Nutrient management

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Contents

Nutrient management

1. Introduction

The sandy soils of the Swan Coastal Plain have little capacity to retain nitrogen and are some of the least fertile in the world. Vegetable growers in the region must therefore recognise the challenge of providing adequate plant nutrition without jeopardising long-term sustainability. In the past decade, recommended practices in nutrition management have advanced considerably. Today, growers and researchers continue to work together to devise and enhance practical strategies that ensure both economic and environmental sustainability.

This chapter outlines practices aimed at improving the efficiency of nutrient application and, in so doing, minimising the environmental impacts associated with vegetable production. Also addressed are:

- factors to consider when choosing a fertiliser;
- the application method and rate of application, and
- the use of tissue/sap testing, soil testing and soil solution testing to help match fertiliser use to crop requirements.

2. Crop nutrient requirements

Know your crop's nutritional needs and select the most appropriate fertiliser.

Plants need various elements in order to live and grow. Air and water supply carbon, hydrogen and oxygen but other major (macro) nutrients – such as nitrogen, phosphorus, potassium, calcium and sulphur – must be supplied by the soil or from fertiliser. Nitrogen (taken up by plants mainly in the form of nitrate) is required in higher concentrations than other elements.

In addition, plants require minute quantities of certain trace elements, including molybdenum, copper, zinc, manganese, boron, iron and chlorine.

Deficiencies or imbalances in the supply of any of these essential elements can compromise growth, affecting root development, cell division, crop quality, crop yield and resistance to disease and drought.

Recognising symptoms of deficiency in a crop can help in the assessment of common nutrient requirements for that crop. Care must be taken not to confuse symptoms of disease with those that indicate nutrient deficiency (see Appendix 1: *Recognising nutrient deficiencies in crops*).

3. Soil texture

'Soil texture' refers to the proportion of clay, silt and sand in soil. Ensure that your fertiliser application is appropriate for the soil texture of your land.

The texture of soil affects both its water- and nutrient-holding capacity (see Table 1 and Appendix 2: *Determining soil texture*), as well as its ability to withstand cultivation and compaction. Sand, for example, is well aerated but has a low water- and nutrient-holding capacity, whereas clay soils tend to be the opposite.

Table 1: The three most common soil types on the Swan Coastal Plain, and the ability of each to retain nutrients.

	Spearwood/Tuart sand	Karrakatta sand	Bassendean/Joel sand
Colour	Red/brown/orange	Yellow/brown	Grey/white on surface, yellow/pale yellow at depth
Ability to retain nitrogen between crops	Limited	Limited	Very limited
Ability to retain phosphorus between crops	Moderate	Low	Nil
Ability to retain potassium between crops	Moderate	Limited	Nil

4. Soil pH

Soil pH indicates the acidity or alkalinity of soil. Consider soil pH when choosing a fertiliser.

Soil pH influences nutrient availability, pesticide efficiency and disease control. Soil with a pH of 7 is neutral, soil with a pH of less than 7.0 is acid, and soil with a pH of greater than 7.0 is alkaline. For most plants, the pH range for optimum growth is $pH_{(Ca)}$ 5.0 to 6.5.

(Note: $pH_{(Ca)}$ is the pH measured in calcium chloride ($CaCl_2$); it gives a reading that is about 0.8 lower than pH measured in water.)

Growers who understand the pH of their soil, as well as the effects of different agricultural practices on soil pH, can control changes and improve the efficiency of both the fertilisers and pesticides they use.

Acidification of soils is a natural process accelerated by agricultural activity. The process by which plants take up nutrients acidifies the soil, while dry plant matter becomes alkaline. When plants are allowed to die naturally, and all their parts are returned to the soil, there is no net change in soil pH, provided no leaching of nutrients occurs. However, with vegetable production (where some plant material is removed and leaching is common), less alkalinity is returned to the soil so soil acidification does occur.

Acidic soils may contain high concentrations of manganese and aluminium, which reduce plant growth. However, increasing soil pH by adding lime can induce deficiencies in a number of necessary elements, including iron, manganese and zinc (which are very sensitive to pH) and copper (less sensitive to pH). For more information, refer to subsections 5 and 7 of this chapter.

