Managing cadmium in potatoes for quality produce: 2nd edition

Consumer demand for quality products is increasing. Concern about the presence of chemical impurities has resulted in monitoring and research into food quality in Australia. Cadmium has been identified as being of potential concern.

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What is cadmium?

Cadmium is a widespread naturally occurring element, present in soils, rocks, waters, plants and animals. It occurs naturally with deposits of lead and zinc, but unlike zinc is not essential to life. Cadmium can accumulate in humans, and high levels can affect human health.

Why is cadmium a problem?

- There is a smaller safety margin in foods, between levels of cadmium and regulatory health limits, compared to other heavy metals such as lead and mercury.
- Cadmium is concentrated in particular parts of plants. Leaves contain the most, followed by storage roots and tubers, seeds or grain and fleshy fruits.
- Human intake of cadmium is through food consumption, smoking and occupational exposure.

Sources of cadmium

- Natural levels in soil range from less than 0.1 mg/kg to 0.5 mg/kg, or about 0.1 to 0.7 kg cadmium/hectare in the top 10 centimetres of soil.
- Rain and irrigation water generally have very low cadmium concentrations. Sewage sludges may contain cadmium as an impurity.
- Cadmium in the atmosphere may be high in the vicinity of industrial activities such as smelting, but in most agricultural regions the amounts added to the soil from the atmosphere are minimal.

Greater use of rock phosphate from the United States, Africa and the Middle East has reduced cadmium inputs to soils.

- Phosphatic fertilisers can contain high levels of cadmium depending upon the source of rock phosphate. Trace element fertilisers and phosphogypsum also may contain high levels. Nitrogen and potassium fertilisers normally have a very low cadmium content.

The Fertiliser Industry Federation of Australia (FIFA) has agreed to progressively reduce the levels of cadmium in phosphate fertilisers by making greater use of rock phosphate with low cadmium content.

FIFA member companies are replacing the current voluntary limit of 250 mg cadmium per kg of phosphorus, for horticultural fertilisers, with a commitment to introduce an appropriate range of differentiated fertilisers with cadmium levels designed to meet defined needs. These products may vary in cadmium content but will generally be below 150 mg cadmium per kg of phosphorus. Horticultural fertilisers are generally applied at higher rates than fertilisers for pastures or other crops.

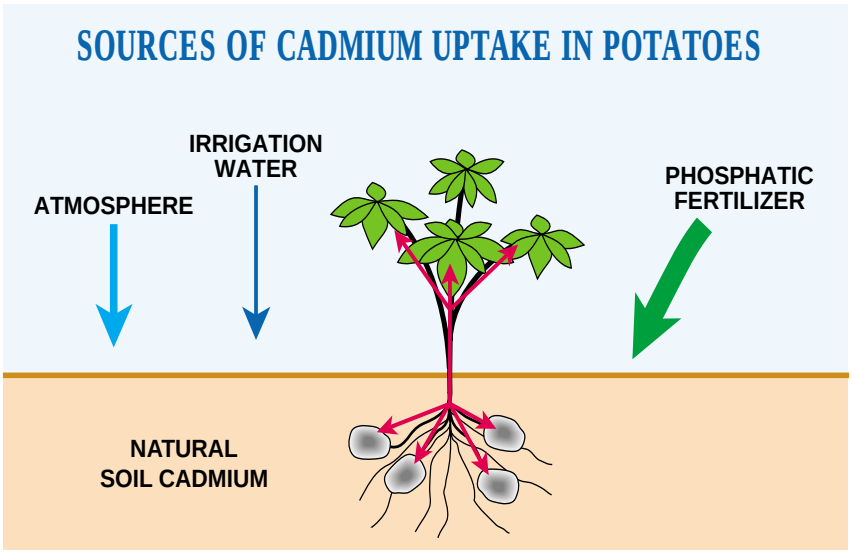
Cadmium levels in Australian food and exports

- Dietary intake of cadmium in Australia is low by world standards and our food exports have a “clean” reputation worldwide. To maintain this quality advantage we need to minimise any potential cadmium accumulation in food products.

How is cadmium taken up by plants ?

- Plants absorb most of their cadmium from soil through their roots.
- Cadmium in soil readily attaches to clay particles and organic matter, making it less available for uptake by plants. Sandy soils with low clay content and organic matter are likely to result in a higher uptake.
- The availability of cadmium to plants decreases as soil pH increases, or as soils become more alkaline.
- Zinc and cadmium uptake by plants occurs in a similar way, and it appears that if soil zinc levels are low then more cadmium will be taken up.
- Cadmium in soil tends to remain in the surface layers where it is available to plants. It can be removed by erosion or by leaching from very light sandy acid soils.

