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Optimising soil pH for the environment

pH optimisation

The impact on soil biology of a small deviation from target pH levels can have a significant effect on the environmental as we move to a more sustainable future. *CPM* investigates.

By Rob Jones

Maintaining soil at optimum pH will be an increasingly important aspect of management for growers needing to maximise productivity, reduce input costs and meet the increasingly stringent environmental demands of a more sustainable future, soil experts believe.

New research is showing how even a small deviation away from a target pH of around 6.5 can have a significant impact on soil biology, nitrogen utilisation, uptake of key nutrients and the emission of injurious gases such as carbon dioxide and nitrous oxide.

"We've got to bring soil management and liming into the 21st century," says David McLellan, a member of the AHDB RB209 fertiliser use steering group and chief agronomist at Omya.

"The old adage that all you need to do is apply 12.5t/ha of agricultural lime every five years or so is still advised and practised by many growers, but it is way short of the mark in terms of what all the latest research is telling us.

"It's far better to keep soil pH at a consistent level year on year and there are ways of doing this that don't rely on applying huge amounts of material using super-heavy equipment once every few years."

Understanding the impacts of pH on soil, its biology, ability to make nutrients available to plants and the potential environmental harms of ignoring it, is key to changing the industry's misplaced complacency around the topic, he says.

"Recent data from the Professional Agricultural Analysis Group (PAAG) indicates that 41% of UK arable soils have a soil pH of less than 6.5 and 57% of grassland soils have a pH of less than 6.0.

"Over the past 40 years, there has been a dramatic decrease in the production and the use of agricultural limestone. Since 2000 there has been less than 2.0m tonnes of limestone produced annually whereas in the 1980s and early 1990s, it was approaching 4.0M tonnes.

"The 2022 British Survey of Annual fertiliser use shows that of almost 7000 farms/fields surveyed, only 8.2% applied lime in 2022 and all this is against a backdrop of soil pH falling steadily in recent years.

"Yet, if you look at virtually any indicator of productivity and soil health you will see that every one of them is adversely affected by poorly managed soil pH.

"This is not only hitting growers hard now in terms of lost production and the purchase of costly inputs they don't really need, it's also storing up major environmental problems at many levels for the future."

Single most important indicator of soil health and productivity

According to Dr Sajjad Awan of independent agricultural and environmental analysis specialists NRM, pH is the single most informative indicator of soil health and productivity a grower or agronomist can have.

That said, a meta-analysis of consolidated data carried out by the company on thousands of soil samples from across the UK shows very few farms have soils at optimum levels and this is costing the industry dearly, he points out.

"It's crucial to manage soil pH effectively as it has such an important impact on so many different elements of crop production, input use and the environment.

"Optimum pH ensures microbial activity functions at its full potential and improves

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the soil's ability to mineralise key nutrients. It's also better for the environment, protecting against erosion and nutrient leaching and improving soil structure.

"But it's a topic that is poorly understood by many growers both in terms of its effects on crops but also how it can be corrected and maintained.

"For a start, pH is based on a logarithmic scale, where pH 6 is 10 times more acidic than pH 7, so even apparently small changes in apparent value can have big implications to nutrient mineralisation and availability.

"Some soils are naturally acidic whereas the pH of others can change from one year to the next through rainfall, growing crops and the application of manures, slurry, and fertilisers.

"Bear in mind that pH can also vary significantly across a farm, so the only way you can track it and make the right decisions is to carry out regular soil mapping and analysis as part of your routine crop management."

New insights into effects of soil pH

The NRM analysis has revealed some particularly interesting new insights into the extent of the issue in the UK and its effects, Sajjad says.

"According to the nutrient Management Guide RB209, the recommended soil pH for growing most arable crops on mineral soils is 6.5. At this pH, most mineral nutrients are sufficiently available for ideal crop growth and yield.

"Yet out of all the samples we have analysed in the past five years, only around 3.5% were at this optimum pH of 6.5 and nearly 41% of samples were below this.

"Getting soil pH right is important because our results suggest soil respiration levels, which are a good proxy for soil microbial activity and overall soil health, could fall by 10-15% for every change in pH of 0.5 on either side of the optimum.

"We've known these pH values are roughly right for some time as RB209 suggests the optimum pH is 6.5 for arable land but the rate of decline in soil respiration either side of this has never really been documented before.

"In fact, if soil pH falls to 5.5, wheat yields can be reduced as much as 25%. phosphate is also restricted at less than optimum pH levels and soils that are more acidic increase the solubility of plant toxic metals such as aluminium, which also leads to impeded growth."

David agrees, pointing out that a soil at pH 5.5 it will achieve only 77% of the Nitrogen uptake one at the optimum pH 6.5 would.

"That's like 1kg of N out of every 4kg you buy, doing absolutely nothing or the bags you're buying being only threequarters full. It has that much impact.

"If your soil biology is suffering as a result of poor pH management, no amount of N is going to deliver the yields you want because the soil is out of balance and all the N gets locked before the plants can get anywhere near it.

"Potassium uptake suffers to a similar degree but it's even worse with phosphate which plummets to just 48% at pH 5.5."

Regular liming also improves soil structure and soil water retention, he points out.

"Unlike some agents that can reduce pH such as magnesium, calcium actually pushes clay particles apart and this aids aeration and water flow through the soil rather than it being trapped and creating anaerobic conditions.

"This encourages the soil biology to thrive and encourages strong root growth, but it also improves soil water retention and availability for plants - an increasingly important factor in light of the increasingly common drought conditions experienced in recent years.

