Crop Nutrition

Key Points:

- Apply N fertiliser using the recommendations table (**below**) but making allowances for N applied in organic manures
- It is important to ensure sufficient N is applied early enough to drive canopy development
- P, K, Mg and Na should be applied using soil analysis results (**see below**)
- Application of P, K, Mg and Na fertilisers should be made in good soil conditions to minimise damage to soil structure

Major Nutrient Recommendations (Kg/Ha)

	Soil Index	0	1	2	3	4	5
Nitrogen	Mineral soils	120	120	100	80	0	0
	Organic soils					40	0
	Peaty soils						0
P, K, Mg & Na	Phosphate (P_2O_5)	110	80	50	0		
	Potash (K_2O)	160	130	100	0		
	Magnesium (MgO)	150	75	0	0		
	Sodium (Na_2O) (using K Index)*	200	200	100	0		

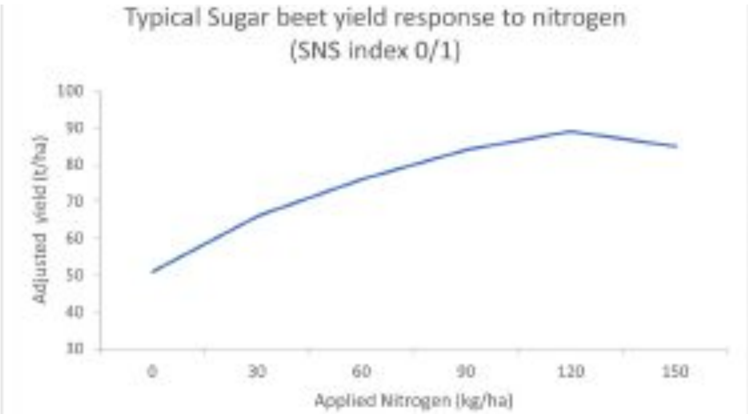
Sugar beet crops require adequate and timely supplies of nutrients to achieve maximum yields, especially during the early months of their growth.

Nitrogen

Nitrogen (N) is a major component of the proteins and enzymes that drive plant growth. It is essential for the rapid development of the leaf canopy and the capture of solar radiation during the early stages of sugar beet growth.

As an example, a typical sandy loam soil with less than 2% organic mater, receiving no organic manure will have 60kg N/ha available after a cereal crop and a further 60kg N/ha may be mineralised during the season. Along with 120kg N/ha of applied N fertiliser this would provide a total of 240kg N/ha, sufficient to support maximum yield. Sufficient N is therefore required during the early stages of growth to enable shoots to acquire the 90-120 kg N/ha required to produce the three units of leaf area index needed to fully cover the soil and maximise radiation interception. Excessive or late uptakes of N do not increase yield, only beet impurities.

The sugar beet yield response curve to nitrogen is based on extensive trials work by both the former Broom's Barn Research Station and more recently by BBRO. Over 150 trials have been undertaken across a range of soil types, and seasons providing a very reliable and consistent response to nitrogen. Based on these data sets, a representative nitrogen response curve for sugar beet is presented below.



With the current trend towards high nitrogen prices, the economic optimum is less than the current recommendation of 120kg N/ha with a fertiliser breakeven price between £350 and £450/t.

Depending on fertiliser costs, the economic optimum is between 75 and 90 kg N/ha. Reducing the rate to 75 kg N/ha is likely to risk decreasing yields too much and will affect overall crop profitability of many commercial crops. Reducing rates to 90-100 kg N/ha is a sensible compromise.

Nitrogen placement

Placement of some of the nitrogen requirement (banded 5-10 cm below and to the side of the seed) has shown that crops can access and utilise N more efficiently. Typically, placement of 40-60 kg N/ha is placed, the remainder being applied at emergence. This frequently improves early canopy development and in some instances plant population. Yield responses of 10-20% have been recorded. Yield responses tend to be greater in dry springs/seedbeds.

