Vegetable R&D
Your national vegetable levy at work

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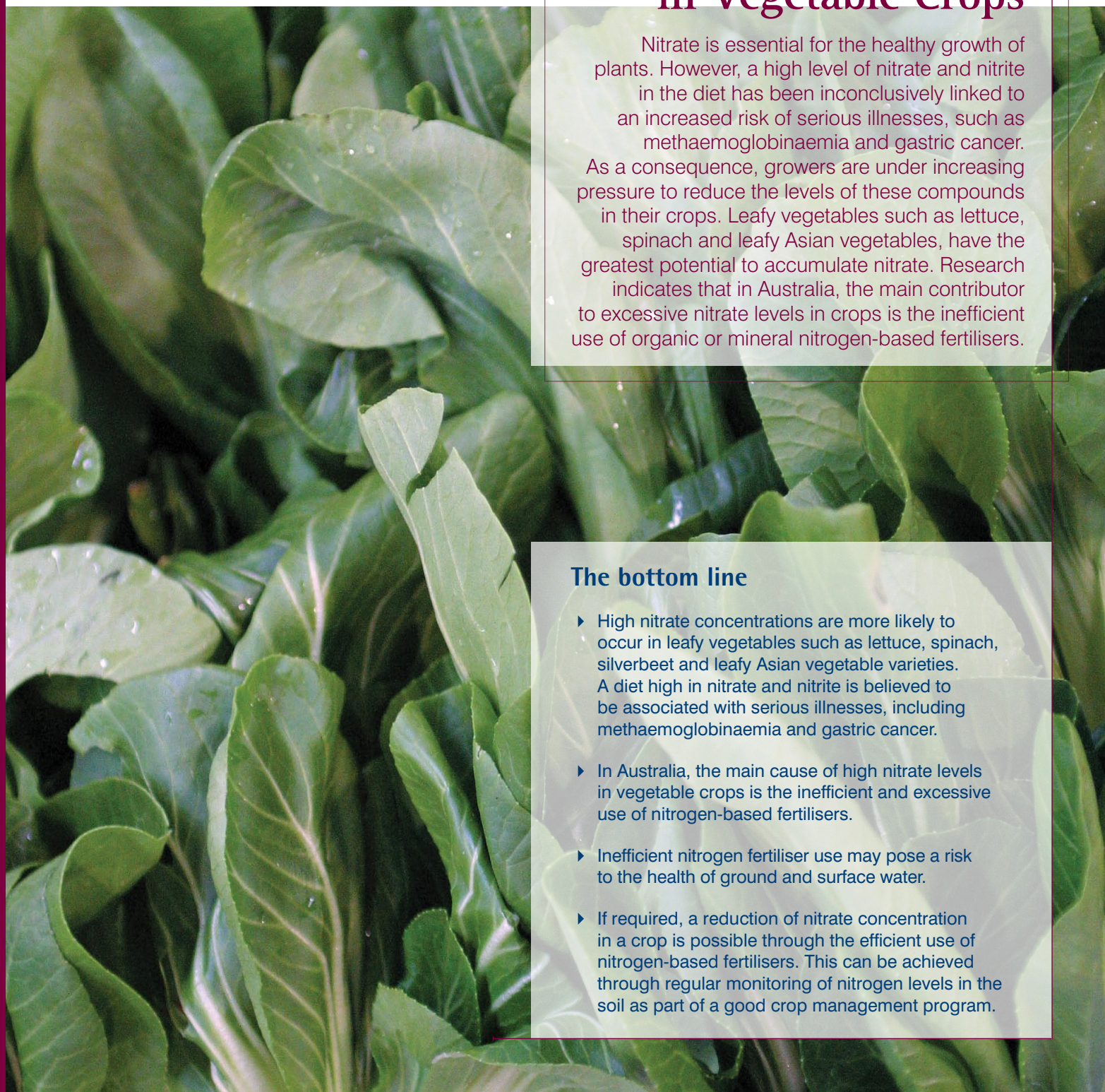
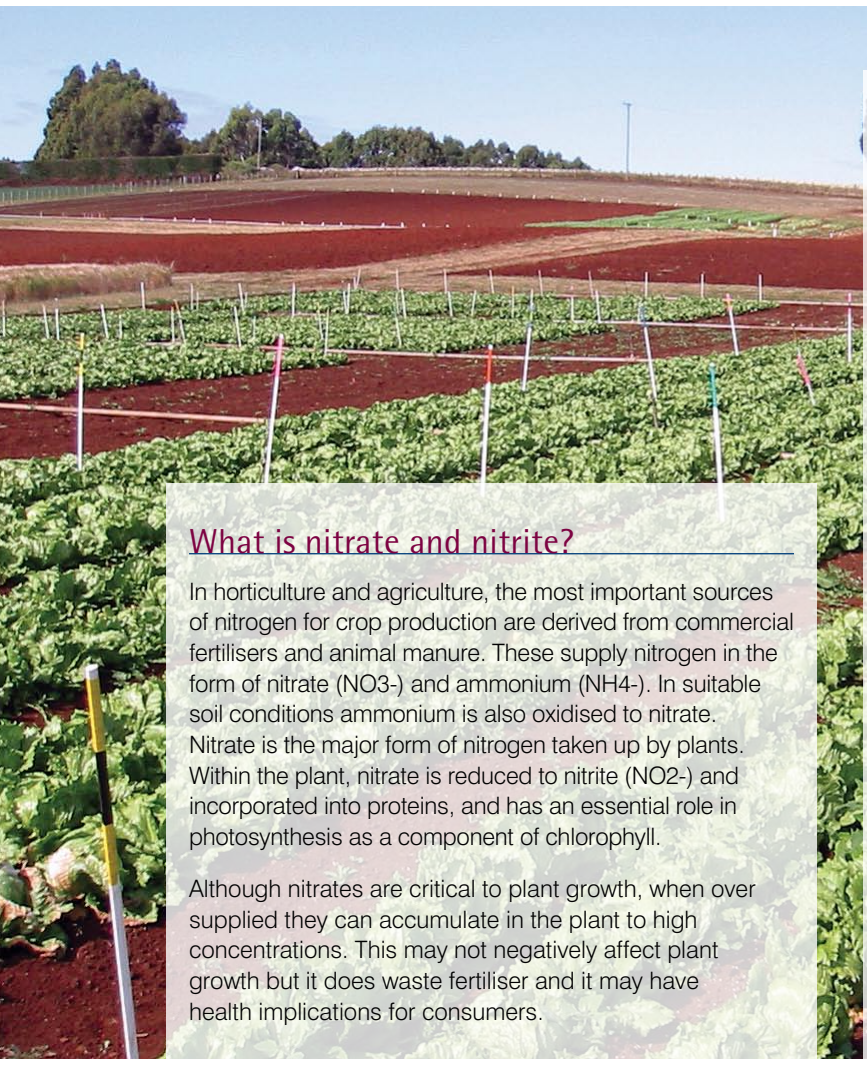
Reducing Nitrate and Nitrite Concentrations in Vegetable Crops