To reduce soil acidification:

- **use less acidifying fertilisers (see Appendix 3: *Rates of, and practices to reduce, leaching*);**
- **reduce leaching of nitrogen by managing the rate and timing of its application, and through the use of appropriate irrigation practices;**
- **return plant material to the soil (for example, by incorporating crop residues into the soil);**
- **use lime, the easiest solution to soil acidity.**

5. Soil testing

Soil sampling is vital to good soil and crop management.

Soil sampling allows you to:

- measure the nitrogen, phosphorus, potassium, sulphur, calcium and magnesium in the soil (plant analysis is recommended to check the adequacy of essential trace elements such as iron, boron, manganese, copper, zinc and molybdenum – see Appendix 4: *Understanding soil analysis*);
- determine the physical, chemical and biological properties of your soil;
- consider possible nutrient deficiencies or toxicities;
- plan fertiliser programs, and
- monitor long-term fertility trends.

The results of soil tests provide a good indication of the type and amount of fertiliser required to achieve optimum growth for a particular crop. However, other factors – such as fertiliser cost, the method of application chosen and the price anticipated for the end product – will also influence the choice of fertiliser and its rate of application.

When to sample

Soil sampling is necessary when:

- **planning a fertiliser program – sample prior to cropping;**
- **identifying nutritional problems – sample during cropping and also organise plant analysis;**
- **monitoring the nutrient usage of crops – sample prior to cropping and again after harvest.**

For more information on soil sampling, refer to Appendix 5: *Soil sampling technique*.

6. Soil analysis

Soil analysis can provide the following key information:

- soil pH;
- total and plant available nitrogen;
- soil carbon;
- available phosphorus;
- available potassium;
- amount of chloride;
- total soluble salts (soil electrical conductivity (EC)), and
- lime requirement

6.1 Laboratory testing

Soil can be chemically analysed in a number of different ways. Thus, soil tests from different laboratories can only be compared if the same techniques of analysis have been used in each case. Some commercial laboratories provide fertiliser recommendations in addition to chemical data from soil tests, while others supply only the test results, without interpretation.

6.2 On-farm testing

Most rural supply stores stock off-the-shelf soil-sampling kits. If growers use such kits they are advised to read and follow the manufacturer's instructions carefully, as these will vary from kit to kit.

Growers can also purchase their own pH and EC meters (at a cost of around $200 each). These are a convenient, inexpensive and reliable method of monitoring changes in soil. However, in the interests of accuracy, any decisions regarding changes to fertiliser programs should be based on laboratory test results. The technique for measuring soil pH and EC on-farm is detailed in Appendix 6: Measuring soil pH and electrical conductivity.

6.3 Understanding soil analysis

The results of soil analysis are often complex and initially may be difficult to understand. Appendix 4: *Understanding soil analysis* provides a guide to some of the terms used and the upper and lower limits for a range of nutrients.

7. Plant tissue/sap analysis

Use tissue/sap analysis to help you:

- **diagnose or predict nutrient deficiencies or toxicities, and**
- **monitor the adequacy of your fertiliser program, making adjustments as necessary.**

Tissue/sap testing is only possible once plants are established. Therefore, for an element deficiency to be detected, yield loss will already be evident. Plant sap analysis, which indicates the amount of mobile nutrients in a plant's system, provides a view of nutritional status that differs from that of traditional dry-tissue analysis. In fact, it highlights minor or temporary deficiencies more easily. However, the interpretation data for sap analysis is not always available.

Rapid sap tests, which a grower can perform cheaply on-site to identify the nutrient status of plants, should be used as a guide only. (Note: results from DAFWA show that such 'do-it-yourself' methods are reliable for nitrate, phosphate and potassium, as long as the crop is not water-stressed.)

For good plant sampling techniques that increase the accuracy of results, refer to Appendix 7: *Plant sampling*. Optimum nutrient concentrations for a range of crops are included in Appendix 8: *Optimum nutrient concentration for different crops*.

8. Soil water sampling

Drainage and suction lysimeters are types of equipment used to collect samples of moisture in soil, in order to determine whether nutrients are draining past the effective root zone of a crop. When installed at the desired depth and left in the place, this equipment permits periodic sampling.

