Chapter 4 Nutrient management

Objective – the productive capacity of the soil is maintained without detriment to the environment

Most Australian soils are naturally low in nutrients. By managing nutrient application and soil fertility, production targets can be achieved without environmental harm.

It is important to apply fertilisers correctly because, if wrongly used, they may contribute to off-site degradation of groundwater and waterways, increase soil acidity, salinity and sodicity problems and contaminate soil.

Fertilisers may be lost from the production area through:

- Inaccurate application;
- Leaching past the root zone and into groundwater;
- Moving as dissolved nutrients in surface water leaving farm paddocks;
- Attaching to soil sediments and within organic particles in surface water leaving farm paddocks;
- Attaching to wind-eroded soil particles; and
- Volatilisation into the atmosphere.

Not only are these nutrients lost for crop production, such losses will potentially have downstream or off-farm impacts on the environment. The nutrients most at risk of causing off-farm impacts are nitrogen and phosphorus.

Nitrogen

Nitrogen is an important macronutrient in soil and is essential to plant growth and high yield. It is present in soils, either as part of organic matter, which is unavailable for plant uptake, or in mineralised form (nitrate or ammonium ions), which is available to plants. In most soils, more than 95% of the nitrogen is present in organic form.

Further references and resources can be located at the end of this chapter.

Nitrogen is a highly soluble element that is easily leached from the soil profile, dissolved in run-off water or volatilised into the atmosphere.

Phosphorus

Like soil nitrogen, phosphorous is also a macronutrient and critically important to crop yield. Phosphorous can be added to the soil through the application of phosphate fertiliser to maintain the productive capacity of the soil. However, only a small proportion of total phosphorous is accessible to plants (1–4%) and its availability is highly dependent on soil pH.

Phosphorus binds strongly to soil particles and so can be lost by soil erosion through water and wind. Environmentally significant quantities of phosphorous can also be dissolved in run-off water when soil phosphorus levels are high.

4a Nutrient requirements

Objective – to effectively manage nutrient inputs to meet crop requirements and soil characteristics

To effectively manage nutrient inputs it is important to determine the amount and type of nutrients to apply for each cropping situation rather than using recipe-type application rates. This can be done through soil testing and nutrient budgeting.

Further references and resources can be located at the end of this chapter.

