Crop Nutrient Management Plans

Advisory Notes

1. pH value and lime requirements

Acidity <------- pH7.0 --------> Alkalinity

The degree of soil acidity or alkalinity is measured by what is known as the pH scale. A figure of pH 7 represents a materials relationship to the neutral position of pure water at pH 7.0. Figures below 7 indicate increasing acidity and above 7 increasing alkalinity.

The crop requirements diagram (Figure 1) provides a guide to the optimum pH levels for some important crops. If soil pH is lower than the bottom of the indicated range, then crop yields will begin to suffer severely due to the crops' inability to tolerate that level of acidity.

Crops which are tolerant to acidity would be more profitable at higher pH values.

Lime also aids soil fertility in grassland and ensures that added fertilisers are utilised to maximum effectiveness and helps to increase crop yield either as hay, silage, or grazing.

It is particularly important to adjust soil pH well in advance for sensitive crops such as barley and peas.

The absolute minimum recommended pH for spring barley crops is 5.9.

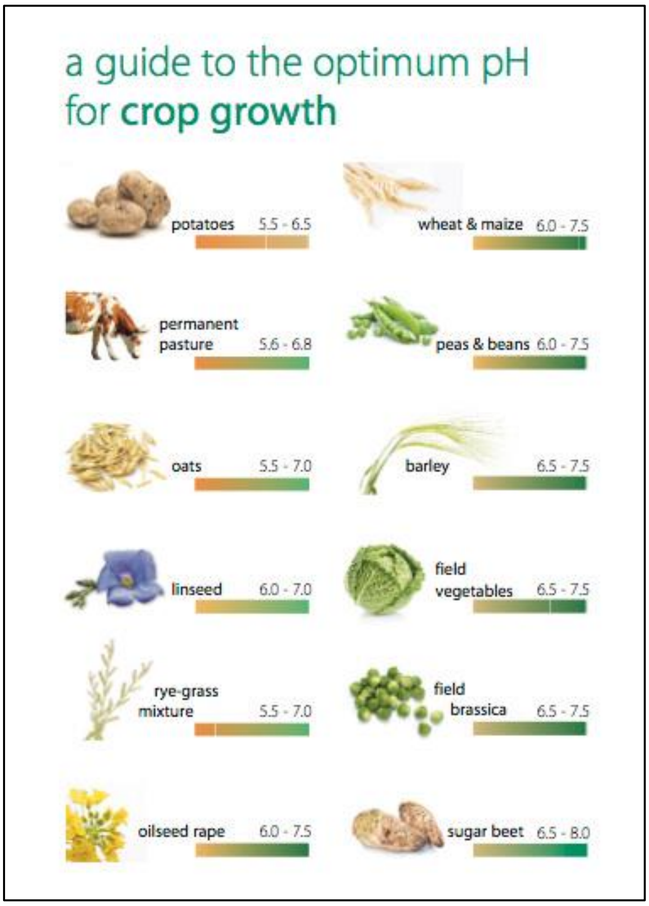

Figure 1 Optimum range of pH's for different crops
https://aglime.org.uk/tech/crop_requirements.php

2. Liming materials

To be effective a liming material must be able to react with and neutralise hydrogen ions (H+) which are the cause of declining and low pH soils.

Common liming materials contain either calcium or magnesium carbonate (CO3)2- or oxide (O2-) which neutralises H+ and increases the soil pH value.

The magnesium and calcium can be beneficial for soil quality and plant nutrition but do not have a direct role in increasing pH value. Materials such as gypsum also contain calcium but not carbonate and will therefore not correct soil acidity.

Liming materials should be purchased on the basis of the price relative to the neutralising value and fineness of the products on offer.

Ground limestone consists largely of calcium and magnesium carbonates of which 100% will pass through a sieve of 5 mm, not less than 95% will pass through a sieve of 3.35 mm and not less than 40% will pass through a 150-micron sieve.

The finer the grinding of the product the more rapid the rate at which neutralisation occurs.

Neutralising value (NV %CaO) is a measure of how much carbonate or oxide is in the product. The higher the neutralising value, the greater its value as a liming material.