Additionally, a reduction in overall nitrogen rates of 15% have been achieved where placing nitrogen in a band to the side and below the seed. Commercial strip trials have shown that reduced rates from 120 to 100 kg N/ha can be achieved. There is limited data on reducing rates more than this using placement techniques.

Potassium

Potassium (K) is the main cellular solute that allows plant tissues to regulate their water content and osmotic balance. This maintains the cellular rigidity (turgor) needed to drive the growth and control the photosynthetic activity of the leaf canopy. It also acts as an activator of the enzymes involved in the production and transport of sugars. Under some circumstances sodium (Na) may replace K as an osmotic solute.

Well grown sugar beet crops contain 350-500kg K/ha, two-thirds of which is used by the shoot and one third present in the storage root at harvest. This is equivalent to soil index 2-. Yields will be reduced on lower K index soils if insufficient potash is applied.

Sugar beet crops require a concentration of 120 to 180mg of exchangeable K/g soil to achieve maximum sugar yield. This is equivalent to a Soil Index of 2-, and almost half of the potential sugar yield is lost on soils that are at K Index 1, and three quarters on those at K Index 0.

Sugar beet is often the crop in the rotation used to adjust P and K status of the soil for the rotation as a whole, however, applying fresh K prior to sugar beet rarely increases it yields even on low K-Index soils.

Recommendations

These are based on the following considerations:

- On K-index 0 and 1 soils, sufficient fertiliser K is applied to replace the K removed in the harvested beet with extra being given to raise Index to 2-. This may not always be possible on very sandy soils whose clay content is insufficient to retain the added K
- On K-Index 2 soils only the K removed in the harvested beet is replaced
- No fertiliser K needs to be applied to soils of K-Index 3 and above

These recommendations require the current K status of the soil to be known from soil sampling and analysis. The amounts of K removed in the harvested beet can be estimated from the tarehouse data of loads delivered to the factory (contact British Sugar to access this information). Alternatively, approximate offtakes can be calculated by using the Potash Development Association's conversion factor of 1.8kg K2O/t beet, but this ratio is extremely variable.

Sodium

Sugar beet is one of the few crops that tolerate **Sodium (Na)** and can use it as an alternative osmotic solute to potassium. Large amounts of agricultural salt have, therefore, been applied to UK sugar beet as a cheap alternative or addition to a K fertiliser for many years.

The two nutrients are not, however, completely interchangeable. Recent research has shown that sugar beet grown on soils that are low in both exchangeable K and Na respond to applied sodium. Furthermore, it has now been shown that very little of the applied Na fertiliser is taken up when crops are adequately supplied with K.

It is, therefore, probable that agricultural salt is currently being applied in many situations where it is unlikely to benefit the crop. Recent surveys, show that much of the UK's sugar beet is grown on soils with K Indices of 2 and above but these also receive an average of 160-170kg Na/ha which will be of little benefit.

Na can partly replace Potash in the nutrition of sugar beet when soils contain too little crop available Potash. An application of 200kg Na_2O/ha is recommended for beet grown on soils at K Index 0 and 1. On K Index 2 soils it is only necessary to apply 100kg Na_2O/ha when the soil contains less than 25mg Na/kg. Fen peats, silts and clays usually contain sufficient sodium and no fertiliser sodium is recommended. Sodium at the recommended rate has no adverse effect on soil structure even on soils of low structural stability.

Crop Nutrition

Phosphorus (Phosphate)

Phosphorus (P) is essential in plants for:

- Plant cell membranes
- Genetic material (DNA)
- Compounds involved in the capture and transfer of energy during photosynthesis
- Enzymes involved in protein synthesis
- Involved in the formation and transport of sugars

Well grown sugar beet crops contain about 80kg P/ha, distributed almost equally between the shoot and the storage root. Trials with long established differences in soil P show that the concentration required for maximum sugar yield is 15-20mg of P/g soil (i.e. Soil P Index 2).

Surveys suggest that over 90% of the national sugar beet area is currently at, or above, P Index 2. Most of these soils continue to receive and average of around 60kg P/ha which is sufficient to maintain them at this level.

Magnesium

Magnesium (Mg) is the central metallic ion of chlorophyll and an essential co-factor for energy transfer, and so essential for photosynthesis and respiration.