Drainage lysimeters, which vary in complexity, are used to collect soil water draining past the effective root zone of a crop. They are commonly used in field trials to determine the efficiency of both irrigation and nutrition programs, as the data collected allows calculation of water drainage and nutrient loss below the root zone.

It is generally consultants who use suction lysimeters, which consist of a porous ceramic cup and a sample collection tube. By virtue of a pump-created vacuum, the apparatus draws water from the soil matrix through the ceramic cup into the sampler. The water sample can then be extracted from the collection tube, taken for chemical analysis and the information used to adjust the fertiliser program.

9. Irrigation water testing

Have your water supply analysed for both quality and nutrients (groundwater may contain many of the nutrients supplied by fertilisers) and adjust your fertiliser program accordingly.

Table 2 shows a quick way of calculating the nutrients applied via irrigation water. If, for example, the irrigation water contains 10 mg/L of nitrogen and 5 mm of water is applied, then the amount of nitrogen applied to the soil is 0.5 kg/ha.

Table 2. Nutrient applied (kg/ha) in irrigation water (mm) of different nutrient concentration (mg/L) (note: mg/L = ppm).

Water applied	Concentration of nutrient in water (mg/L)						
(mm)	**1**	**5**	**10**	**15**	**20**	**25**	**30**
1	0.01	0.05	0.10	0.15	0.20	0.25	0.30
5	0.05	0.25	0.50	0.75	1.00	1.25	1.50
10	0.10	0.50	1.00	1.50	2.00	2.50	3.00

kg/ha = kilograms per hectare; mm = millimetres; mg/L = milligrams per litre; ppm = parts per million.

Salinity is the most important measure of water quality. A salinity test will indicate whether water is suitable for irrigation. Table 3 provides a guide to water component levels considered 'good' through to the upper limits, which are considered 'problematic'.

Table 3. Summary of water components and suitability of water for irrigation

		Good	Care required	Problem
Salinity	mS/m	<80	80 to 230	>230
	mg/L or ppm	<500	500 to 1200	>1200
pH		5.5 to 8.0	5.0 to 5.5	<5 or >8
Carbonate level (mg/L or ppm)		<150	150 to 350	>350
Chloride	Drip irrigation (mg/L or ppm)	<140	140 to 350	>350
	Spray irrigation (mg/L or ppm)	<70	70 to 150	>150
Calcium carbonate	Levels causing corrosion (mg/L or ppm)	>-0.5	- 0.5 to -1.5	<-1.5
	Levels causing encrustation (mg/L or ppm)	<+0.5	= 0.5 to +1.5	>+1.5
Sodicity	(level of sodium ions in water)	SAR <3	SAR = 3 to 12	SAR = >12
Iron	(mg/L or ppm)	0	0.1 to 1.0	> 1.0

mg/L = milligrams per litre; ppm = parts per million; mS/m = milliSiemen/metre; SAR = sodium absorption ratio.

Dissolved salts in irrigation water affect crop performance in different ways. Not only do the salts inhibit moisture extraction in the root zone but some of the elements they contain (such as chloride, sodium and boron) are also toxic to plants. As a result, growth and yield will be adversely affected.

Information on collecting water samples for chemical, nutrient and bacteriological analysis, and on techniques for monitoring water pH and EC, are described in Appendix 9: *Collecting a water sample*.

10. Timing of nutrient application

10.1 Important considerations

Factors that significantly affect the timing of nutrient application are as follows.

