FACTSHEET

GREATSOILS

Soil pH – how to measure and manage it based on an understanding of soil texture

Figure 1. Lime spreading

Background

Maintaining optimum soil pH values in all parts of the field is essential in order to maintain soil quality and health, crop quality and yield. This guidance document explains why soil pH is important and outlines the impact of soil type and texture on pH. It describes how and when to test soils for pH, how to calculate the amount of lime or other neutralising materials required, which liming product(s) to use and how and when to apply them.

Action points

- **Know the texture and type of soils on your farm and on rented land**
- **Test soil pH regularly (at least once every four years and ideally once every two years if you are a high value crop grower on a light soil) and interpret the results correctly for the soil type**
- **Choose an appropriate sampling strategy for your fields and be prepared to spend money on more samples where you find evidence that soil pH could be impacting on crop yield or where you suspect big differences in soil pH within fields**
- **Be aware that some organic materials applied to improve soil health (eg composts, digestates and some types of paper crumble) have a liming (or neutralising) value. Get the materials tested for their liming value to determine the likely impact of using them at different application rates on soil pH**
- **Be aware of the differences between different types of liming agents and their relative advantages and disadvantages. As well as bearing in mind price, choose those appropriate for your soils**

Soil pH is a measure of the relative acidity or alkalinity of a soil. While the scale goes from 0 to 14 (with a neutral pH represented by 7.0) most agricultural soils have pH values of between 5.5 and 7.5. The pH scale is logarithmic; that is a pH of 5 is ten times more acidic than a pH of 6. The natural pH of a soil is determined by its chemical composition, but most agricultural soils with natural pH values of less than 7 will gradually acidify over time and regular applications of lime will be needed to maintain soil pH at target (Figure 1).

Soil pH has a profound effect on nutrient availability to crops, with most essential plant nutrients being most available to most crop plant species within the pH range of 6.0 to 6.5. Crop quality and yield can be severely affected where soil pH is not maintained close to target for the soil and crops in question and total crop failure is possible in vegetable crops where trace element deficiency has resulted from inappropriate soil pH. Soil pH also affects uptake of potentially toxic elements (PTEs), with PTEs such as cadmium becoming more available for crop uptake at lower pH values.

Soil pH also affects the numbers, diversity and functions of beneficial and pathogenic micro-organisms as well as the larger organisms including both soil-dwelling pest species and beneficial macrofauna species. For example, the soil-borne pathogen *Plasmodiophora brassicae*, which causes clubroot in vegetable brassicas and oilseed rape, prefers more acidic soils, and liming to raise the soil pH is a management option for clubroot control. Earthworms are most abundant and active in soils with pH values between 5.5 and 7 and most species cannot function well in soils with pH values lower than 5.0.

Failure to correct soil acidity can cause substantial yield losses and a decline in soil quality and health. Over-use of lime (or certain organic materials which have neutralising values) can create problems with trace element availability. A survey by the Professional Agricultural Analysis Group in 2015/16 found that soil pH was less than 6.0 in 17 per cent of arable soils tested and less than 5.5 in 19 per cent of grassland soils tested.

Understanding soil types and soil texture

You can more effectively manage the pH of your soils if you understand their key properties including, in particular, the depth, texture and organic matter content of the main horizons (or layers). Texture can be defined as the relative proportions of sand, silt and clay in a soil. The depth, texture and organic matter content affect the target pH value which you should set for each field and will help determine how much lime (or liming agent) to add and how often.

UK soils have been comprehensively surveyed, tested, classified and studied over the past 75 years, but it is only very recently that practical information on soil types has become widely available digitally and online through the development of web-based tools.

In England and Wales, the LandIS Soils Portal, developed by Cranfield Soil and AgriFood Institute (CSAI), allows users to access a wide variety of information on soils.

Within the portal, the Soilscapes website (**www.landis.org.uk/soilscapes**) conveys a summary of the broad regional differences in the soil landscapes of England and Wales. It has been tailored to provide extensive, understandable and useful interpreted soil data for the non-soil specialist. It is not intended as a means for supporting detailed studies of farm soils or to support commercial activities. For such applications, a parallel service, Soils Site Reporter (**www.landis.org.uk/services/sitereporter.cfm**) provides comprehensive reporting for specific locations.

In Scotland, the National Soils Database for Scotland is held by the James Hutton Institute and the SIFSS (Soil Information for Scottish Soils) website has been created with the aim of allowing users to access information on soils throughout Scotland (**sifss.hutton.ac.uk**). SIFSS is also available from the same web page as a free iPhone app for you to find out about the soil types in your area, discover the differences between cultivated and uncultivated soils and also to examine a range of key indicators of soil quality.