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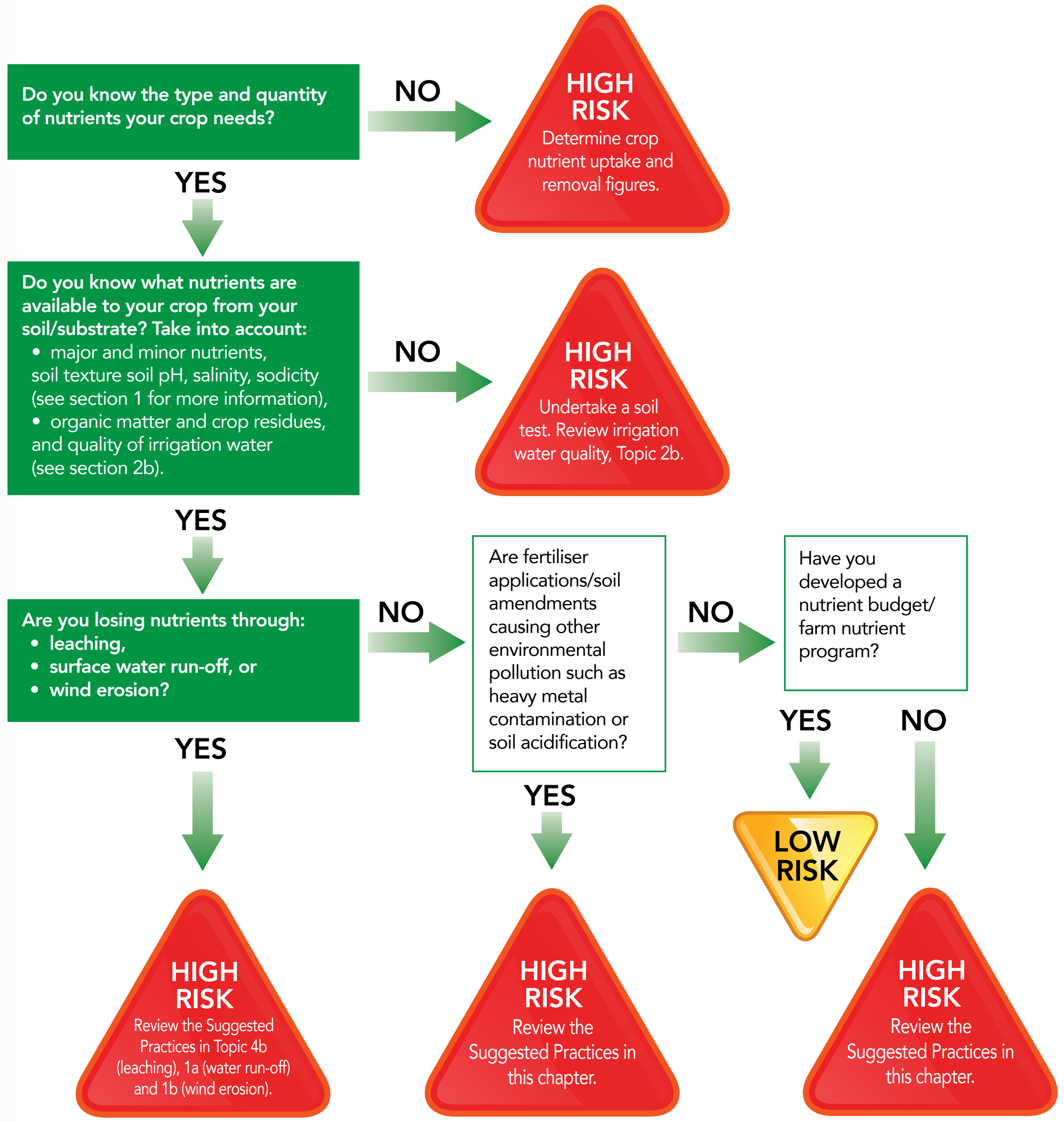
Risk assessment



LOW RISK – You probably don't have a significant problem in this area. You may like to read the Suggested Practices to check your understanding of the issue.

HIGH RISK – You need to take some action. Read the Suggested Practices for that chapter.

Further references and resources can be located at the end of this chapter.

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Review checklist

To go straight to the worksheet for this chapter click here.

Relevant legislation and regulation

Legal requirements are subject to change. Regularly check with Federal, State and Local authorities for updated requirements. See here for links.

Suggested practices

Selecting nutrient types and amounts

Objective methods such as soil testing, plant tissue testing and sap testing, combined with yield data and visual assessments of crop or tree health, provide the basis for good fertiliser management. Fertilisers should be applied efficiently, taking seasonal conditions into account. This means applying just enough nutrients for good crop growth without providing excess nutrients that may be lost off farm into groundwater and surface waterways.

An understanding of the role of different nutrients in plant growth, the levels needed for good growth by particular crops and the cycles of key nutrients such as nitrogen is important. It is a good idea to either do formal training to learn to estimate the quantity and type of fertiliser to use, or to use the services of a soil consultant or agronomist to decide on the nutritional needs of crops. Both over- and under-application of fertiliser can create problems.

The Australian fertiliser industry has established the Fertcare® program to assist in the sustainable use of fertilisers. Fertcare® provides training and accreditation for agronomy, sales and logistics staff. Training options also exist for growers, depending on their particular needs.

Nutrient deficiencies can lead to low yields, poor quality crops and financial loss. They can also lead to indirect environmental damage because other nutrients are used inefficiently and will be vulnerable to loss off-site. Poor crop growth also leads to reduced organic matter returns to the soil, which can reduce soil health and cause erosion and still poorer crop growth.

The relatively low cost of fertiliser compared to other inputs means growers have tended to over-compensate with fertiliser application rather than face the risk of production losses.