- **Growth stage of the crop** – fertiliser should be applied when the crop is actively growing and can use the nutrients. Shortly after planting, when the plant's root system is immature, the crop's need for fertiliser will be 1% or less of its full life requirement. At this stage in the growth cycle, it is important that the fertiliser remain at a shallow depth long enough for the crop to take up what it needs. Later, the crop may be doubling in weight weekly so larger amounts of fertiliser will be required to meet its needs. By that time, the plants' root systems will be more extensive, enabling the crop to recover applied nutrients from a greater volume and depth of soil.
- **Type of fertiliser applied and how often** – generally speaking, to minimise leaching of nutrients beyond the crop's root zone, fertilisers should be applied in small amounts but frequently, especially on sandy soils.
- **Irrigation schedule** – irrigation should be accurately scheduled, using evaporation replacement, and monitored with soil moisture probes. If it is necessary to leach a build-up of salts from the crop's root zone, do this during a time of low fertiliser input, thereby reducing the degree of nutrient leaching.
- **Rainfall** – if heavy rains are predicted, do not apply fertilisers. Both ammonium and nitrogen in nitrate form are very soluble in water and will readily leach past the crop's root zone. In addition, phosphorus can be lost through surface run-off.
- **Alkaline soils** – losses of nitrogen through volatilisation (conversion to ammonia gas) can be higher in alkaline soils than in acid soils. Incorporation of urea and ammonium-based fertiliser by irrigation will minimise such losses. Nitrate sources such as potassium nitrate, calcium nitrate and magnesium nitrate are more suitable. (Note: sulphate of ammonia is useful in alkaline soils, as it helps acidify the soil and thereby enhances the availability of trace elements.)

10.2 Timing application to crop needs

Apply nutrients when your crop needs them most.

How quickly a crop takes up various essential elements will affect the timing of fertiliser application.

Nitrogen tends not to accumulate in plants and so needs to be supplied constantly. Ideally, nitrogen application rates should be matched to the growth stage of the crop. With young crops, which require a lesser amount of nutrients than crops at the mid-growth stage, it is better to apply nitrogen in smaller, more frequent doses because the plants' root systems are smaller. During the first four weeks of the crop's growth, application rates may be less than half of those required subsequently. To minimise nutrient losses due to rainfall, weather should be taken into account when applying nitrogen; for example, more nitrogen may be necessary if there is higher-than-usual rainfall during winter. To maximise the efficiency of nitrogen usage by the crop, the first (light) application should occur after planting but before emergence for direct-sown crops, or immediately after planting for transplanted crops. Consideration should be given to drenching transplants with dilute nutrient solution in the trays before transplanting, as well as the use of starter solutions.

Phosphorus – on coastal sands, phosphate fertilisers should be broadcast and incorporated before planting, except on Bassendean sands where phosphorus may leach. Local research has shown that banding at planting reduces yield on sandy soils. While most plants take up the bulk of their phosphorus requirement early in life (at the seedling stage for annuals and during early regrowth for perennials), it is still required throughout their lifecycle. The need to side dress phosphorus is reduced because it is necessary for early root development, is mobile in plants and can be stored in stems and leaves. However, if soils have a low Phosphorus Retention Index (PRI) (see Appendix 4: *Understanding soil analysis*), phosphorus should be applied frequently at low rates. Karrakatta and Spearwood sands, for example, can retain significant amounts of applied phosphorus, whereas Bassendean sands (low PRI) cannot. Therefore, on Bassendean sands it is better to apply phosphorus with every fertiliser dressing until the total amount of phosphorus required for the life of the crop has been applied.

Potassium leaches from all three of the above-mentioned coastal sand types almost as readily as nitrogen. Therefore, in order to promote optimum early growth, sufficient potassium should be applied early in the life of crops grown on such soils. Later in the crop's life, however, weekly applications are not critical because potassium, like phosphorus, can be stored in the plants' leaves and stems, thereby reducing the need to side dress this nutrient as frequently as one would nitrogen. On Spearwood/Karrakatta sands, soil testing for potassium is meaningful where this element has been shown to resist leaching, and soil test results may reach 40 ppm.

Sulphur is generally incorporated into fertilisers containing the elements magnesium, potassium and phosphorus in a quantity sufficient to meet crop needs.

Calcium – as with sulphur, calcium is often present in fertilisers such as superphosphate, or in soil improvers such as lime, in a quantity sufficient to meet crop needs. In some areas, significant quantities of calcium can be applied through the irrigation water. If additional calcium is required, it can be applied pre-planting as gypsum, or post-planting by using calcium nitrate as a source of nitrogen.

Magnesium is commonly deficient on acidic coastal soils. In most cases, it can be side dressed regularly, at the appropriate rate, during the life of a crop to avoid deficiency.