Nitrate is essential for the healthy growth of plants. However, a high level of nitrate and nitrite in the diet has been inconclusively linked to an increased risk of serious illnesses, such as methaemoglobinaemia and gastric cancer. As a consequence, growers are under increasing pressure to reduce the levels of these compounds in their crops. Leafy vegetables such as lettuce, spinach and leafy Asian vegetables, have the greatest potential to accumulate nitrate. Research indicates that in Australia, the main contributor to excessive nitrate levels in crops is the inefficient use of organic or mineral nitrogen-based fertilisers.

The bottom line

- High nitrate concentrations are more likely to occur in leafy vegetables such as lettuce, spinach, silverbeet and leafy Asian vegetable varieties. A diet high in nitrate and nitrite is believed to be associated with serious illnesses, including methaemoglobinaemia and gastric cancer.
- In Australia, the main cause of high nitrate levels in vegetable crops is the inefficient and excessive use of nitrogen-based fertilisers.
- Inefficient nitrogen fertiliser use may pose a risk to the health of ground and surface water.
- If required, a reduction of nitrate concentration in a crop is possible through the efficient use of nitrogen-based fertilisers. This can be achieved through regular monitoring of nitrogen levels in the soil as part of a good crop management program.



What is nitrate and nitrite?

In horticulture and agriculture, the most important sources of nitrogen for crop production are derived from commercial fertilisers and animal manure. These supply nitrogen in the form of nitrate (NO3-) and ammonium (NH4-). In suitable soil conditions ammonium is also oxidised to nitrate. Nitrate is the major form of nitrogen taken up by plants. Within the plant, nitrate is reduced to nitrite (NO2-) and incorporated into proteins, and has an essential role in photosynthesis as a component of chlorophyll.

Although nitrates are critical to plant growth, when over supplied they can accumulate in the plant to high concentrations. This may not negatively affect plant growth but it does waste fertiliser and it may have health implications for consumers.