"Bulk density is reduced, giving increased porosity and water infiltrates more quickly with less risk of run-off or erosion.

"Calcium is also essential for the proper functioning and health of plant tissues, being essential for opening the stomata and allowing the plant to maintain its transpiration even in hot weather."

While the productivity benefits of maintaining soil pH at optimum levels are many, so too are the environmental ones, he says.

"Without your soil pH being properly balanced, it's like every bag of fertiliser you buy being only threequartersfull," says David McLellan

"The European Agricultural Fertiliser Association has suggested that if the whole of France's agriculture was balanced for pH, nitrous oxide (NOX) gas emissions would be reduced by 15%.

"Plus, you've got the added benefits of reduced volatilisation of ammonia to the atmosphere, lower incidence of nitrogen leaching and the prevention of phosphate run-off.

"The bottom line is that you're only having to put on exactly what you need in terms of crop nutrients because the efficiency of their uptake is so much higher."

Reactivity an increasingly important metric

In terms of maintaining the optimum pH, big strides forward have been made in recent years with a greater ▸

Calcium Carbonate benefits to crop production

Calcium:

- Brings vital element to the plant
- Improves air and water circulation
- Stimulates microbial activity and colonisation of roots
- Improves plant structure and stability

Carbonate:

- Improves major element uptake
- Increases and restores the clay/humus complex
- Mineralises organic matter
- Activates soil micro flora

The granulated lime breaks apart very rapidly and increases the surface area that is available to react with the hydrogen ions.

▸ understanding of the importance of 'reactivity', David says.

"For a long time, we've just talked about the neutralising value (NV) of treatments and the cost per unit value of this and we're only just starting to think about reactivity, but this is potentially one of the most important elements of a successful liming programme.

"Reactivity is the speed at which a product can raise pH and it's linked to the surface area that is able to come into contact with the soil.

"It's a bit like a Rubik's cube, where if you look at the surface area from the outside it is many times less than if you add up the surface area of all the smaller constituent cubes.

"A granulated lime is made of micronised powder which, in the case of Calciprill, is made up of particles just 150 microns in size. This breaks apart very rapidly and increases the surface area that is available to react with the hydrogen ions.

"This ultrafine product outperforms coarser limestone treatments with the rapid reaction bringing soil pH to an optimal level very quickly — usually within six months — and the effect is longer lasting than with coarser agricultural lime.

"It's also important on certain crops such as brassicas and oilseed rape etc where you are trying to raise the pH very quickly before you plant to avoid problems like clubroot.

"Another benefit is that it can be simply applied through a conventional fertiliser spreader by growers rather than having to bring in contractors with heavy, specialist equipment."

Granulated lime is not the answer for everything, however, and there are many different types of lime with every one having its own purpose, he points out.

"We would never tell a farmer with soils of pH 5.5 on lighter land, for example, to use granulated lime.

"His soil is acidic enough to melt rocks, so the solution is to buy something cheap and cheerful to raise it to pH 5.8 or 5.9 then we can look at maintenance using granulated lime from there.

"On heavier clay loam, the same pH of 5.5, although potentially very rare, would require more $CaCO_3$ to adjust it, so would need the reactivity of granulated lime to effect even small changes as the cation exchange capacity is much higher."

But growers and advisers need to move away from the thinking that sets a target above an optimum pH with a view that this will reduce to an optimum level over time, he says.

"That thinking suggests if you want a pH of 6.5, for example, you set a target of 6.7 in the expectation it will drop down to 6.5 eventually.

"This is a completely false economy as in the first instance you're putting on too much and secondly you're only going to get one optimum pH level every three to four years depending on how often you lime.

"For optimum yield and crop quality you need an optimum pH at all times, so once you get your pH up there, you need to do regular testing and then use small maintenance dressings to keep it that way.

"We're in danger of not putting enough importance on lime because people think they know how to utilise it and there's not a lot of money to be made from it, compared with other more exciting technology.

"We've got to change the mindset that says that is the way we have always done it and we're going to stick with that. There is so much evidence on how to make soil pH management more effective and the benefits resulting from that.

"If the UK wants to be self-sufficient in food, then we need to be able to getthe maximum yield but also farm in a sustainable manner and balance new technology with a more regenerative approach.

"We've learned a lot about calcium and pH its effect on production and environment in recent years but we're really only scratching the surface — there are so many more benefits still to discover." ■

The ROI of maintaining optimum pH

The Return on Investment (ROI) of granulated lime is typically 2:1, with every £1 spent on product delivering a £2 return in yield, David says.

"You can calculate it quite simply by comparing the cost of the lime to the savings in key nutrients such as NPK and the increased yield achieved from having the optimum pH.

"So, for example, taking a soil pH from 6 to 6.5 would require approximately 600kg of granulated lime at an average of £200/ha (£80/acre).

"You would save 20% of the 2.5 t/ha (1t/acre) of NPK you would otherwise have to apply, which at a current price of approximately £400/t, is a saving of another £200/ha (£80/acre).

"Field trials in winter barley show that the increased yield from having the correct pH is £300/ha (£120/acre) so the ROI is £500/ha from increased yield plus savings on NPK from an investment of £200/ha in granulated lime.

"Rothamsted research have been running a yield trial on several plots based on pH and liming for over 35 years and this further supports this level of ROI," he adds.

"They found that in crops such as spring barley, liming improves the overall economic benefit with the difference between liming and not liming being £436/ha (£181/acre) and that liming needs to be correctly considered as a capital cost (ref Holland & Behrendt).

"So, an ROI of around 2:1 is realistic metric to work from and this is supported by several sources in arable crops."