Boron leaches readily in sandy soils so, where it is deficient, soil applications should occur before planting and a number of times during crop growth. Celery, carrots, turnips, beetroot and swedes are particularly susceptible to boron deficiency, while beans are sensitive to its overuse.

Both **zinc** and **manganese** deficiencies are sometimes seen in a range of crops on alkaline soils to which high rates of phosphorus have been applied. While foliar sprays of these elements will correct the deficiency, recovery from symptoms can be very slow if spraying is delayed until they are severe.

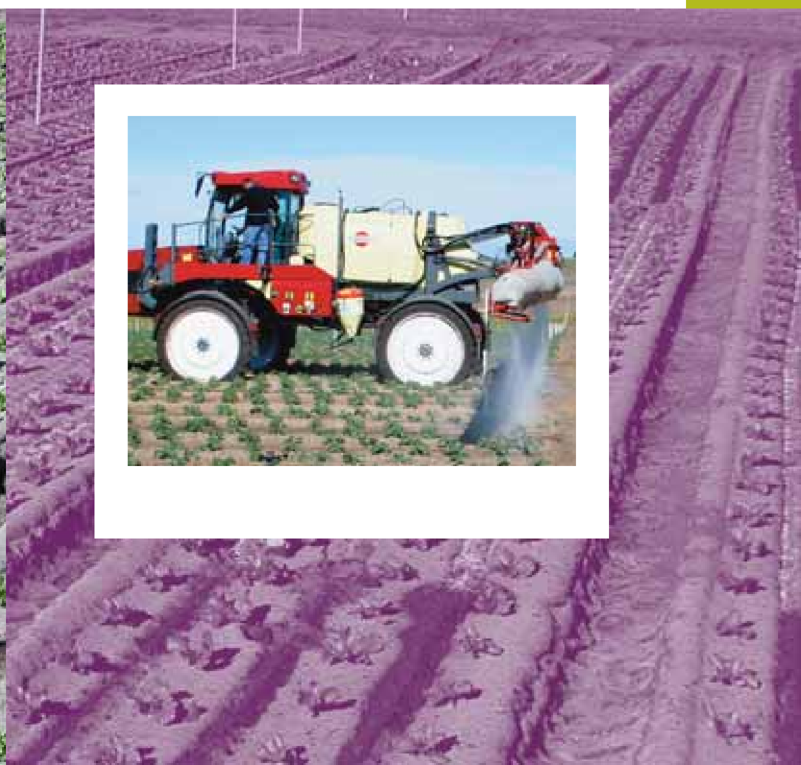
11. Quantity of fertiliser

Understanding the nutrient composition of fertilisers will help you decide what to apply and when.

11.1 Nutrient composition of fertilisers

A wide range of fertilisers – and hence a wide range of nutrient compositions – is available. However, proprietary mixed products may not contain the correct ratio of nutrients for a particular crop type or growth stage. Understanding the nutrient composition of various fertilisers helps in choosing the most appropriate for a given situation, saving money and time and preventing wastage.

For a comparison of the nutrients found in major fertiliser brands, refer to Appendix 10: *Comparison of nutrients in major fertilisers*. Information on the advantages and disadvantages of some fertilisers, including inorganic and organic varieties, can be found in Appendix 11: *Comparison of major fertilisers* and Appendix 12: *Advantages and disadvantages of inorganic and organic fertilisers*.



11.2 Manure as a nutrient source

In addition to their nutrient value, organic manures help improve the physical properties of the soil, thereby improving its water- and nutrient-holding capacity.

Poultry manure is readily available at a reasonable price; however, it should be used with caution to reduce the risk of fly breeding and nutrient leaching.

For information on the advantages and disadvantages of poultry manure, as well as various alternatives, see Appendix 13: *Poultry manure*.

In 2007, the use of raw poultry manure in areas affected by stable fly is permitted from June 1 to August 31 only. In such areas, pre-planting applications of poultry manure should be incorporated into the soil immediately for better control of this pest.

To minimise nitrogen loss, poultry manure should be applied within 7 days of seeding or planting. (Note: applying raw poultry manure at a high rate may cause plant roots to burn.) Conditioned poultry manure – which is available for use all year 'round – has been composted to a standard, in order to reduce its fly-breeding potential.

