



Soil pH & Lime

The Fertilizer Association of Ireland
In association with Teagasc



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Introduction

The benefit of liming Irish soils is well known and was one of the earliest soil management practices that farmers adopted to improve the productivity of soils. It is no different today, as managing soils to keep them in the optimum soil pH range offers many benefits, including maintaining productive ryegrass swards and increasing the availability of major (N, P & K) soil nutrients.

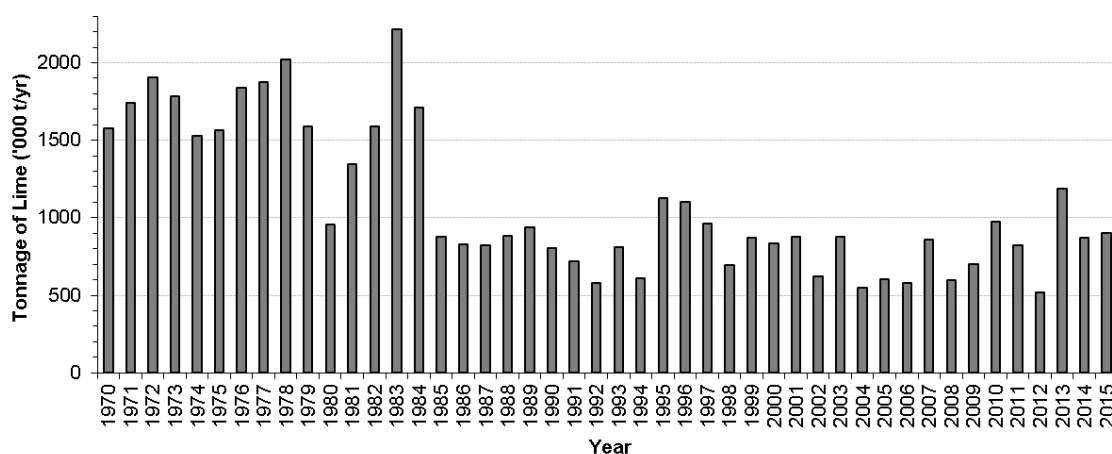
Over the last number of decades, the application of lime to Irish soils has decreased dramatically. For example, in the 1970's and early 1980's, Irish farmers applied an average of 1.7 million tonnes of lime to control soil acidity and improve the productivity of grassland and tillage cropping. Since 1985 the average amount of lime applied has been 800,000 tonnes per year which is less than 50% of the amount applied during the 1970's and 80's. However, over the last 2 decades, lime applications have again increased. For example, in 1995 and 1996, lime applications exceeded 1 million tonnes. This can be directly attributed to targeted measures within the environmental scheme known as REPS which promoted the use of lime as a component of nutrient management planning.

Despite the importance of lime, current indications show that a large proportion of both grassland and tillage soils now require lime. For example, soil samples analysed by Teagasc show that on average in 2015 65% and 55% of grassland and tillage soils are below the optimum pH. In some counties up to 80% of soils have a lime requirement. This is a major limiting factor to the productivity of our soils and is a serious impediment to achieving production targets for the industry.

Correcting soil pH is the first step to improving the productivity of soils and exploiting our competitive advantage on livestock farms of maximising the level of grazed grass in animal diets.

This booklet highlights the importance of adopting and putting in place a liming plan for grassland and tillage farms. It will present the latest research findings on the agronomic and economic benefits of liming for Irish farmers.

Lime usage 1970 - 2015





Lime deficiency in fodder beet

Lime as a soil nutrient

Lime is a natural and cost-effective soil conditioner, and corrects soil acidity by neutralising acids present in the soil. This allows the soil biology and earthworms to thrive and break down plant residues, animal manures and release nutrients required for healthy plant growth.

Lime neutralises soil acidity and reduces the availability of harmful heavy metals to plants which are present in acidic soils. By neutralising soil acidity, the availability of nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and calcium (Ca) increases. Soil pH has a major effect especially on the availability of soil phosphorus.

Lime supplies calcium and / or magnesium as crop nutrients - calcium being essential for healthy bone development in livestock and in milk production. Magnesium lime is a cost effective route to correcting a soil Mg deficiency which is essential for many crops such as cereals / beet / potatoes etc.