Table1 shows a list of common liming materials and typical neutralizing values.

- Burnt lime, CaO, does not contain carbonate but reacts in soil to increase soil pH value.
- Hydrated lime, $Ca(OH)_2$, is a product obtained by slaking burnt lime or magnesian burnt lime of which not less than 95% will pass through a 150-micron sieve.
- Fertiliser regulations require calcareous seashells e.g., scallops, to be pulverised in order that 100% will pass through a sieve with a mesh of 6.3 mm.
- Calcareous sea sand also requires 100% to pass through a sieve with a mesh of 6.3 mm.
- Granulated or prilled lime is usually finely ground calcium or magnesium limestone that has been processed in a similar way as fertiliser making it into a convenient liming product since it is easy to handle and can be spread without the need for specialised equipment.

Material	Typical range of NV values (%CaO)
Ground magnesian limestone	50 – 56
Ground limestone	44 – 55
Burnt lime (or known as Quicklime)	80 – 95
Hydrated lime (or known as Slaked lime)	70 – 72
Lime-stabilised sludge cake	5 – 13
Shell sand	25 – 30
Pulverised shells	45 – 52
Bulk calcified seaweed	44 – 47
Lafarge Redland – *pH* ASTLIMET[M]	58
G-lime, Granulime, Calciprill and Crop Fertility Pelleted Lime	52 – 54

Table 1 Neutralising values (NV%CaO) of some common liming materials
https://www.fas.scot/publication/technical-note-tn714-liming-materials-and-recommendations/

3. pH and its impact on crop nutrients

It is important to maintain the optimum pH for the farming system; insufficient pH management and lack of attention to liming will cause yield losses, while excessive liming may trigger trace element deficiencies, as well as accelerating lime losses. The pH range for optimum availability of most plant nutrients is shown in Figure 2 although the availability varies somewhat between types of crops and is lower on high organic matter soils.