Also available for soils throughout the UK is the British Geological Society (BGS) mySOIL smartphone app (**www.bgs.ac.uk/mySoil**). This app seeks to promote the distribution of freely available data through smartphone and tablet technologies. mySoil lets you take a soil properties map of Britain with you wherever you go, helping you learn about the soil beneath your feet.

At the national level, soils are often mapped by Major Soil Group or sub-group, but at the farm level, soil series is the mapping unit and there are typically between two and four soil series on any one farm. Being able to identify the soil types on your farm and linking them to knowledge of the soil characteristics is an important first step in helping you to manage your soils more sustainably and profitably. Recent improvements in the availability of soils information online means that farmers can learn about their own soils easily and with very little cost.

Nutrient Management Guide (RB209) and Scottish Technical Notes

A simplified approach to soil types is taken in the **Nutrient Management Guide (RB209)** and Technical Notes, although the definitions used differ between England/Wales and Scotland. In England and Wales, mineral soils (<10 per cent organic matter) are grouped into light sand; shallow; medium; deep clayey and deep silty soils. Organic soils are defined as containing between 10 and 20 per cent organic matter and peaty soils more than 20 per cent organic matter.

In Scotland, mineral soils (<15 per cent organic matter) are grouped into shallow; sands; sandy loams and “other mineral soils”. “Other mineral soil” textures include sandy silt loam, silt loam and clay soils (with >15 per cent clay content). Organic soils are grouped into humose (between 15 and 35 per cent organic matter) and peaty soils (>35 per cent organic matter).

Determining soil texture

Soil texture can be determined accurately through laboratory analysis, but for practical purposes, it can be assessed by hand using the following method:

Take about a dessert spoonful of soil. If dry, wet up gradually, kneading thoroughly between finger and thumb, until the soil aggregates, or crumbs are broken down. You need to add sufficient moisture to hold the soil particles together and to allow the soil to show its maximum stickiness. Follow the instructions in Figure 2 below to identify the textural class.