Nitrates and food safety

In the human diet, vegetables and water are the main sources of nitrate, and processed meats are the major contributor of nitrite. It is suggested that the consumption of foods with excessive nitrate and nitrite may be a risk to human health.

"Although nitrate is relatively non-toxic, in the digestive system it is readily converted to nitrite and N-nitroso compounds that are toxic and these have been associated with the potentially fatal methaemoglobinaemia [also known as 'Baby Blue Syndrome', and caused by a decreased ability of blood to carry oxygen], gastric cancer and bladder cancer. However, a true link between these conditions and the consumption of vegetable-derived nitrate has not yet been demonstrated," said Sophie Parks, a research horticulturist with the NSW Department of Primary Industries. Over the last several years, Sophie and her team have been investigating the concentration of nitrate and nitrite in Australian leafy vegetables.

Sophie believes it is this possible link between nitrate consumption and ill health that has prompted research, both locally and internationally, into nitrate levels in vegetables and their impact on those who consume them.

"In New Zealand, a recent consumption survey suggested that up to 10 per cent of people exceed the acceptable daily intake of nitrate and nitrite, potentially increasing their risk to the associated adverse affects of nitrite." As issues surrounding public health become a growing concern for government, Sophie believes that the connection between nitrate levels and potential health problems means that the Australian vegetable industry could potentially be subject to regulatory standards, such as those imposed on producers in Europe.

Nitrates and product quality

Large applications of nitrogenous fertiliser are undesirable as they can compromise vegetable quality. For example, the incidence and severity of bacterial soft-rot in vegetables has been shown to increase in Chinese cabbage and some susceptible broccoli cultivars associated with increasing applications of nitrogen-containing fertiliser. The vitamin C concentration of lettuce has also been shown to drop as nitrate concentration is increased.

Maintaining product quality through good post harvest techniques is important in keeping nitrite levels low. High storage temperature and long storage periods have been shown to increase nitrite in vegetables such as Chinese cabbage and spinach.

Factors influencing nitrate levels

Leafy vegetables, such as lettuce, spinach, silverbeet and many Asian vegetables, have been found to accumulate nitrate at higher concentrations than root or fruit vegetables. Research has indicated that these concentrations can accumulate to levels that exceed optimal plant growth, and lead to a reduction in crop quality.

Sophie explains that around the world, high nitrate levels can be influenced by a number of factors, including light levels, supply of nitrate (as fertiliser) and plant variety.

"In Europe, for example, it has been found that the nitrate concentration in spinach and lettuce increases during the winter months because of the reduced levels of light. We thought that this might have some implications for the protected cropping industry in Australia, however, in our experiments with silverbeet, the level of light had no impact on the concentration of nitrate found in the plants."

Plant variety is also a major consideration when assessing nitrate levels. A recent survey of fresh leafy vegetables on the Australian market undertaken by Sophie's team at the NSW Department of Primary Industries showed that 27 per cent of the vegetable varieties surveyed were high in nitrate. Of those tested, it was discovered that many Asian leafy vegetables were particularly prone to accumulating nitrates.

"Our research revealed that a number of leafy Asian vegetable varieties have the potential to accumulate a high concentration of nitrate. However, further research is required to more accurately ascertain the nitrate requirements of these varieties. We are also looking at developing easier protocols for measuring plant nitrate on farm. Following this work we will be able to provide growers with recommendations for managing nitrate in leafy Asian vegetables."

Sophie has concluded from her research that the main contributor to nitrate levels in leafy vegetables is the quantity of fertiliser used on the crop.

"High levels of nitrates in vegetables is generally symptomatic of excessive use of nitrogen-based fertilisers, and as an industry, we should be aiming to be as efficient as possible in managing nutrients on farm," Sophie said.

Doris Blaesing of Serve-Ag Pty Ltd in Tasmania believes that the need for Australian growers to become efficient users of nitrogen-based fertilisers is also an environmental issue. For the last ten years, she has been monitoring the impact of nitrates on the surrounding environment.

"Excessive nitrogen in the soil has the potential to leach into surrounding waterways, which may have significant environmental impacts, for example, on the occurrence of blue green algae blooms and general river and estuary health," she said.

Originally from Germany, Doris believes that some of the issues experienced in Europe, such as nitrogen leaching into water reserves, could potentially affect Australians in the future.

"In Europe, people drink groundwater, and with production in Europe often conducted over groundwater reserves, nitrogen leaching into surrounding waterways is a major concern," Doris said.