Well grown sugar beet crops contain around 23kg Mg/ha, almost three quarters of which is in the shoot. Trials show that crops require a minimum of 50mg of exchangeable Mg/kg soil (Mg Index 2) to produce maximum yield.

Surveys suggest that three quarters of the current national sugar beet area is currently at, or above, Mg index 2.

Sulphur

Sulphur (S) is a structural component of enzyme proteins, the sulpholipids of cell membranes, and plant polysaccharides.

The uptake of S by well grown crops is around 50 to 70kg S/ha and those of a high yielding crop closer to 100kg S/ha. Crops may suffer from sulphur deficiency especially higher yielding crops grown on sensitive soils (sands, sandy loams and shallow soils) and where there is no routine use of organic manures in the rotation. Where deficiency is possible, previous trials of 10kg S/ha (25kg SO_3) was as effective as higher rates. Higher rates of sulphur (40-50kg SO_3) are likely to be needed where the yield is expected be greater than 80-90t/ha. A new programme of BBRO trials is currently assessing this.

Recommendations

Sulphate containing fertilisers are likely to be needed in sugar beet crops grown on sands, sandy loams and shallow soils, where there is no routine use of organic manures. Consider applying 25-50kg SO_3/ha, depending on the likelihood of deficiency. This can be estimated by the appearance/history of deficiency symptoms appearing in more sensitive crops such as oilseed rape and barley.

Photo: Sulphur deficiency in sugar beet is characterised by small stunted pale green plants, often with small and slightly cupped leaf margins.

Crop Nutrition

Guidelines for foliar nutrient application

BBRO trials have shown that sugar beet grown in fertile and healthy soils, especially where organic manure/ammendments and cover crops have been applied or grown regularly, with the exception of manganese and magnesium and soils with specifc deficiencies, that other foliar nutrients are not usually required routinely. However, especially in the early stages of canopy growth from the 4-leaf stage (BBCH 14) up to the 12- leaf stage (approximatley 40-50% crop cover BBCH34-35) nutrient dificiencies can occur under certain circumstances. These include:

- Recovery from drought, herbicide or frost damage
- Periods of rapid growth, particularly after a dry or cold period
- Dry and/or cobbly seedbeds where early rooting and water and nutrients uptake has been poor
- Where there are soil structural (compaction, slumping, water logging) issues
- Where roots may be damaged due to soil pest (BCN issues)

Early growth stages of canopy development (BBCH 12-18) are the key target for foliar applications and their use can be broadly split into three strategies:

1) Most sugar beet crops

Manganese

- Minimum of 1-2 applications during early canopy growth starting from BBCH 14 repeating at 7-14 days
- Target 1 kg Mn/ha in normal growing conditions
- Target 2 kg Mn/ha where there is a higher likelihood of deficiency: rapidly growing crops (all soil types) organic and sandy soils, high pH, after liming, fluffy seedbeds. During cold, wet conditions
- Remember symptoms can be transient depending on the growing conditions but don't wait for severe symtoms to show

Magnesium

- Where magesium has been soil applied, routine use of foliar magnesium may not be required however, where there is a history of magnesium deficiencies, foliar application will help early canopy growth. Target light sandy, more acid soils or where crops are sitting in cold wet soils
- Target 1-2 kg/Mg/ha, repeating at 7-10 days

2) Crops on light and thin soils, especially in dry conditions

Manganese and **Magnesium** apply as above (using higher rates)

Boron

- Consider applying boron, as deficiency can reduce new shoot growth
  Target 1-2 kg boron/ha, especially early growth stages BBCH 14-18

Sulphur

- Target crops in dry conditions on light sandy soils with no history of organic manure application. Sulphur deficiency can result in slow and pale canopy development.
- Target 2-3 kg S/ha from BBCH 14 onwards, repeating at 7-14 days

Recent trial work has indicated that the application of Calcium (0.5kg Ca/ha) at BBCH 14-18 improved susceptibility to drought. BBRO work is on-going on calcium