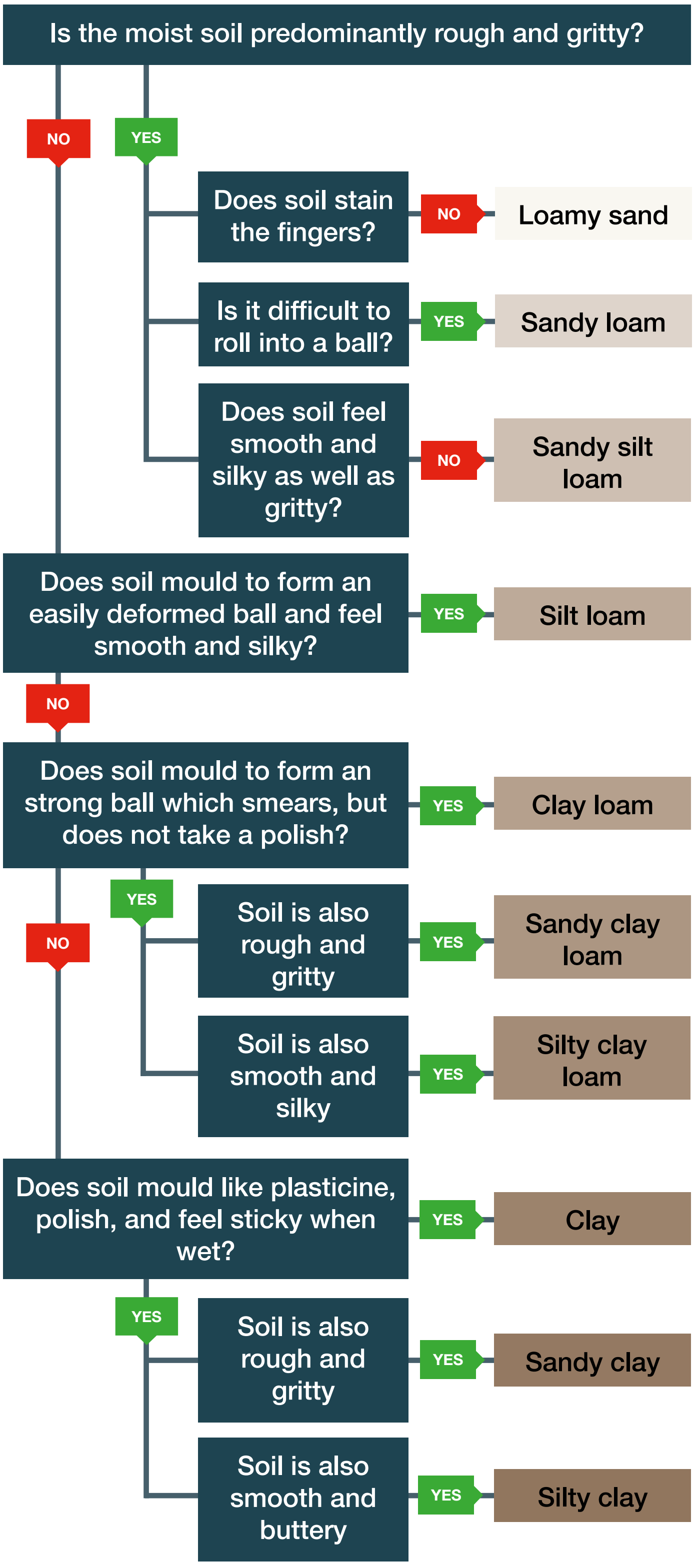

Figure 2. Assessment of soil texture, courtesy of SRUC

Table 1. Target values for soils in England, Wales, Northern Ireland and Scotland

	Optimum soil pH			
	England, Wales, Northern Ireland		Scotland	
	Mineral soils	Peaty soils	Mineral soils	Peaty soils
Continuous arable cropping	6.5	5.8	6.0–6.2	5.7–5.9
Continuous grassland	6.0	5.3	6.0	5.3–5.5

In arable rotations, maintaining soil pH at 6.5–7.0 is justified when growing acid-sensitive crops, such as sugar beet

Soil pH targets and soil pH testing

There are broad differences between soils in England and Wales and Scottish soils. For example, Scottish soils often have naturally lower pH levels than those in England and they often contain higher organic matter levels. For these and other reasons, soil testing methods and recommendations for use of lime and fertilisers have been developed separately for the Nutrient Management Guide (RB209) for use in England and Wales from those in Scotland (SRUC, Technical Note 656).

Recommended target soil pH values for England, Wales and Northern Ireland and for Scotland are shown below in Table 1 for arable and grassland on mineral and peaty soils.

Different laboratories use different solutions when testing soil pH and care must be taken when interpreting the results. In England and Wales, water is used. The (Scottish) SRUC soil testing lab uses calcium chloride solution (0.01M $CaCl_2$), but adds 0.6 to their results so that they can be compared with the results of tests done using water. Some other labs are now using calcium chloride solution too, but do not add 0.6 to their results before sending them out to farmers.

It is important to clarify whether water or calcium chloride solution has been used and whether 0.6 is being added to the results where calcium chloride solution has been used. Only if this is known can soil pH values be compared with target values and past results so that appropriate management decisions can be made for the soil in question.

Lime recommendations for different soil types

Lime recommendations in the **Nutrient Management Guide (RB209)** take the form of look-up tables. In their routine soil analysis package, the SRUC soil testing lab measures dry soil bulk density along with pH and provides a lime requirement for each soil in tonnes per hectare (t/ha) of ground limestone. Look-up tables are also provided in the SRUC (2014), which are similar to those in the **Nutrient Management Guide (RB209)**.

Although the recommendations and the way in which they are presented differs somewhat between England/ Wales and Scotland, the principles are very similar. For each field, the amount of lime to apply will depend on the soil pH, soil texture, soil organic matter content and the target pH.

Clay and organic soils require more lime than sandy soils to increase the soil pH by one unit, but sandy soils will generally require more frequent liming. Lime recommendations are usually for a 20cm depth of cultivated soil or for a 7.5cm depth of grassland soil.

Where soil is acid below 20cm and soils are ploughed for arable crops, a larger dressing of lime should be applied. However, if more than 10t/ha is needed, then half should be deeply cultivated in, with the remainder applied to the soil surface and worked in. Where cultivations are minimal, no more than 7.5t/ha should be applied in a single application. Lime should be applied at least six months prior to sowing in order to allow soil pH to increase before sowing, and before application of phosphate fertilisers.

Types of liming materials and their use

Liming materials are usually purchased on the basis of price relative to their neutralising value, that is the extent to which they can increase soil pH and, to the fineness of the products. The more finely ground the product, the more rapidly soil pH tends to rise following application. However, properties other than the neutralising value should in some cases be taken into account (eg calcium content, magnesium (Mg) content), the additional value gained from organic matter in the liming material, such as with some types of compost, or phosphate content, as with some types of biosolids.

Some UK farmers and growers are now testing their soils for base cation saturation ratios, which places emphasis on the importance of the ratio between the quantities of certain cations present including Ca and Mg. A common question is whether there is a detrimental effect from adding extra Mg (in the form of magnesian limestone) where soil pH is below target but where the soil Mg is above the target of Index 2 (moderate in Scotland).

Calcium can improve the structure of heavy soils by causing the soil particles to move apart, thus improving aeration and drainage, whereas magnesium makes the soil particles stick together.