To further protect waterways, an unfertilised, vegetated buffer of around 10 to 30 metres wide should be maintained around block boundaries and adjacent to any watercourses.

Mineral nitrogen can be used in place of poultry manure. If so, it should be applied throughout the crop's growth cycle.

In recent research, DAFWA successfully applied chemical nitrogen to transplanted lettuce and broccoli crops by spray for 14 to 21 days after planting (at the time of writing, the outcomes of this research are yet to be published) and obtained encouraging results using the same technique with celery, cauliflower, cabbage and Chinese cabbage.

11.3 Compost as a nutrient source

As a nutrient source, well-processed, greenwaste-based compost will:

- supply nitrogen, phosphorus, potassium, magnesium and minor plant nutrients;
- build soil carbon and organic nitrogen;
- increase soil microbial activity;
- increase soil cation exchange capacity;
- reduce bulk density, and
- increase the soil's ability to hold water.

For growers to maximise the benefits of compost, they need to adjust their fertiliser programs to account for the nutrients it supplies. While this is relatively simple for phosphorus, potassium and magnesium, adjustment for nitrogen involves monitoring crop vigour and making the necessary adjustment to nitrogen fertiliser.

(Note: further information on the benefits of compost will be included in a section on Soil management scheduled for inclusion in this guide.)

11.4 Calculating quantity of fertiliser to apply

Apply fertiliser at the correct rate for your crop.

A 'unit' of nutrient equals a kilogram of nutrient (a unit of phosphorus, for example, equals a kilogram of phosphorus) but not a kilogram of fertiliser. Often, the nutrients a fertiliser contains are indicated on the container (bag) or packing slip as percentages or as N:P:K:S (that is, nitrogen:phosphorus:potassium:sulphur). Single superphosphate, for example, contains 0:8.8:0:11, meaning that a 100-kilogram bag would contain no nitrogen, 8.8 kilograms of phosphorus, no potassium and 11 kilograms of sulphur.

The following equation can be used to calculate the amount of fertiliser needed to provide a given amount of a nutrient.

nutrient (kg/ha) ÷ **% of nutrient in fertiliser** x **100** = **amount of fertiliser to be applied (kg/ha)**

Example: 20 units (kg/ha) of phosphorus is needed, and the plan is to use single superphosphate with 8.8% phosphorus; therefore:

20 (kg/ha) ÷ **8.8** x **100** = **227 kg/ha of superphosphate required**

The calculation can be reversed in order to determine how much of a nutrient is being applied:

amount of fertiliser (kg/ha) x **% of nutrient in fertiliser** ÷ **100** = **nutrient applied (kg/ha)**

Example: the plan is to apply 125 kg/ha of single superphosphate:

125 (kg/ha) x **8.8** ÷ **100** = **11 kg/ha of phosphorus applied**

For more information on fertiliser rates, as well as practices to reduce leaching, see Appendix 3: *Rates of, and practices to reduce, leaching*.

11.5 Selection of fertiliser

The choice of fertiliser should not depend on price alone – the following factors should also be taken into consideration.

- **Response to fertiliser** – is it necessary to use a fertiliser at all? Legumes, for example, fix their own nitrogen, so no additional nitrogen is required. Moreover, other crops that follow a crop of legumes will also require less nitrogen.
- **Nutrients in the soil** – what, if any, are they?

- **Availability** – is the fertiliser of first choice (for example, poultry manure) available locally and/or at the right time of year? (Note: any freight and spreading costs involved must also be factored in.)
- **Nutrient availability** – are the nutrients in the fertiliser slow-release or rapidly available?
- **Handling** – what size of bag (a small or a 1-tonne bag) is easiest to manage, and is there machinery available to apply the fertiliser at the correct rate? Blends, although often more expensive, may be easier to handle.' (Note: again, additional manpower may be required to handle/spread some types of fertiliser, in which case this cost must be factored in.)
- **Detrimental effects** – how much of a particular fertiliser is it safe to apply (phosphatic fertilisers, for example, contain cadmium)? Is the fertiliser highly leachable? Are there other precautions associated with its use? (Note: some fertilisers are more acidifying than others and must be used sparingly on soils with a low pH, while others contain heavy metals or salts.)