Over-supply of fertiliser or incorrect use of blended fertilisers (e.g. NPK mixes) also brings problems. It is not only an unnecessary cost, but can cause reduced yields through toxic levels of nutrients or by inducing deficiencies through nutrient imbalances. Over-supply can also lead to long-term, off-farm impacts like degradation of sensitive environmental areas, algal blooms in waterways and groundwater contamination, and on-farm impacts such as increased soil acidity, soil sodicity and soil salinity.

Inorganic fertilisers are only one method for supplying nutrients. Cover crops, fallow crop residues, composts and animal manures not only add organic matter to the soil but also release significant amounts of nutrients as they break down. The gradual release of nutrients from organic sources can help to reduce the loss. For example

Further references and resources can be located at the end of this chapter.

Horticulture Australia

4a Nutrient requirements

researchers have found that banana plant crop residues can contribute 60 kg N/ha to the following ratoon crop in Far North Queensland conditions. Crop residues from a cauliflower crop can contain about 170 kg of nitrogen (N), 27 kg of phosphorus (P) and 180 kg of potassium (K) per hectare. Animal manures can add significant amounts of phosphorus to the soil. Manures should be tested for nutrient content, chlorine levels and presence of contaminants such as heavy metals before application.

Fertilisers should be selected that have low levels of contaminants such as heavy metals (cadmium, lead or mercury). High levels in fertilisers may lead to accumulation in the soil or uptake by crops in excess of maximum levels for human safety (for information regarding maximum levels, see the Food Standards Code www.foodstandards.gov.au).

Soil and sap testing

Soil testing is a useful way to objectively measure the nutrient status of your soil. It is a particularly valuable nutrient management tool before planting a crop or orchard. Ongoing soil testing (say every one to three years) also provides valuable insights into longer-term trends in soil properties that may alert managers to developing sustainability problems. Soil organic carbon decline or the build-up of high available phosphorus levels are examples of this.

Soil testing, plant tissue testing, sap testing and visual crop inspection can all be used post-planting to monitor nutrient availability and determine an appropriate post-planting fertiliser program.

Soil tests measure soil properties that influence nutrient availability to the plant. These include pH, electrical conductivity (a measure of salt content), organic carbon, individual macro- and micronutrients and other elements. It is a good idea to use a laboratory that is accredited to carry out the required tests. Look for NATA (National Association of Testing Authorities) accreditation, a laboratory that uses NATA methods or one that participates in Australian Soil and Plant Analysis Council (ASPAC) proficiency trials. See http://www.nata.asn.au or http://www.aspac-australasia.com.

For soil test results to be meaningful, the sample must be carefully collected. When collecting a sample make sure it represents the area being tested, by taking into account the total area of the block, any changes in soil type within the block and the depth of sampling. The samples should be representative of the root zone. Taking a 10-15 cm sample from soil that has been worked to rooting depth will achieve this. In orchards, where soil is not worked, a shallow sample may not represent actual nutrient availability. Subsoil samples may be of value to determine nutrient availability for deep-rooting crops and identify possible causes for nutrient imbalances.

Sufficient samples should be collected to be representative of the site and should not include soil from any unusual areas. These samples should be bulked, mixed well and then a sub-sample of this bulk soil sample sent in for testing. The testing laboratory or its agent should provide instructions on taking the sample. Soil consultants or agronomists can also collect samples for you and there are accreditation programs for these services.

Nitrogen levels undergo dynamic changes during the season, being influenced by factors such as soil organic matter content, soil temperature and moisture. It is therefore important that soil samples for nitrogen budgets be taken separately from conventional soil samples and sampling should occur as close to the proposed nitrogen application date as possible to give an accurate picture of current nitrogen availability.

Soil test results and optimum soil nutrient levels should be discussed with an appropriately qualified person, such as an agronomist or soil consultant. Based on this interpretation and consideration of soil type, cropping history, specific crop needs and agronomy, a written fertiliser recommendation should be provided. This may include recommendations for adding lime, dolomite or gypsum.

Further references and resources can be located at the end of this chapter.