Lime can have a beneficial effect on soil structure, particularly on some of our heavier soils, by assisting in building up soil crumbs, keeping heavier soils open and friable. This also aids soil drainage in some soils, in that the land is warmer and easier to prepare a fine tilth in the soil for particular crops.

Lime is as important as any other fertilizer input on the farm

Soil pH: Did you know.....????

- pH is a chemical measurement of acidity
- The pH scale goes from:
 - 1 (Strong acid) to 7 (neutral) to 14 (strong alkali)
- Irish Mineral Soils:
 - 90% have a soil pH between 4.4 and 7.1
 - 50% have a soil pH between 5.0 and 6.2
- Target soil pH:
 - o Grassland → 6.3
 - o Tillage → 6.5
 - o Peat soils → 5.5

Soil pH & Lime Requirements

Soil pH is a measure of the soils acidity / alkalinity and is measured as part of a standard soil test. Soils above pH 7.0 indicate increasing alkalinity while soils below pH 7.0 indicate increasing soil acidity.



The aim should be to maintain grassland soils between pH 6.0 and 6.3 while the optimum pH for tillage crops is between pH 6.5 and 7.0.

Lime requirement is determined by measuring the soils buffering capacity which is determined by a buffer solution called Schumacher McLean and Pratt (SMP) and is reported as “SMP pH” on the soil test report. The buffer pH determines the lime requirement to adjust the soil pH to the target pH for the crop. The buffering capacity of the soil will depend on the soil type, such as whether it is a light soil or a heavy soil. In general, heavy soils will tend to have higher lime requirements compared to lighter type soils.

Peaty soils have lower levels of aluminium (Al) and manganese (Mn) present and therefore the target pH required is lower at pH 5.5 to 5.8.

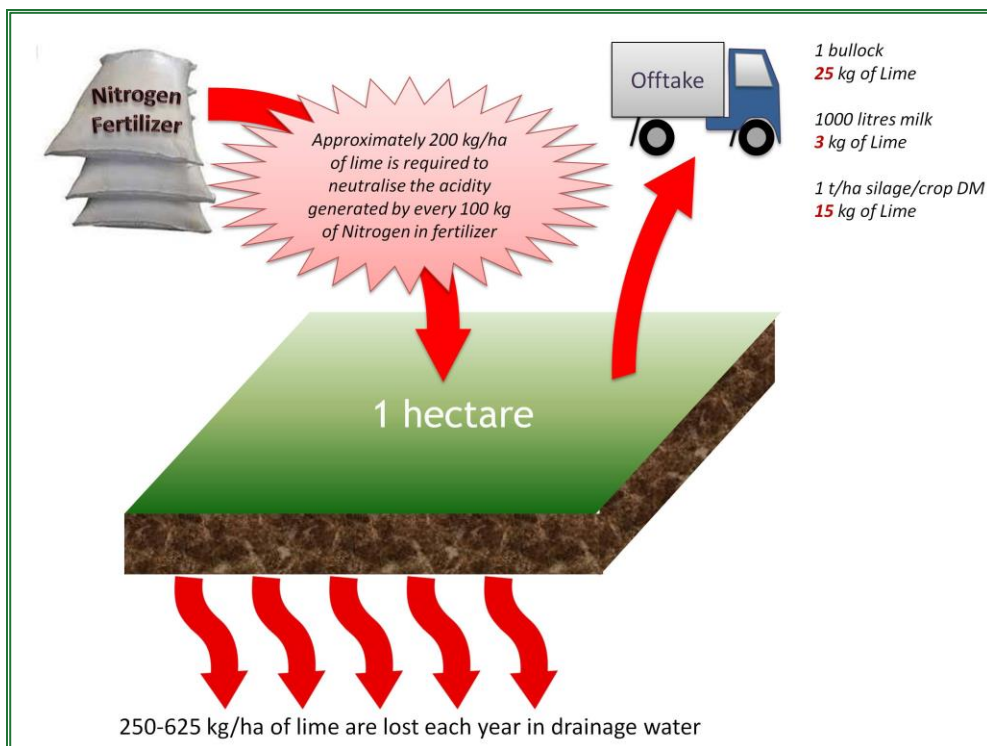
Lime advice is reported in tonnes per acre or per hectare on soil analysis reports. Soil pH and lime requirements will depend on the soil type, the crop being grown, and the previous lime use. For example, crops will vary in their sensitivity to acidity / alkalinity and therefore require different soil pH levels. For example, barley or beet requires soil pH 6.5 to 7.0 while the optimum for grassland is between pH 6.0 to 6.3.

