Manaaki Whenua
Landcare Research

SOIL HEALTH FACTSHEET

Soil Nutrients

This factsheet is part of a series on Soil Health that provide summarised information on a wide range of soil related topics. A summary of information and principles of good soil nutrient management practices in agriculture and horticulture are presented in this factsheet.

Best management practice guidelines for maintaining optimal levels of nutrients in soils

Soil health and nutrients

Soil health is defined as "*the continued capacity of a soil to function as a vital, living ecosystem that sustains plants, animals, and humans*" (Doran & Zeiss 2000). Soil health seeks to maintain or improve the different functions that soils perform. These functions can include retention and cycling of nutrients, climate regulation and supporting biodiversity as well production of food and forage (which also benefit from maintaining the other soil functions).

Nutrient losses occur on farms when farm produce (e.g., milk, meat, crops, fruit, vegetables) and supplemental feed leave the farm, and via loss pathways such as leaching, runoff, and atmospheric losses (though one of the goals of soil health is to minimise nutrient loss pathways to the wider environment). Nutrient inputs for farms occur when natural sources, such as nitrogen fixation from clover, or fertiliser inputs (synthetic or organic such as manures and compost), and supplementary feed are applied on the farm.

Nutrient replacements may be necessary for soil health, ecosystem services and plant yields to reach sustainable levels but nutrient additions above that which is needed is both economically unsound and harmful to the environment. Soil testing and nutrient budgeting are useful tools to help estimate the quantities of nutrients to apply. In some circumstances, there may be no need to apply additional nutrients to maintain healthy soils, particularly where a paddock has a history of regular nutrient or effluent additions. In this case a soil test is a useful check. Further information can be sourced from the web-links provided at the end of the factsheet.

Nitrogen guidelines

- Nitrogen (N) fixation by clover is often an important N input in mixed pastures.
- Fertiliser nitrogen should be applied as recommended in the Code of Practice for Nutrient Management, and industry-agreed good management practices.
- Whole farm planning and nutrient budgeting can identify improved nutrient planning and risks to water quality. A nutrient management plan by a suitable qualified consultant is recommended and describes how the major plant nutrients and any other nutrients of importance to crops will be managed.

- Manage the amount and timing of fertiliser inputs, taking account of all sources of nutrients, to match plant requirements and minimise risk of nutrient losses.

To make an informed nitrogen decision the Foundation for Arable Research recommends the 5 R's: Right product, Right amount, Right time, Right place, and Right records. Several other best practice guidelines are also included in Table 1.

Table 1 Recommended best practice guidelines for nitrogen

The 5Rs	Recommended best practice guidelines for nitrogen
Right product Right place	• Catch crops grown after harvest can mop up any surplus nitrogen left by the previous crop, reduce drainage and nitrogen leaching risk, aid in soil restoration and increase annual dry matter production. • Plant maize or other deep-rooted crops to utilise or mop-up nutrients from high fertility soils e.g., effluent or whey blocks.
Right amount/rate	• Soil nitrogen testing is a key step to ensuring fertiliser nitrogen is applied at the correct rate. • Tools such as the Nitrate Quick Test and 'AmaizeN' are designed for growers to undertake and interpret soil nitrogen tests and optimise nitrogen fertiliser application rates. • When applying urea and other nitrogen fertiliser, apply recommended amounts per application, e.g., no more than 50 kg N/ha per application. The need for application should be assessed against the need for extra pasture growth and utilisation. **Effluent** • Nitrogen (N) and phosphorus (P) are important to consider for effluent loading rates. • Nitrogen loading rates are often recommended at a maximum of 150 kg N/ha/yr, but this depends on regional council requirements. • A nutrient budget is important when considering dairy (or other) effluent application as there may be no need for additional N and P fertiliser. **Water drainage** • NZ studies on nitrogen fertiliser inputs and losses to drainage water recommend applying no more than around 150 kg N/ha/yr to dairy farm pastures. This is a good management practice and general guide for drinking water limits. • Recent N application limits have been regulated by government for pastoral land due to water quality concerns. The nitrogen component of any synthetic nitrogen fertiliser applied to pastoral land must not exceed 190 kg/ha/yr.
Right time	• Timing of fertiliser nitrogen application should coincide with periods of crop demand to minimise surplus soil nitrogen that may be lost as nitrate leaching or nitrous oxide. • Reduce the accumulation of N in the soil, particularly during autumn and winter. Related practices include reducing N inputs in fertiliser and imported feed, managing grazing practices, using catch crops, using low-N feed in autumn (e.g., cereal), timing N application with demand or splitting applications, and optimising irrigation use.
Right records/tools	• Undertake regular soil tests, including deep N, and use decision support software such as 'AmaizeN' for fertiliser recommendations. • Use precision cropping tools for fertiliser application and tillage e.g., GPS guidance, crop sensing.

Phosphorus guidelines

Fertiliser Phosphorus (P) should be applied as recommended in the Code of Practice for Nutrient Management, and industry-agreed good management practices. As in the previous section, whole farm planning and nutrient budgeting can identify improved nutrient planning and risks to water quality. A nutrient management plan by a suitable qualified consultant is recommended to manage the amount and timing of fertiliser inputs, to take account of all sources of nutrients, to match plant requirements and to minimise risk of nutrient losses.

Phosphorus management practices – using the 4Rs

To minimise dissolved reactive P or dissolved organic P losses, use the 4Rs for the application of P fertiliser and test the soil regularly to determine if P fertiliser is required, and to calculate the correct amount to apply (Table 2). Soil type is also an important consideration for P recommendations.