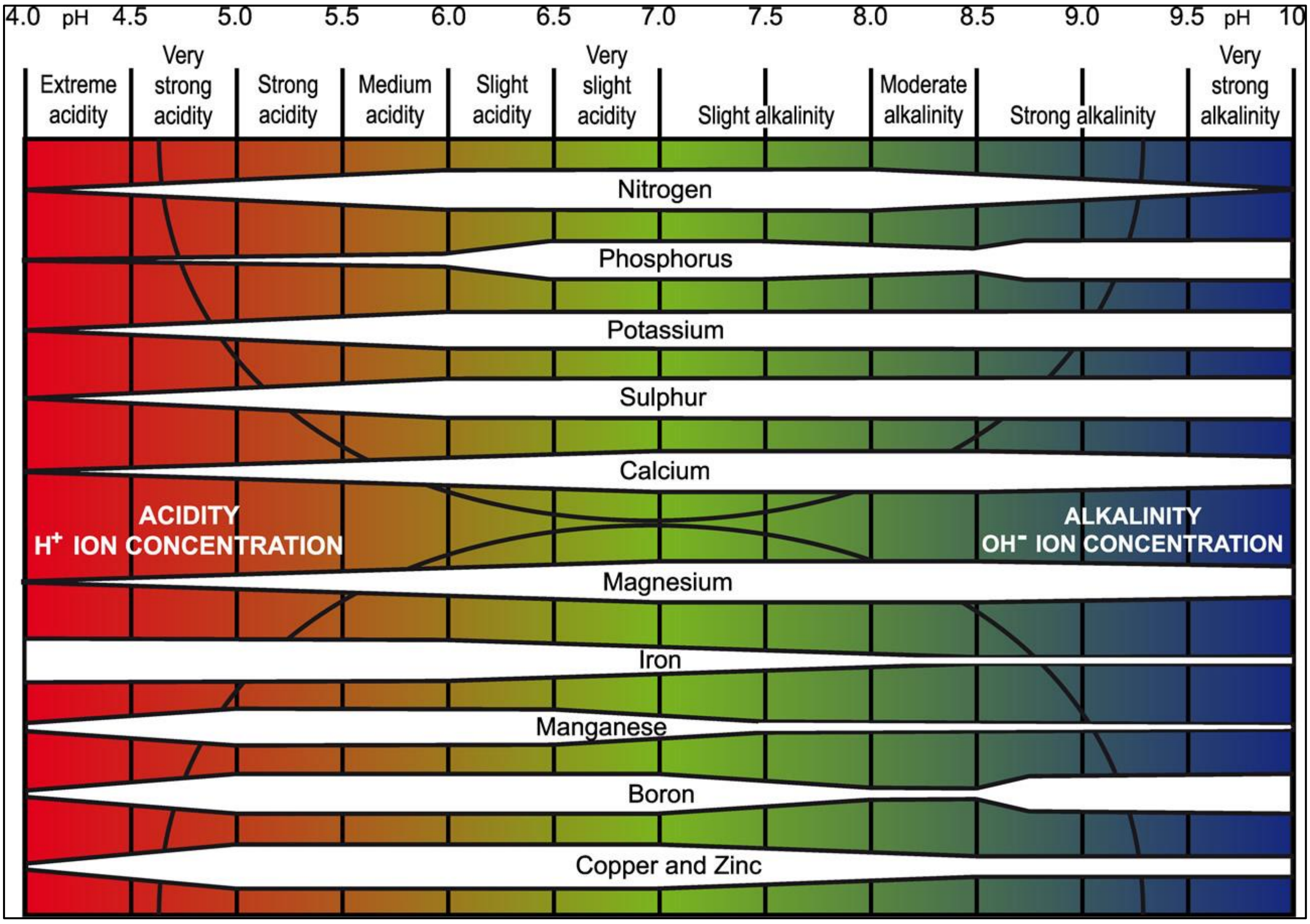

Figure 2 The availability of different nutrients at the different pH bands is indicated by the width of the white bar: the wider the bar, the more available is the nutrient https://www.pda.org.uk/impact-of-ph-on-nutrient-availability/

4. Nitrogen for field crops

- Most agricultural soils contain too little naturally occurring plant-available nitrogen to meet the needs of a crop throughout the growing season.
- Supplementary nitrogen applications are normally made each year to meet crop demand.
- Applying the correct amount of nitrogen at the correct time is an essential feature of good crop management.
- The crop nitrogen requirement is the amount of nitrogen that should be applied to give the on-farm economic optimum yield. Crop nitrogen requirement should not be confused with crop nitrogen demand, i.e., the total supply of nitrogen (including that from the soil) that is needed by the crop.
- Provided there are adequate supplies of water and other nutrients, nitrogen usually has a large effect on crop growth, yield and quality. Applying nitrogen gives a large increase in yield, but applying too

much can reduce yield by aggravating problems such as lodging, foliar diseases and poor silage fermentation.
- When too much nitrogen is applied, a larger proportion is unused by the crop. This is a financial cost and can also increase the risk of nitrogen losses to water and air.
- At nitrogen rates up to the on-farm economic optimum, there is a roughly constant amount of nitrogen left in the soil at harvest. At nitrogen rates above the on-farm economic optimum, there will be a larger surplus of residual nitrogen, usually as nitrate, in soil after harvest. This nitrate is at risk of loss, which can cause environmental problems like leaching to ground or surface water and denitrification to nitrous oxide (a greenhouse gas).

5. Nitrogen supply

Nitrogen supply can be from the soil, organic manures and the atmosphere , as well as from fertiliser.

- **Soil mineral nitrogen (SMN):** Nitrate-N (NO3-N) and ammonium-N (NH4-N) are often called mineral nitrogen. Both are potentially available for crop uptake and the amount in the soil depends on the recent history of cropping, organic material and nitrogen fertiliser use.
- **Nitrogen mineralised from organic matter:** Mineralisation results in the conversion of organic nitrogen to mineral nitrogen by soil microbes. The amount of organic nitrogen mineralised can be large: on organic and peaty soils; where organic manures have been used for many years; where nitrogen-rich and when organic material is ploughed into the soil
- **Nitrogen from the atmosphere:** Small amounts of nitrogen are deposited in rainfall and directly from the atmosphere.
- **Manufactured fertiliser nitrogen:** Manufactured fertiliser nitrogen is used to make up any shortfall in the crop's requirement for nitrogen.