3) Where canopy development has been compromised by poor seedbed conditions, herbicides, frost damage or by soil pests such as nematode or early disease infection, consider foliar application of:

Manganese

Magnesium

Sulphur

Boron

Phosphorous

- Higher risk soils include low organic matter, acid & very calcareous soils. Low P soils and cold and wet soils Phosphate is essential for early rooting and leaf growth. Target an application of 2kg P/ha

Nitrogen

- In cases where root uptake has been badly affected, foliar nitrogen can help with supply of nitrogen for new leaf growth. Target a 'little and often' approach, applying 3-6kg N/ha at each application. Be careful with urea-based products and applying to crops under hot and full sunlight conditions, to reduce the risk of scorch

Crop Nutrition

Additional Notes

Zinc deficiency is not routinely seen in sugar beet crops but more likely to occur in organic soils, where large amounts of phosphate have been applied, high pH soils and in cold, wet growing conditions.

Copper deficiency is also not routinely seen in sugar beet crops but more likely to occur in organic and chalky soils and is sometimes associated with high amounts of nitrogen in the soil.

Sulphur deficiency may also occur in poorly aerated and waterlogged soils. Plants low in sulphur cannot make full use of nitrogen, so sulphur deficiency symptoms are often very similar to those of nitrogen such as low chlorophyll production and pale plants. However, the distinguishing feature is that due to poor plant mobility, sulphur deficiency symptoms appear first in the youngest leaves as opposed to nitrogen which tend to show in older leaves first.

Foliar biostimulants - BBRO trials have tested a range of different products over a number of types and seasons. Whilst occasional responses were measured, the work concluded that in healthy growing crops there is no consistent yield response to their use. Occasional improvements in foliage vigour and canopy 'greeness' were observed but these were generally poorly related to increased root yield and sugar content. Some products contain major nutrients such as nitrogen and micronutrients as well as the biostimulant element. The use of foliar biostimulants to aid the recovery from a specific weather, soil or pest issue has not been investigated fully. There is however grower testimony that this can be of value.

Application of foliar nutrients - early canopies

Target application to actively growing canopies, where possible avoiding high tempeartures and full sun. Higher humidity also encourages leaf uptake. Don't apply to wilted crops or to crops which are likley to wilt. Target the recovery period when the crops starts actively growing again. Check compatibilites with herbicides and pesticides before using as a tank mix.

Application of foliar nutrients - established canopies

There is little work which has assessed the use of foliar nutrients applied to crops later than stages BBCH 35 (50% crop cover) in sugar beet. Early canopy develoment and plant establishment are considered key to yield and the greatest cost-benefit. Treatment of, or recovery from a specific problem such as severe foilar pest, hail damage or flooding may be aided but each case requires a specific solution.

Late foliar application nitrogen - later harvested crops

BBRO has investigated this aspect and concluded that there is no requirement for this. Frequently, later applications of nitrogen will encourage more top canopy growth and greener crops but not lead to an improvement in root yield or sugar content. Remember, high nitrogen levels can decrease sugar content and increase impurity levels.

Most common deficiencies

Boron

The first signs of boron deficiency are brown corky patches with transverse cracks on the upper surface of the petiole and a network of small cracks on the outer leaves. Gradually these outer leaves turn yellow, and the heart leaves turn black and die. This blackening can extend to the crown.

Magnesium

Pale yellowing of the leaf appears between the veins at the upper margin. In severely affected plants the edges blacken and eventually disintegrate.

Manganese

Usually seen early spring as small, pale yellowish areas on the leaves. The yellowing can affect the whole interveinal space of the leaf leaving the green veins highly visible.