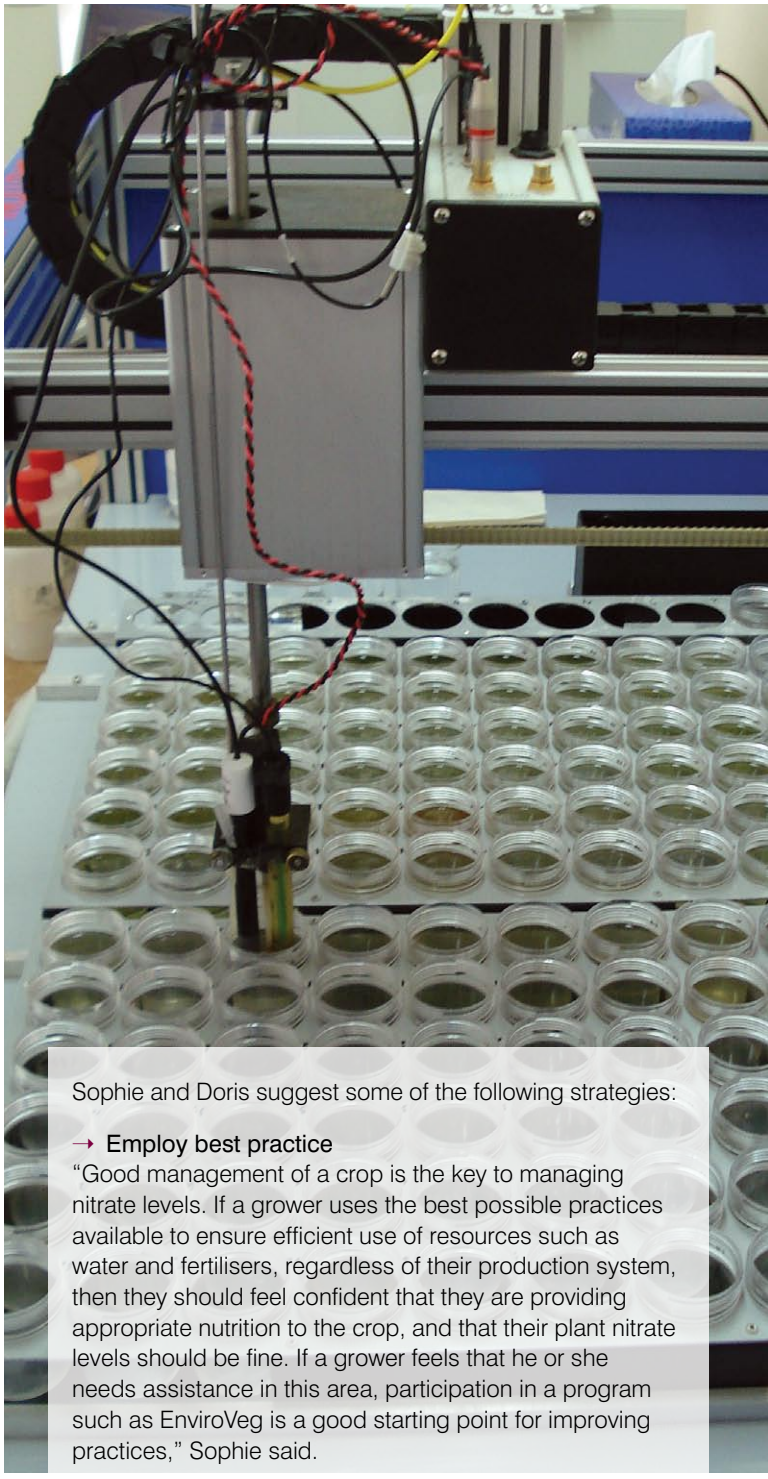
"There are some areas in Australia that are considering the use of groundwater for drinking water, and this means the levels of nitrogen leaching are becoming more pressing for local industry."

Efficient application of fertilisers also has economic implications for growers, given the rapid rise in fertiliser prices over recent months.

"With rising fertiliser prices in the last 12 months, growers now have a very good reason to reduce their fertiliser use," Doris said.

Managing nitrate levels

Despite the debate about the impact of nitrates on human health, the negative effect of accumulated nitrate on vegetable quality, and of nitrate in environmental pollution, is indisputable. Unlike the European Union, Australia has not yet found it necessary to implement strict standards regarding nitrate levels in crops. However, growers should be aware of the risks of excessive nitrate levels, and work to actively minimise the levels of nitrates and nitrites in their crops.