12. Fertiliser application

Practise good fertiliser management by choosing the best application method to apply the correct amount of nutrients at the right time, in the right place and at the right depth (that is, in the area containing the most roots) for your crop, to ensure that all the nutrients are used, not wasted.

How a fertiliser is applied will depend on a range of factors, including the:

- type and amount used;
- type of crop and stage of crop growth;
- soil type, and
- irrigation system used.

Appendix 14: *Fertiliser application* lists the advantages and limitations of different fertiliser application methods, including banding, broadcasting, fertigation, boomspray and drip irrigation. Further, it highlights the significance of fertiliser placement for optimum yield with minimal loss of nutrients into the environment, and provides information on fertilisers suitable for fertigation, plus details of their solubility.

13. On-farm trials

Fine-tune your fertiliser application methods, rates and timing by conducting annual strip trials on your property.

Strip trials/test strips or on-farm testing sites – that is, simple, large-scale comparisons that allow quantification of the effect to be tested – are especially useful for fine-tuning fertiliser programs. Careful establishment is essential, as poorly conducted test strips may produce misleading, even meaningless, results.

For test strips to be of real benefit, the following points need to be considered.

- **It is important to define exactly what is being tested** (such as the effects of different amounts of phosphorus, different sources of lime, etc.) – the test strips should reflect this. (Note: only one factor at a time should be tested.)
- **All variables, apart from those being tested, should be eliminated** (for example, the area should be as uniform as possible in terms of soil type, topography and slope, and only one product rate should be changed at a time) and the plot size must be large enough to show measurable differences.
- **The test strip should include a control area** to which no treatments are applied (other than the standard management regime).
- **Good record-keeping is vital** – details of planting and harvesting dates, seeding rates, fertiliser types, rates and timing, crop varieties, cultivation treatments, rotations, weed populations and sprays used must be recorded.
- **Test strips should be replicated**, as repeat treatments will eliminate any natural and/or unexpected variations that may arise and affect results. Each fertiliser treatment should be repeated two or three times.
- **Tests should be run over a number of years**, as results from any single year will require confirmation.

14. Calibrating and maintaining equipment

To ensure even spreading at the correct rate, it is important to maintain and calibrate your fertilising equipment regularly.

All fertiliser spreaders (including boomsprays, fertigation equipment, spreaders and broadcast machinery) require careful calibration and must be recalibrated every season, as fertiliser products change in size and/or consistency each year. In addition, wear and tear on machinery will affect spreading rates from season to season, even if the same product is put through the machine. Most machinery comes with detailed manufacturer's instructions regarding calibration and maintenance. Again, it is important to keep records of equipment calibration and maintenance. For more information, refer to Appendix 15: *Care of equipment*.

15. Fertiliser storage

Ensure that fertiliser storage areas are:

- **well-ventilated;**
- **appropriate for the type of fertiliser;**
- **protected from direct sunlight and rain;**
- **designed for easy containment and removal of spillage, and**
- **located away from watercourses (such as rivers and creeks).**

Fertiliser storage requirements may vary depending on the type of fertiliser, how it is packaged (bulk, bagged, liquid, manure, etc.), local conditions and local government legislation. Appendix 16: *Correct storage of fertiliser* contains broad guidelines. The relevant local government authority should be contacted for any additional special requirements.

16. Record-keeping

Keep detailed records – they are essential for soil testing and nutrient management.

Monitoring of nutrient applications, crop performance and other relevant factors (such as weather patterns) facilitates decision-making with respect to the efficiency of fertiliser use. It allows nutrition programs to be fine-tuned and any environmental impacts associated with fertiliser use to be minimised.

It is important that the following information be recorded.

- Details of **fertiliser application** (including location of the block/s fertilised, date of application, type and quantity of fertiliser used, the method of application and by whom, etc.).
- Information on **soil condition** and **characteristics**.
- **Results of nutritional analyses** (such as soil and tissue/sap testing).
- **Crop type**, **variety**, **planting date** and **harvesting date**.
- **Crop performance** and **quality measurements**.
- **Crop health** and **nutritional disorders**, if any.

Detailed records provide vital information on production and environmental management, which is important for crop performance, market access and sustainability.

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