Crop Nutrition

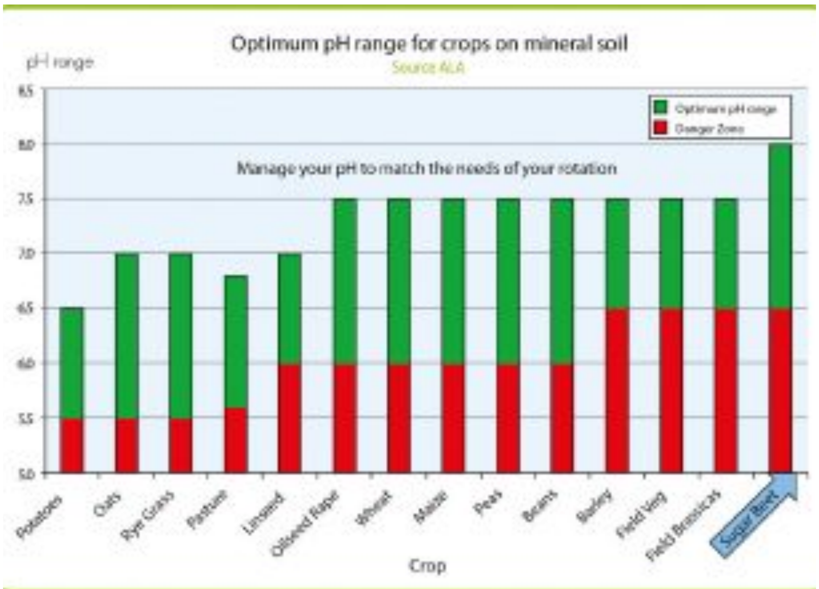
Lime and pH

Key Points:

- Lime is required to correct soil pH to maximise yield of sugar beet (and many other crops)
- Mild yield effects can be seen on mineral soils below pH 6.5
- Serious effects of soil acidity occur on the soils below pH 6.0
- It is risky to rely on a composite soil sample pH result as few soils are truly uniform for pH
- Calcium is a major nutrient - a 70t/ha crop contains over 100kg of calcium
- Liming on many soils is an essential rotational investment
- Low pH limits the availability of essential nutrients (depressing yield)
- Select a liming product that is both reactive and long lasting
- Apply in good time to allow thorough mixing into the top 20cm

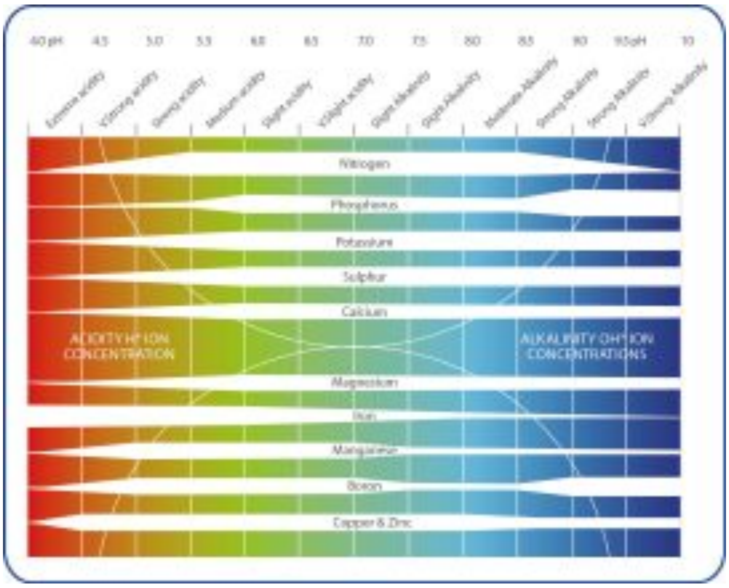
Current crop situation

Graph illustrates that c.25% sugar beet land is limed ahead of cropping. This will provide rotational liming benefit to other pH sensitive crops, such as barley, brassicas and maize – however, all crops will benefit.