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Soil testing and analysis needs to be completed early enough to allow nutrients and soil ameliorants to be applied in a timely manner.

Sap testing can also be used to develop nutrient uptake graphs, so fertiliser applications can be timed to the appropriate growth stage of the crop. Samples for sap testing need to be collected carefully and tissues analysed by a suitably proficient laboratory.

Nutrient budgeting

Nutrient budgeting can help growers better understand the whole nutrient cycling and transformation system. This can lead to the design of more sustainable, integrated nutrition strategies.

A nutrient budget is like an accounting system for nutrients. It involves:

- Estimating the amount of nutrients available from the soil (soil test results);
- Obtaining uptake and removal figures for the target crop and the previous crop (to account for nutrients in crop residues, for example, consideration should also be given to the contribution of legumes to nitrogen availability). Figures should be in kg/tonne of crop grown (for uptake) and harvested (for removal);
- Determining the target yield to calculate actual uptake and removal figures;
- Calculating the amount of nutrients, especially nitrogen, that will be applied with irrigation water (50 ppm nitrate in irrigation water will add about 1 kg n/ha with every 10 mm of irrigation water applied);
- Calculating the amount of nutrients already applied to a paddock;
- Estimating the amount of nutrients that will be removed through harvested product; determining possible nutrient losses through leaching (see Topic 2b – Water quality), volatilisation or soil erosion (see Topic 1a – Soil erosion caused by water, and Topic 1b – Soil erosion caused by wind). Deep soil nitrate testing can be an important tool in assessing leaching; and
- Replacing nutrients lost to the system through appropriate fertiliser applications.

Nitrogen, phosphorus and other major nutrients are the main elements considered in nutrient budgeting. Along with soil, leaf and sap testing and visual assessments, nutrient budgeting is another tool for fine-tuning the nutrient management program.

A nutrient budget should be prepared for a 3–5 year rotation. Break or cover crops should be considered as ‘catch crops’. Nutrients that have not been used by the previous crop will be taken up by the break crop, thus avoiding leaching past the root zone.

Reviewing local research and advice from agronomists can also assist in determining fertiliser requirements, particularly in situations where key information such as crop nutrient removal rates are not known.

It is also important to determine if any nutrients are required in 'luxury' amounts (that is over and above the nutrient removal figures). For example, potassium may be applied at higher rates because of its role in preventing bruising.

Further references and resources can be located at the end of this chapter.

Monitoring and recording

Soil test results, sap test results and corresponding fertiliser recommendations support responsible use of fertilisers. It is also a good idea to have documentation to support the credentials of the person providing the fertiliser recommendation.

Testing run-off and drainage water for nutrient content gives a good indication of any losses being experienced. Water can be monitored for nitrates using systems such as the CSIRO FullSTOP™.

References and further resources

For access to relevant references and further resources click here.

Further references and resources can be located at the end of this chapter.

4b Nutrient application

Objective – to ensure nutrient application methods and timing maximise benefits to the crop and minimise potential negative environmental impacts

Applying fertilisers correctly is as important as using the correct amount and type of fertiliser. Effective fertiliser application involves:

- The right rate and frequency, the right time; and
- The right placement.

To achieve this, application equipment must be set up correctly.

A note on organic farming:

Organic farming avoids using synthetic chemicals, artificial fertilisers or genetically modified (GM) organisms. Organic farming practices are described by an organic standard, Australia Certified Organic Standard (ACOS 2013), which describes parameters for compliance, noting that these requirements do not override legislative requirements but differentiate organic agriculture practices from traditional farming practices. The standard considers all other primary production or food preparation that does not conform as 'conventional' production. These guidelines would therefore be seen to cover 'conventional' horticulture production.

For more information on organic farming methods visit the Australian Organics website http://austorganic.com.

Further references and resources can be located at the end of this chapter.