Leguminous crops, like peas, beans and clover, have bacteria in the nodules on the roots that can 'fix' atmospheric nitrogen into a form that can be used by the plant.

6. Nitrogen losses

Nitrogen losses may occur by leaching, run-off, ammonia volatilisation and denitrification.

- **Leaching:** Nitrate is soluble in the soil solution and, unlike ammonium, is not held on soil particles. Once the soil is fully wetted, nitrate may leach into field drains or subsurface aquifers as drainage water moves through the soil. The amount of winter rainfall has an important influence on the amount of nitrate leached.
  Under normal conditions, ammonium-N in the soil is rapidly converted to nitrate. Therefore, sources of ammonium-N will have a similar risk of leaching as sources containing nitrate when used in excess of the requirement of
  a crop.
- **Run-off:** During and following heavy rainfall, nitrogen in solution or in organic form can move across the soil surface and/or via drains and enter watercourses. The amount of nitrogen lost from soil in this way will vary widely from field to field and season to season depending on the amount, timing and intensity of rainfall and nitrogen applications. Sloping ground, proximity to surface waters and surface application of organic manures present particular risks of nitrogen loss in run-off.
- **Denitrification:** In anaerobic soils (poorly aerated soils lacking oxygen), nitrate can be denitrified and lost to the atmosphere as the gases nitrous oxide and nitrogen (N2). Denitrification is a biological

process and is most significant in wet and warm soils where there is a supply of nitrate after harvest, or where there has been a recent nitrogen application and there is enough organic matter for the microbes to feed on. Some nitrous oxide is formed during nitrification of ammonium-N to nitrate-N and some of this also can be lost to the atmosphere.

- **Ammonia volatilisation:** Nitrogen may be lost to the atmosphere as ammonia gas. Significant losses commonly occur from livestock housing, livestock grazing and where organic manures are applied to fields and are not immediately incorporated by cultivation. There can also be significantly larger losses of ammonia when urea is applied to a growing crop compared with losses when other forms of nitrogen fertiliser, such as ammonium nitrate, or inhibitor-treated urea, are used.

7. Phosphate, potash and magnesium for field crops

Phosphate, potash and magnesium applied in fertilisers and manures move slowly through the soil unless carried down through cracks or by earthworm activity. Many soils can hold large quantities of these nutrients in forms that are potentially available for crop uptake, after release from fixed forms. Crop-available levels are much smaller than potentially available levels. Consequently, managing the supply of these nutrients for optimum yield is based on maintaining appropriate amounts in the soil for the needs of the rotation, rather than on those of an individual crop. In practice, this means maintaining target Soil Indices that ensure optimal phosphate, potash and magnesium nutrition.

As the amount of crop-available phosphate or potash in the soil increases from a very low level, crop yield increases, rapidly at first, then more slowly until it reaches a maximum. Typically, maximum yield of arable crops or grass is reached at Index 2 for phosphorus and Index 2- for potassium.

The principle for phosphate and potash management is to maintain the soil at the appropriate target Index. If the Index is lower than the target, yield may be reduced and additional phosphate and potash should be applied. If the Index is higher than the target, savings can be made by reducing or omitting applications until the soil level falls to the target Index.

Effective use of target Indices depends on representative soil sampling. If it is felt that significant areas of the field could differ in P or K Index, these areas should be sampled and treated separately.

Soils can be maintained at the current Index by replacing the amount of each nutrient removed from the field in the harvested crop. These amounts can be calculated from the actual or estimated yield (including straw if removed) and the concentration of the nutrient in the harvested product(s) as analysed or assumed.

To check that this approach is maintaining the required P or K Index (i.e., the phosphate and potash status of the soil), soil sampling should be carried out every 3–5 years, at a suitable time in the crop rotation. Maintaining the appropriate level of phosphate and potash in the soil is especially important, as once a deficiency has occurred, a fresh application of phosphate and potash is unlikely to be available for uptake by roots in time to benefit the crop being grown.

For help with answers and for further information please see:
Nutrient Management Guide (RB209) https://ahdb.org.uk/nutrient-management-guide-rb209