Role of liming

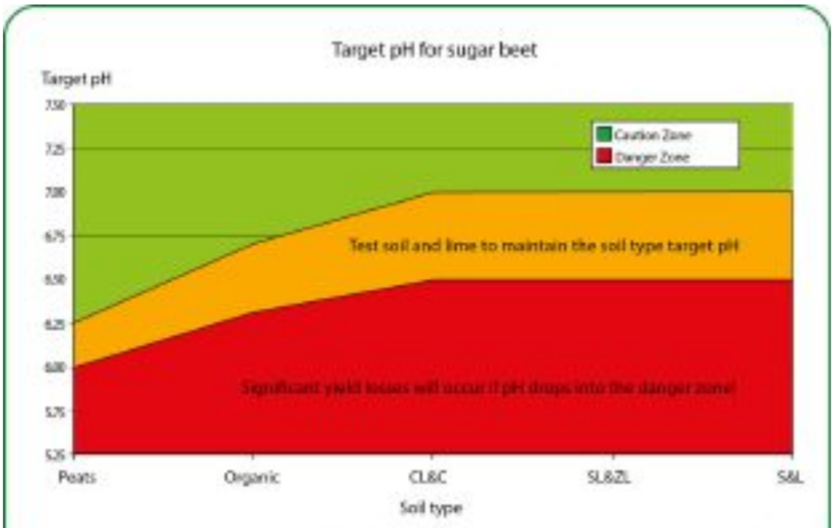
The correct soil pH is a fundamental requirement for the availability of macro and micro nutrients, and will significantly influence the efficient utilisation of nutrients applied from fertilisers and organic manures/materials.



Soil type and optimum pH range

A managed soil pH programme should ensure the most pH sensitive crops are protected from risk of yield loss due to i) low pH and ii) compromised nutrient availability; and, therefore, the following guide identifies the green and amber pH ranges by soil type. Lower optimum pHs are required on the organic and peat soils in response to their unique Cation Exchange Capacity (CEC).

Neglecting soil pH will only lead to consequential yield loss across the rotation.



In summary, target pH is 7.0 on minerals soils, pH 6.7 on organic soils, and pH 6.3 on peaty soils.

Crop Nutrition

Lime & pH

Product selection

Check product specification for neutralising value and size, ensuring you choose a fine product that will be reactive and correct pH more rapidly. Finely ground products (>40% passing 0.15mm) are preferable.

Most good limestone and chalk products (calcium carbonate) should offer this level of fineness (or reactivity) in combination with c.50% neutralising value (NV) compared to pure CaO equivalent (calcium oxide).

LimeX is an extremely fine precipitate of calcium carbonate with >85% passing 0.15mm and an average NV of 30% CaO. This offers very rapid and lasting pH correction as a direct function of surface area. This also contains P_2O_5, MgO and SO_3 to support least cost crop production when applied overall for pH management and calcium supply.

Avoid coarse, hard materials as particles >1.3mm may offer no liming value in practice.

Timing of application

Ideally lime products should be applied 12-18 months before pH sensitive crops to ensure thorough incorporation of the liming product with the soil. However, finer, more reactive products such as LimeX or ground chalk and limestone products with >40% passing 0.15mm can be applied successfully in the autumn before cropping with sugar beet.

Rate of application

If primary cultivations are deeper than 20cm, application rates should be increased pro-rata to avoid dilution and hence a reduced efficiency of the pH increase.

Generic application rate tables can be found at aglime.org.uk assuming a 54%NV product with 40% passing 0.15mm.

For LimeX70, please use the following guide:

Soil Type	Arable 20cm depth t/ha (t/ac)	Grassland 15cm depth t/ha (t/ac)
Sands	6.0 (2.5)	5.0 (2.0)
Light	7.0 (3.0)	5.0 (2.0)
Medium and Clay	8.0 (3.3)	6.0 (2.5)
Organic	10.0 (4.0)	7.0 (3.0)
Peat and Peaty	16.0 (6.5)	7.0 (3.0)

Information on LimeX45 can be found at **limex.co.uk**

Additional benefits

LimeX products also contain valuable nutrients and when applied overall can be taken into account within the nutrient management plan (NMP):

Minimum nutrient content kg/t

Element	LimeX70	LimeX45
P_2O_5	10	7
MgO	7	5
SO_3	6	4

Soil pH testing and mapping

Ideally fields should be grid sampled to show the range of ‘as found’ soil pH. Sampling on a 60m x 60m grid will provide 2.5 samples/ha (1/ac) from which an objective decision to lime, or not, can be determined.