A soil test is the best indication of the lime requirement of a soil. Lime should only be applied on the basis of a recent soil test report (1 to 3 years old).



Lime Offtake & Losses

Lime has to be applied on a regular basis to control soil acidity as lime is continuously leached from the soil, mainly through drainage water. The use of N fertilisers, and removals in crops and livestock also remove lime from the soil. Typical annual off-takes of lime are shown below. Loss through drainage will vary from 250 to 625 kg/ha/year. Lime required to neutralise acidity produced by fertiliser N use will vary from 180 to 220 kg/ha/year per 100 kg/ha of N applied as CAN or urea, respectively. Offtakes by grazing animals are relatively small, estimated at 3 kg/litre of milk, and 25 kg per finished beef animal. Estimated crop offtakes (grass silage or cereals) are 15 kg per tonne of dry matter. High rainfall and high N use are the 2 main drivers of soil acidity on Irish soils.



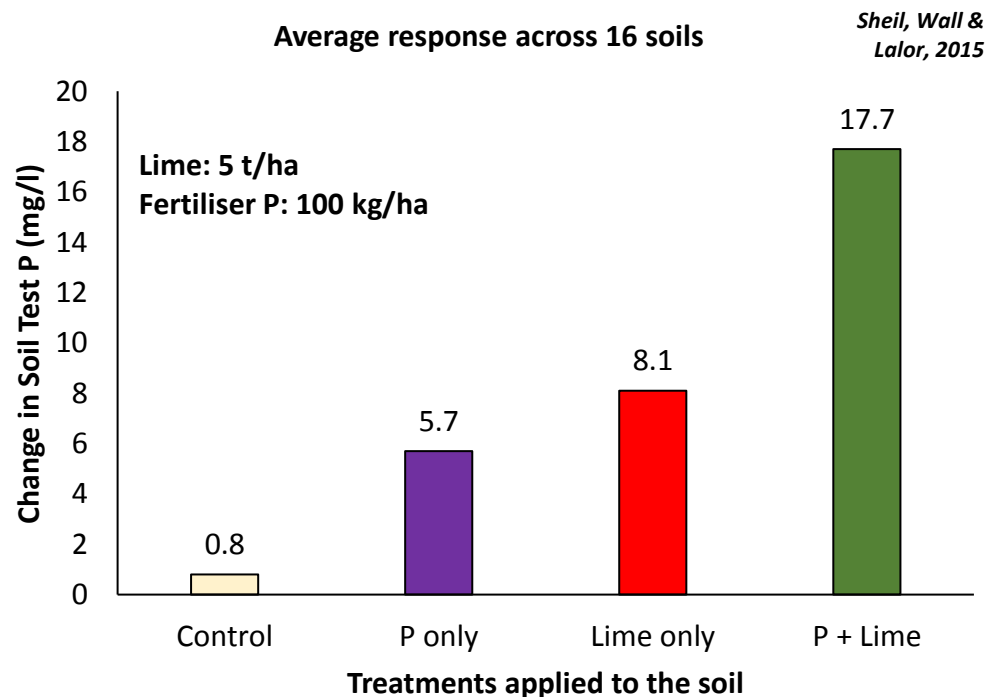
Ground limestone is a cost effective route to replacing lime offtakes

Having the soil pH at the right level will maximise the availability of other nutrients

Effect of soil pH and nutrient availability

Soil pH has a large influence on soil nutrient availability. Aim to maintain mineral soils in the range pH 6.5 to 7.0 and peat soils pH 5.5 to 5.8 to maximise nutrient supply.

Recent research from Teagasc, Johnstown Castle clearly shows the importance of lime in relation to the availability of soil P and the improved efficiency from P applied in bagged fertiliser. The graph below shows the benefit of lime in un-locking soil P (red bar) and increasing the efficiency of freshly applied P (green bar). This shows that the application of lime for pH correction is the first step to consider when building soil P levels.