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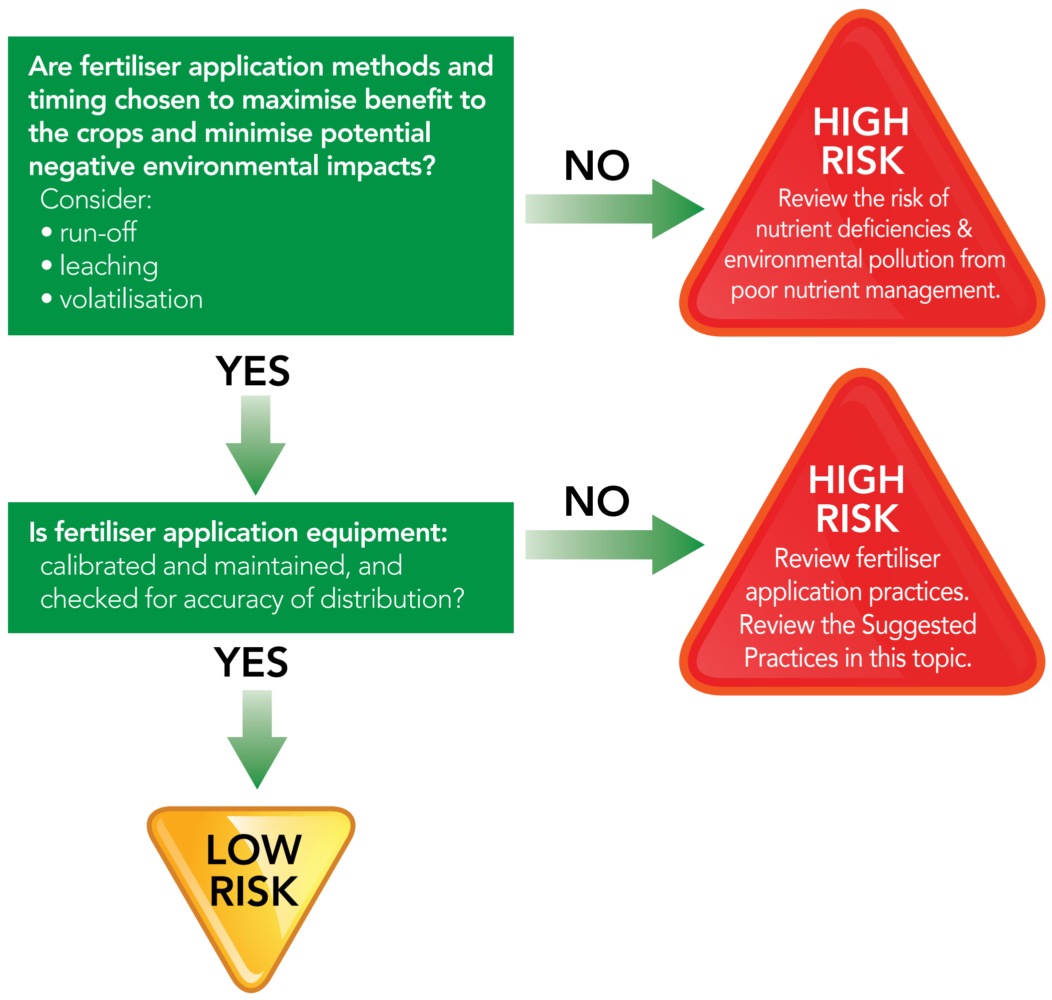
4b Nutrient application

Risk assessment



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Suggested practices

When applying fertilisers, some general rules should be followed:

- Avoid applying fertilisers to saturated soil or when heavy rain is forecast;
- Avoid applying fertiliser during extended drought;
- Avoid fertiliser application to steeply sloping ground. Use contour drains to minimise run-off;
- Monitor soil moisture to avoid leaching of nutrients past the plant root zone;
- Maintain vegetation cover during typically rainy periods to minimise run-off and leaching.

Type, timing and rates of application

Fertilisers need to be applied when they will do the most good for the crop. As a general rule, applying small amounts regularly is less likely to cause off-site losses from leaching and run-off. Schedule fertiliser applications according to seasonal conditions, cropping cycle and periods of greatest use by the crop. For instance, young vegetable crops require small amounts of nutrients until they begin to grow rapidly.