Table 2 Recommended best practices guidelines for phosphorus

The 4 Rs	Recommended best practice guidelines for phosphorus
Right placement	• Achievable with accurate GPS mapping, proof of placement, spreader control technology and irrigation management tools. • Identify and manage critical source areas, e.g. where run-off occurs more frequently, near stream margins, soils with low anion sorption capacity, and mole and tile drained soils. • For effluent areas, loading rates of P are important to consider. A nutrient budget is important when considering dairy (or other) effluent application as there will probably be less need for additional P fertiliser. • Plant split grass/clover swards in near-stream areas. Ensure that plants that have a relatively high P demand, such as clover, are located away from near-streams areas. Conversely, grasses that have a lower P demand can be located in near-stream areas.
Right timing	• Achievable with strategic and tactical timing, guided by an agronomy plan, weather, and farmer knowledge. • Do not apply soluble P fertiliser if rainfall is likely to produce runoff within 7 days of application. Run-off can occur in winter due to saturation or in warmer months due to soil hydrophobicity. • Fertilise outside the risky months (May to September inclusive are risky). • Reactive phosphate rock (RPR) fertiliser has less water-soluble P than most other P fertilisers. RPR should not be used where annual rainfall is < 800 mm and soil pH is > 6. A lead-in time is usually required when changing fertiliser to RPR.
Right rate	• Apply only enough capital fertiliser to raise Olsen P to the agronomic optimum. • Apply only enough maintenance fertiliser to stay at the agronomic optimum. • For soils unable to retain much P, such as soils with low anion storage capacity (ASC) (i.e., Podzols, Organic and Semi-arid soils), reduce the rate of P applied and consider lower P requirement crops. • Reduce P fertiliser where Olsen P soil test values are above the agronomic optimums and targets. The amount of P lost from soil via surface runoff or subsurface flow is generally proportional to soil P concentration.
Right form	• Use lower water-soluble P fertiliser forms for high-risk soils, soils with ASC <15%, shallow and stony soils, mole and tile drained soils and where runoff risk is high

It is important to keep P levels within optimum ranges and targets values. These values for dairy, sheep and beef pasture, cropping and vegetables are available from industry booklets[1].

Many examples of good P management practices and recommendations for specific vegetable crops are provided in 'Nutrient management for vegetable crops in New Zealand' (Reid & Morton 2019). For example, additional fertiliser P is not required above optimum soil test values.

3 Other macro-nutrients and micro-nutrients

A number of the above principles apply to other macro-nutrients. Further information on calcium, potassium, sulphur, magnesium, sodium, and micro-nutrients (trace elements) for New Zealand conditions is available in some of the links listed below, and in industry booklets[2].

For dairy and other effluent, loading rates of potassium (K) and a nutrient budget are important. Increasing the effluent application area can be beneficial where effluent K loads are above pasture requirements with potential to affect animal health e.g., milk fever. There are other good practices for effluent application, but these are not detailed here.

The report 'Nutrient management for vegetable crops in New Zealand' (Reid & Morton 2019) provides recent recommendations for specific vegetable crops for other macro- and micro-nutrients. For example, potatoes may take up large amounts of K, but yield response will vary with soil, so a specific soil test is recommended. Examples are provided where nutrient addition is not required above optimum soil test values.

Further information on nutrient management

Dairy NZ. Managing and reducing nitrogen fertiliser use

https://www.dairynz.co.nz/feed/pasture/growing-pasture/managing-nitrogen-fertiliser/
https://www.dairynz.co.nz/environment/on-farm-actions/strategies-to-reduce-n-fertiliser-use/
https://www.dairynz.co.nz/media/2832537/farmers-guide-to-managing-fde.pdf

[1,2] https://www.fertiliser.org.nz/Site/resources/booklets.aspx

Environment Canterbury. Industry agreed good management practices. https://www.ecan.govt.nz/your-region/farmers-hub/gmp/what-are-industry-agreed-good-management-practices/

Fertiliser Association. Resources for farmers https://www.fertiliser.org.nz/Site/resources/

HortNZ. Code of practice for nutrient management. https://www.hortnz.co.nz/assets/Compliance/Code-of-Practice-for-Nutrient-Management-v-1-0-29-Aug-2014.pdf

Waikato Regional Council. Resources for farmers. https://www.waikatoregion.govt.nz/community/your-community/for-farmers/farm-menus/

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Houlbrooke D, Laurenson S, Carrick S. (2011). Categorising the environmental risk from land application of liquid wastes based on soil properties. Prepared for Marlborough District Council June 2011. AgResearch. https://www.marlborough.govt.nz/repository/libraries/id:1w1mps0ir17q9sgxanf9/hierarchy/Documents/Services/LIMs%20-%20Useful%20Information%20List/961_MLDC61_Environmental_Risk_of_Effluent_Application_to_land.pdf

Ministry for the Environment (MfE) (2020) Synthetic nitrogen fertiliser cap fact sheet. 7p, https://environment.govt.nz/assets/Publications/Files/FS08-Synthetic-nitrogen-fertiliser-cap-factsheet-final.pdf

Norris M, Johnstone P, Sharp J, Selbie D, Dexter M, Houlbrooke D, Longhurst B. (2019) Using dairy effluent to grow crops – an update for industry, farmers and consultants. AgResearch and Plant & Food Research. PFR SPTS No. 18216. https://www.far.org.nz/assets/files/blog/files//fc15cdd7-50e1-510c-9e15-bf3cb74a83b6.pdf

Reid JB, Morton JD (2019). Nutrient management for vegetable crops in New Zealand. Wellington, Horticulture New Zealand. https://www.fertiliser.org.nz/site/resources/booklets.aspx

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Website

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