Average change in soil test P (Morgan's) across 16 soils treated with Lime (5 t/ha of lime), P fertiliser (100 kg/ha of P), and P + Lime and incubated over 12 months in controlled conditions.



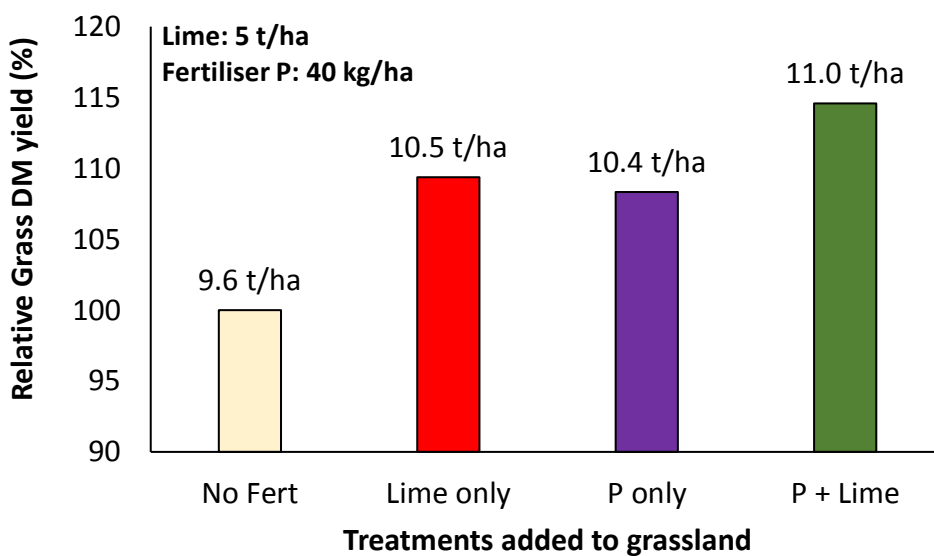
Importance of Soil pH for Grass Production

Correcting soil pH close to the optimum pH will increase the annual production of grass. The graph below shows the grass yield response to lime and P fertiliser application. The application of 5t/ha ground limestone (red bar) produced similar grass yields compared to the application of 40 kg/ha P fertiliser (purple bar). However, the addition of lime + P fertiliser in combination (green bar) produced the largest grass yield response (1.5 t/ha more grass than the control). These results show how effective lime is at unlocking P that is stored in the soil (from previous fertiliser and manure applications) and improving the efficiency of freshly applied fertiliser P.

Optimum soil pH of 6.3 in mineral soils will increase ryegrass persistence and productivity

Average response across 2 grassland sites

D.P. Wall, 2015



Average soil pH:

5.2

6.4

5.2

6.4

Relative grass DM yield response in grassland treated with Lime (5 t/ha of lime), P fertiliser (40 kg/ha of P), and P + Lime over a full growing season.

Grassland - Target soil pH

Lime is an essential ingredient for grass production. The target for grassland mineral soils is pH 6.3. The target for peaty type soils is pH 5.5. Maintain high Molybdenum (Mo) soils at a pH <6.2.

Maintaining the optimum soil pH has many benefits, including:

- Increased biological activity of soils which increases the turnover of major nutrients (N, P, K, Mg, Ca & S)
- Makes P and K more available in the soil
- Increases earthworm activity which improves soil structure
- Provides a valuable source of calcium and/or magnesium necessary for healthy plant and animal growth
- Increased survival & productivity of ryegrass & clover

Grassland soils can release up to 80 kg/ha more N per year when restored to the target soil pH.



Tillage - Target soil pH

Some tillage crops can be more sensitive to acid soil conditions than others and therefore require different target soil pH levels for optimum growth and to produce high yields. The target soil pH for a number of important tillage crops are shown in the table below.

Ideally, soils should be limed to the target soil pH for the most sensitive crop in the rotation.



Aim for soil pH 6.5 for spring barley crops

Optimum soil pH for a range of crops on mineral soils

Crop	Optimum soil pH
Beet, Beans, Peas and Oilseeds	7.0
Cereals and Maize	6.5
Potatoes	6.0
Peaty Soils	5.8

Cereals - Barley is the most sensitive cereal crop to soil acidity.

