in times of high growth. Last year the farm was walked and grass cover was measured 50 times. This information is then entered into the Pasture Base Ireland web-based programme. Pre-grazing covers and cover per cow are 2 key figures we use when making decisions about grazing.

The weekly farm cover measurements are also marked onto a farm map which is printed on a white board and located on the wall in the dairy. This is an essential piece of equipment as all members of the family can clearly view the grass supply on the farm every week and the next paddocks to be grazed.

Farm Performance

Currently there is a stocking rate of 3.3 cows/ha on the milking block and the overall farm stocking rate is around 2.75 LU/ha. Our focus on output and profit on this farm is based on high grass utilization. About 550 kgs meal/cow was fed in 2017 and the rest of the herds diet was made up of grazed grass and grass silage. The farm sold over 480 kgs milk solids/cow to GII (Glanbia) in 2017 or over 1400 kgs milk solids/ha from the milking platform. The target is to sell over 1500 kg/ha of milk solids from a predominately grazed grass diet.

Soil Fertility Management

Our farm is soil tested on a regular basis (about 3 times in 5 yrs). Our plan is to soil sample the farm every 2 years. We are due to soil sample our milking platform in January 2019. We apply for a Nitrates Derogation every year and a nutrient management plan is drawn up by our Teagasc advisor. This forms the basis of our fertiliser and slurry plan for the year. The soil fertility analysis for each paddock is marked onto a farm map which is printed on a white board and located on the wall in the dairy. We have a paddock slurry map on a white board also. These are essential pieces of equipment as all members of the family can clearly view where compound fertilisers and, or, slurry needs to be targeted i.e. low index paddocks.

In January 2017, about 60% of the farm was low in lime and index 1or 2 for potassium (K). We have a lot of soils index 3 or 4 for phosphorus (P). Since then we have spread 800 tonnes of lime (500 tons on the milking platform). A small amount of lime is required this autumn on about 10 ha. Our main compound fertiliser application is in spring with 2 bags of N-P-K: 18-6-12 /acre. We have also spread fertilisers high in K (Muriate of Potash 50% K in autumn time) to help fix our K deficiency and we target slurry on our paddocks which are low in soil K or that are cut for silage (surplus grass).

We believe our farm responds well to sulphur application and we start applying sulphur in April. We use a CAN 27%N + S type product where about 25 units/acre of sulphur is applied to every paddock every year.

Conclusions

Our farm aims to grow and utilise as much grass as we can and in turn convert that grass into milk solids. Soil testing is carried out every 2 years and this forms the basis of our fertiliser and slurry plan for the year. Farm maps printed on white boards located in our dairy help us keep track of soil fertility for every paddock and slurry application for each paddock. This has proven to be a successful strategy and has helped us to increase grass growth over the last decade.

Notes

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5 STEPS TO BETTER SOIL FERTILITY

1 SOIL TESTING

- Provides you with vital information about your soils
- A foundation for your fertilizer plan
- A small farm expense costing in the region of €1.25/ha/yr and is valid for 5 years
- A standard soil test will give the soils fertility status as follows; pH, lime requirement, phosphorus (P) and potassium (K).

2 SOIL PH & LIME

- Lime improves the availability of Nitrogen, Phosphorus, Potassium, Sulphur, Calcium and Magnesium
- Lime at least every 5 years
- Ground limestone can be spread at any time
- Apply lime as per soil test report. Avoid over-liming as it can result in trace element imbalances.

3 TARGET INDEX 3 FOR P & K

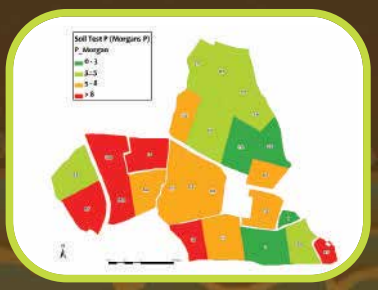
- Index 3 is the optimum level for crop growth
- Only by soil testing will you know your P & K levels
- Index 4 soils (high fertility) are a resource - use them to save money on fertilizer
- Index 1 and 2 soils (low fertility) need additional nutrients
- Monitor your soil fertility by looking at previous analysis.

4 SLURRY & MANURES

- Plan when and where slurry/manure will be best utilised
- Aim to apply slurry in spring during moist cool conditions
- Apply slurry and manures on land that requires P & K
- Take account of nutrients contained in slurry if applying chemical fertilizer to the same area
- Always observe buffer zones from watercourses and wells.

5 NUTRIENT BALANCE

- Develop a fertilizer plan for your farm
- Get the best value from fertilisers and organic manure
- Enhance crop yield and animal performance
- Reduce environmental risks due to field losses of excess nutrients
- Potential cost savings when all nutrient inputs are accounted for.



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