Nitrogen, in particular, should not be applied in large amounts while crops are young and nitrogen demand is low. Large applications of pre-plant fertilisers are vulnerable to loss in the slow growth period. Select the most suitable fertiliser type depending on the speed of availability of nutrients in relation to crop demand, acidity, alkalinity or salinity of fertiliser.

Pre-plant fertilisers should be incorporated. If there is a likelihood of heavy rain, minimise the amount of pre-plant fertiliser applied to reduce risks of fertiliser losses through leaching and soil wash from paddocks into nearby waterways. It may then be necessary to increase top-dressed fertiliser applications later in the season. However, light rain or irrigation is beneficial to incorporation and to reduce volatilisation of some fertilisers such as urea.

An auto steering system for application equipment will allow precise applications without overlaps and may reduce fertiliser costs.

Fertiliser placement

Accurate placement of fertilisers helps plants to access the nutrients required. Choose the right equipment and adjust it correctly to make sure fertiliser is applied to the area where it will do the most good but have the least impact on the environment.

Further references and resources can be located at the end of this chapter.

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4b Nutrient application

Apply small amounts of fertiliser near the root zone of plants. Application methods suited to achieving this include:

- Fertigation using micro/trickle irrigation systems, banding to the side or below seeds or transplants, banding or drilling fertiliser in beside plant rows;
- Broadcasting fertiliser along the drip line of tree crops, and broadcasting fertiliser before the crop canopy closes.

Foliar application through spray equipment is a useful method for applying targeted amounts of micronutrients.

Be careful not to apply fertiliser to non-crop areas or adjacent to waterways. Take steps to prevent contamination of water sources from pump backflow during fertigation.

Care and calibration of equipment

Brand new spreaders can have poor spread patterns, and with use and 'wear and tear' even a well set up spreader can become inaccurate. Therefore fertiliser application equipment needs to be carefully calibrated and maintained to make sure it is capable of spreading fertiliser evenly at the correct rate.

Refer to the manufacturer's specifications when carrying out calibration.

Accu-Spread® is a testing and accreditation program that ensures your spreader can apply fertiliser evenly across the paddock, maximising productive response and minimising environmental risk.

Storage of fertilisers

All fertilisers including animal manures should be stored in such a way that prevents nutrients leaching into surface waterways and groundwater. Inorganic fertilisers should be stored in a covered area away from waterways. Manure heaps should also be covered to reduce leaching through rain.

Storage areas should be:

- Protected from direct sunlight and rain;
- Well ventilated with fresh air to keep fertilisers dry;
- Designed to minimise the chance of pest infestation, mould growth and damage; and
- Designed to confine any spillage and allow easy clean up.

Store fertiliser in a way that lowers the risk of seepage into groundwater. With the exception of fertilisers applied with pesticides, fertilisers should be stored separately from other agricultural chemicals.

All liquid fertiliser storage should be bunded to eliminate the chance of run-off into waterways. In the absence of any national or state legislation, the bund should be 125% of the largest container, plus 25% of total volume stored.

In addition to regulations regarding storage of dangerous goods, there are new security regulations in place regarding ammonium nitrate that cover how these products are supplied, handled and stored. Advice from the appropriate local authority should be sought.

Disposal of packaging

Used fertiliser packaging should be stored in a manner that prevents contamination and environmental harm and meets local government waste disposal regulations.

Further references and resources can be located at the end of this chapter.

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Monitoring and recording

Fertiliser application records

It is recommended that an accurate record be maintained of all fertiliser applications, including foliar applications and fertigations. This applies both to organic (e.g. sheep, cattle, chicken manure) and inorganic fertilisers (e.g. superphosphate). Fertiliser application records are essential for nutrient budgeting.

Suggested headings in fertiliser records are:

- The location of the treated areas (block or paddock identification);
- Application dates;
- The type of fertiliser used including the trade name, type of fertiliser or concentration of nutrients;
- Amount of fertiliser applied per hectare (weight or volume);
- Method of application and machinery used e.g. fertigation, spreader; and
- Name of the operator applying the fertiliser.