For high yields, a pH at or above 6.5 should be maintained. Barley grown on acidic soils can result in a severe reduction in grain yield.

Wheat is more tolerant of acidic soils compared to barley. However, it is still desirable to maintain a pH 6.5 in order to avoid a yield penalty in wheat crops. Application of lime in high Take-All years will accentuate the problem especially where high rates are applied.

Oats is the most tolerant of the cereal crops to acidic soils and will grow at soil pH of 5.8 to 6.0.

Beet - Beet is one crop that requires high soil pH levels as it utilises soil nutrient better at neutral soil pH (7.0). Ideally lime should be applied in advance of sowing the beet crop. Where lime recommendations advise in excess of 7.5 t/ha, it is good practice to apply the lime over a 3-year period. This helps avoid too much lime applied at any one time which can lead to boron and manganese deficiencies. In addition, certain soil acting herbicides and pesticides are not as effective in acid soil conditions.

Return on Investment from Ground Limestone

Grassland

When the pH of grassland soils is maintained close to the optimum range, an increase in grass DM production of at least 1 t/ha/year can be achieved. In addition to P and K release from the soil, N supply worth up to €80 euro may also be achieved, boosting spring growth in particular. If this extra grass production is utilised by the grazing livestock it has the potential to reduce farm feed bills by at least €181/ha year. One tonne of additional grass production each year over a typical 5 year liming period (5 t/ha lime applied) represents a 7:1 (grass €181/ton; lime €25/t) return on investment in lime, plus the potential for reducing fertiliser costs into the future.

- A dairy farm making a €100 investment in lime will get an annual return of approximately €725 through extra grass production.
- This represents a return of €7.25 for every €1 invested in lime.

Tillage

- Research shows average cereal grain production response of at least 1.5 t/ha from lime alone
- This is worth €225/ha of extra grain (15% moisture content) (assuming grain price of €150 /t)
- Return on investment - maintenance lime application costing €33/ha/year enabling the production of extra grain worth at least €225/ha/year
- This represents a return of €6.82 for every €1 invested in lime



Investment in lime will increase long-term soil productivity

Lime application gives a **7:1** return on investment

Lime Quality

The quality, specification and standards for Ground Limestone are currently regulated by SI 248 of 1978.

Minimum standards for ground limestones include:

- Product must have a Total Neutralising Value (TNV) greater than 90 per cent
- 100% must pass through a 3.35 mm sieve (*Very coarse limestone is less effective at increasing pH due to lower reactivity, and needs additional time to break down and dissolve*)
- At least 35% must pass through a 0.15 mm sieve (*finely ground*). *Therefore, a minimum of 350 kg/tonne of ground limestone is fine, very reactive and will begin to work immediately*
- The moisture content must be less than 3.0%

Granulated Liming Products

Granulated lime is composed of fine lime and therefore is all very reactive (i.e. 100% will react within the year of application). They should be considered like a fertiliser in that they should be applied annually.

Where soil pH is close to the target level, granulated lime could be considered as a liming product for soil pH maintenance. The rate of application for maintenance will be soil and farm-specific depending on the level of lime loss and acid production. Suppliers recommend applying granulated lime at a rate of approximately 1:3 (compared to ground limestone) this would equate to a granulated lime application of 150 to 300kg/ha annually to maintain soil pH in optimum range. Consider costs over a 3-5 year period when considering liming options.

Lime Plan for the Farm

It is good practice to apply lime every year to a proportion of the farm based on recent soil analysis. This will ensure that soil pH is maintained in the optimum range for both grassland and tillage crops.

Correcting soil acidity is the first step in fertiliser planning and goes hand in hand with efficient management of fertiliser and manure applications.

A planned approach to farm lime planning will ensure the following:

- A more systematic approach to liming
- Quantification of total lime requirements for the next 3-5 years.
- Provide a planned programme to address fields with large lime requirements
- Planned financing for lime to spread costs over a number of years
- Identification of appropriate windows of application based on weather or soil conditions

*Have a
'LIME PLAN'
prepared
for the
farm.*

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