It is the ratio between the concentrations of these two cations that has an impact on soil structure. As a general rule, if your soil has a Mg index of 3 (high in Scotland) then it would be wise to consider applying a liming agent which contains little or no Mg rather than choosing magnesian limestone. This may also help to avoid potash (K) deficiencies which can be brought on by an excessively high Mg:K ratio.

A considerable amount of research has been done worldwide aimed at interpreting the role of cation ratios on soil structure. However, very little of it clearly demonstrates the benefit of having a particular ratio of Ca:Mg (both of which are essential plant nutrients). It would be quite possible to achieve the "chosen ratio" between them, yet have a soil which contained either very low or very high levels of both. Although there is no definitive ratio, a ratio of extractable Ca:Mg in clay soils of between 4:1 and 7:1 is expected to ensure that Mg is not excessive and likely to be detrimental to soil structure and aeration.

Liming agents are labelled as having a neutralising value (NV) compared with pure calcium oxide (CaO). Lime recommendations are usually given in terms of ground limestone or ground chalk (which has a NV of 45–55 per cent) but other liming materials can be used providing the application rate is calculated based on their known NV. Table 2 shows the NV (or typical NVs) of common liming materials including some bulky organic fertilisers.

It is important to take into account the NV of certain organic materials, which are often applied for reasons other than their NV (for example for the phosphate in biosolids or the organic matter in composts).

Table 2. NV or typical NV and average nutrient contents of common inorganic and bulky organic liming materials

Liming material	NV (per cent of CaO)	Also contains (kg/fresh tonne)				
		N	P_2O_5	K_2O	MgO	SO_3
Ground chalk/Limestone	50–55					
Magnesian limestone	50–55				150	
Hydrated lime	~70					
Burnt lime	~80					
Sugar beet lime	22–32		7–10		5–7	3–5
Mushroom compost	10–30*	6.0	5.0	9.0		
Lime stabilised biosolids	12–17	8.5	26.0	0.8	8.5	2.4
Green compost	2–10	7.5	3.0	5.5	3.4	2.6
Green food compost	5–15	11.5	3.8	8.0	3.4	3.4
Paper crumble	2–4	Nutrients depending on type and source				
Cattle FYM	0	6.0	3.2	8.0	1.8	2.4

*No published UK average value for the neutralising value of mushroom compost has been found. The value has been estimated based on results obtained from testing a limited number of samples

Figure 3. PAS 100-accredited food/green compost, which can be a useful limiting agent

Sometimes soil pH can change in ways which growers don't expect.

In 2002, a Scottish grower with an arable and vegetable rotation began using quality food/green composts in an effort to improve the health and quality of soils in some of his fields (Figure 3). He had tested his soil pH just prior to starting to take compost and it was between 6.3 and 6.5 – on target for an arable/vegetable rotation in Scotland.

He applied food/green compost at 20t/ha each year for three years in a row to his chosen fields and felt that by year four, the soil was more water-retentive in dry spells and easier to work in wet conditions. However, he then started seeing trace element deficiencies in several crops (eg manganese deficiency in cereals).

He then conducted tissue analysis on his crops and tested his soil for pH. The crops were indeed manganese-deficient and the soil pH was sitting at 7.6. What the farmer had failed to realise was that this particular compost had a significant neutralising value (as some, but not all, composts do).

Applying this compost had had a measurable (and in this case undesirable) impact on the pH of his soils.

When applying organic materials which might have a neutralising value (in particular composts [including mushroom composts], fibre digestates, paper crumbles and biosolids) you should always ask the seller/provider for test results showing its neutralising value. If the seller/provider does not know (and they often don't!) then it is worth getting the material tested for its neutralising value at a reputable, accredited lab.

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Further information

Practical information on soil classification and soil types are provided here:

- SIFSS (Soil Information for Scottish Soils) website
  sifss.hutton.ac.uk
- Soilscapes tool
  www.landis.org.uk/soilscapes
- British Geological Society MySoil app
  www.bgs.ac.uk/mySoil

Information on the importance of soil pH and liming and how to use liming materials is provided here:

- SRUC Technical Note TN656 Soils information, texture and liming (2014)
  www.sruc.ac.uk/downloads/file/1697/tn656_soils_information_texture_and_liming
- Nutrient Management Guide (RB209)
  ahdb.org.uk/rb209
- Managing risk of common scab
  potatoes.ahdb.org.uk/publications/managing-risk-common-scab
- Management of clubroot in winter oilseed rape
  cereals.ahdb.org.uk/media/198551/pr487.pdf

In addition, a range of resources to help you with soil management is available on the AHDB Great Soils website: **ahdb.org.uk/greatsoils**

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