Soil test results for the paddock and sap and leaf tests for the crop support these fertiliser records.

Machinery calibration and maintenance records

It is suggested that maintenance and calibration records for fertiliser application equipment be kept. This should include:

- Equipment/machinery name;
- Date on which calibration/maintenance was performed;
- Work undertaken; and
- Signature or initials of the person who performed the calibration/maintenance, or an appropriate invoice.

References and further resources

For access to relevant references and further resources click here.

Further references and resources can be located at the end of this chapter.

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Nutrient management - references and further resources

(web links accurate as at 11 February 2014)

Note: A number of Horticulture Australia Limited (HAL)-funded project final reports have been identified as references within this document. This is by no means representative of all the research & development (R&D) or final reports available in this area. For full list of HAL final reports visit the HAL website www.horticulture.com.au. Alternatively, contact HAL or your peak industry body for more information on research & development outcomes specific to your industry.

Accu-Spread - independent testing and accreditation of fertiliser spreading equipment for accuracy and evenness of spreading. http://www.afsa.net.au/index.php?action=content&page=12

Armour, J. & Daniells, J. 2002. Banana nutrition in North Queensland. HAL project report FR95013. Department of Natural Resources & Mines, QLD.

Australian Certified Organic (2013) Australian Certified Organic Standard, Australian Organic http://austorganic.com/australian-certified-organic-standard1/

Australian Soil and Plant Analysis Council http://www.aspac-australasia.com
An independent international organisation consisting of individuals, laboratories, research and commercial organisations involved in soil and plant tissue analysis.

CSIRO FullStop www.fullstop.com.au The FullStop Wetting Front Detector helps you to "see" what is happening down in the root zone when you irrigate the soil.

FertCare http://www.fertilizer.org.au/files/pdf/fertcare/Fertcare%20Booklet.pdf
FertCare is a national product stewardship initiative of the Fertilizer Industry Federation of Australia (FIFA) and the Australian Fertiliser Services Association (AFSA), supported by Australian Government. It provides training to assist industry participants understand the food safety and environmental risks involved in handling, transporting, storing and spreading fertilizers.

Fertilizer Industry Federation of Australia, (2001), Cracking the nutrient code: Guidelines for developing a Nutrient Management Code of Practice for your industry, region or farm, FIFA, Canberra, ACT.
http://www.fertilizer.org.au/files/pdf/publications/cracking%20the%20nutrient%20code%20optimized.pdf

Food Standards Australia New Zealand (FSANZ) www.foodstandards.gov.au
FSANZ is responsible for the development and administration of the Australia New Zealand Food Standards Code, which lists requirements for foods such as additives, food safety, labelling and GM foods.

Incitec Pivot Fertilizers http://www.incitecpivotfertilisers.com.au/Soil%20Plant%20Tests/FieldFacts
This website provides link to fact sheets, such as Horticulture soil sampling procedure.

National Association of Testing Authorities, Australia http://www.nata.asn.au
NATA provides assessment, accreditation and training services to laboratories and technical facilities.

National Land & Water Resources Audit (2008) Signposts for Australian Agriculture — The Australian Horticulture Industry. NLWRA, Canberra. http://lwa.gov.au/files/products/national-land-and-water-resources-audit/pn21405/pn21405.pdf

NSW Department of Primary Industries – Crop nutrient replacement in tropical horticulture - Links to Excel spreadsheets are provided for the following fruit crops so that you can calculate crop nutrient replacement – Avocados, Custard apples, Low-chill peaches, Mangoes, and Passionfruit.
http://www.dpi.nsw.gov.au/agriculture/horticulture/tropical/nutrients/replacement

Phillips, D. (2010) Developing guidelines for environmentally sustainable use of mineral fertilisers (HAL Project Number: VG07036). Horticulture Australia Ltd, Sydney, NSW. www.horticulture.com.au

Potassium in Agriculture http://www.pda.org.uk/technical-potash-notes.php
This website provides technical information on soil fertility, plant nutrition and fertiliser use with particular emphasis on potash (based in UK).

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