Sophie and Doris suggest some of the following strategies:

→ **Employ best practice**

"Good management of a crop is the key to managing nitrate levels. If a grower uses the best possible practices available to ensure efficient use of resources such as water and fertilisers, regardless of their production system, then they should feel confident that they are providing appropriate nutrition to the crop, and that their plant nitrate levels should be fine. If a grower feels that he or she needs assistance in this area, participation in a program such as EnviroVeg is a good starting point for improving practices," Sophie said.

Sophie believes that if Australian growers can demonstrate that they are producing their crops according to best practice, then the enforcement of an industry standard may not become necessary.

→ **Test your soils regularly**

Before preparing soil for planting, it is recommended that growers undertake suitable soil testing of freely available nitrate to determine the need for additional nitrogen.

"Growers should be aware of the quantities of nitrogen that the plant actually removes, and should not apply quantities of nitrogen that exceed this," Doris said.

In the case of new plant varieties, such as Asian vegetables, where optimal levels are unknown, she recommends testing available soil nitrate in the root zone and then topping up these reserves with appropriate fertilisers to meet crop requirements, rather than following a one-size-fits-all approach.

"In new crops, growers should test their soils, and we recommend that their soil nitrate levels should not exceed 50-80kg per hectare of freely available nitrate. If, for example, your soil test indicated that there is 200kg of available nitrate, then you would know that you would not need to apply further nitrogen to your crop."

Doris explains that there are a variety of tests available to growers that will provide them with the necessary information to make informed decisions.

"In the last ten years, we've picked up on a soil monitoring method, called N-Check, to measure nitrate levels in the soil. It's a crop management tool that evaluates available nitrogen levels in the root zone, and can provide results within 24-36 hours of sampling to allow precise nitrogen fertiliser applications," Doris said.

Testing the nutrient concentration in plants is an additional tool that can be used for fertiliser management. For some crops like lettuce, there are sampling protocols and established nitrate standards for optimum growth and quality.

Sophie highlights that it is important to be aware of the method used for nitrate analysis and the unit used for reporting the nitrate concentration, when considering plant analysis. Nitrate analysis can be carried out on fresh or dried plant tissue. Drying plant tissue concentrates the nitrate present into a smaller volume and it follows that the nitrate concentration obtained using this method will be higher than that obtained from fresh tissue. Also, the nitrate sample concentration can be expressed as NO3- nitrate or NO3- -N nitrate-nitrogen. If you need to make a conversion: NO3- -N x 4.43 = NO3- and NO3- -N / 0.226 = NO3-. Therefore, 2000 mg/kg (ppm) NO3- nitrate = 452 mg/kg (ppm) NO3- -N.

→ Select and apply appropriate fertilisers for your crops

Good fertiliser and irrigation management requires skill and experience.

Growers may benefit from observing practices from overseas. Doris explains that in Germany, vegetable growers are more likely to use calcium nitrate fertilisers, as it allows for nitrate levels to be easier to control in soils and plants.

"There are also products, available locally, that contain nitrification inhibitors which are useful to prevent excessive nitrate uptake by plants and leaching into the surrounding waterways," she said. They should also save growers' money by increasing the nitrogen use efficiency of fertilisers.

"However, growers should contact the agronomist in their area to discuss the best fertiliser products for their requirements," Doris said.

Further reading

Blaesing, D. *Controlling nitrogen losses - can we learn from the European experience?* Serve-Ag Pty Ltd, PO Box 690, Devonport, Tasmania, www.serve-ag.com.au

Parks, S. (2007) *Asian Foods Newsletter*, Issue 97, RIRDC Asian Foods Program

Parks, S., Huett, D., Campbell, L., Spohr, L & Jarvis, J. (2007) *Assessing nitrate and nitrite levels in Australian leafy vegetables*, Project Number VG04019, NSW Department of Primary Industries www.ausveg.com.au/levy-payers/login.cfm

Reuter, D. J. & Robinson, J. B. (eds.) (1997) *Plant analysis, an interpretation manual*, Melbourne, CSIRO

Soilwise – pocket guide to looking after soils and Soilwise – managing soils and fertilisers DVD. Available also in Khmer, Cantonese, Arabic and Vietnamese. Contact the NSW Department of Primary Industries on: 1800 028 374 or 1800 025 520 or visit <www.dpi.nsw.gov.au/bookshop> or <www.det.nsw.edu.au/industryprograms/resources>

Cover image, bunches of Asian vegetable, *Buk Choy*;
p.2 Lettuce trial; p.3 The nitrate analyser with water samples;
p.4 Leafy vegetables ready to be sold for consumption

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