A regular testing program of the harvested crop is recommended.



- Higher concentrations of chloride in the soil appear to mobilise cadmium and increase uptake by plants. This could occur from irrigation with saline water, in areas subject to dryland salinisation, or from the intensive use of chloride based fertilisers.
- Uptake varies considerably between different plant species and between varieties or cultivars.
- Cadmium present in farm produce can also be as a result of soil or dust contamination either in the field or during processing, as well as by direct uptake from the soil.

How do you know you have a cadmium problem ?

In most cases you can not tell visually if a plant has high cadmium. A regular plant testing program is recommended for growers. Tuber samples of the harvested crop should be forwarded to accredited laboratories as cadmium analysis is a specialised service.

The Australia New Zealand Food Authority currently has set a limit for potatoes in the domestic market of 0.1 mg/kg cadmium on a fresh weight basis.

Research has indicated that the probability of cadmium levels of tubers reaching the MPC was increased if the soil contained more than 15mg/kg cadmium extracted in 0.01M calcium chloride. Soil cadmium levels are likely to be high in paddocks with a history of heavy applications of phosphate fertiliser containing high levels of cadmium as an impurity. If possible avoid growing potatoes on these soils.

There are no critical levels for cadmium in agricultural soils.

Management practices to minimise cadmium levels

Varietal selection

Data collected from CSIRO and state department trials have suggested the following variety ratings for susceptibility to cadmium uptake.

High

Toolangi Delight, Kennebec, Crystal, Nadine

Medium

Wilcrisp, Sebago, Nooksack, Winlock, Tarago, Pontiac, Atlantic, Desiree, Delaware

Low

Wilwash, Russet Burbank, Lemhi Russet

Low or medium rated varieties are recommended where the likelihood of cadmium uptake is high.

Select varieties with low or medium susceptibility to cadmium uptake

Correction of soil pH.

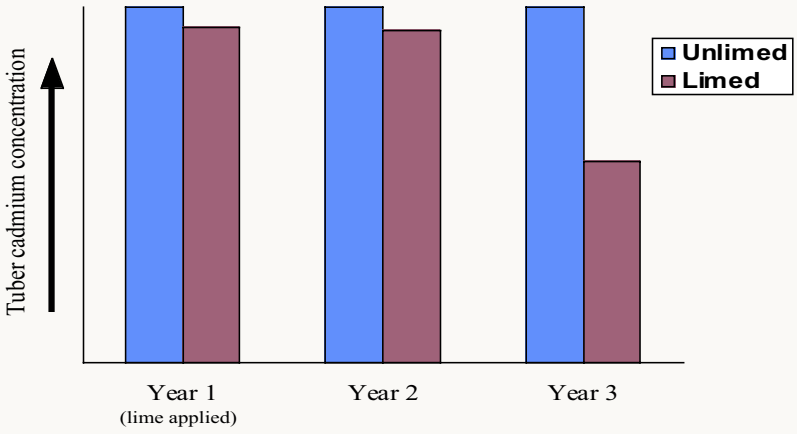
In highly acid soils (pH in water of less than 5.5, or pH in calcium chloride less than 4.8) a liming program should be initiated to increase soil pH. Aim to maintain soil pH (water) between 6.2 and 6.7, or pH (calcium chloride) between 5.5 and 6.0. Avoid overliming which can induce problems of micro-nutrient deficiency and the disease common scab.

Field studies have shown that lime has had little or no effect on tuber cadmium concentrations in the year of application. However, reductions have occurred 2-3 years later.

Potatoes are tolerant of low pH values and so yield increases by liming are unlikely, but responses in crops and pasture during other phases of the rotation are possible.

Field experiments with gypsum were ineffective in reducing tuber cadmium levels and resulted in some small increases. Gypsum has little or no effect on soil pH, ie it is not a liming agent, but is used to reduce the effects of high sodicity in soil, such as hard setting surface crusts or waterlogging. Naturally occurring (mined) gypsum should be considered in place of phosphogypsum for the treatment of sodic soils to be used for potato production, particularly if cadmium uptake is already high. Phosphogypsum is a by-product from the manufacture of phosphatic fertilisers.

A liming program is needed in highly acid soils



An example of tuber cadmium levels in response to liming an acid sandy loam soil

Management practices to minimise cadmium levels

Use of phosphatic fertilisers with low cadmium content

It is recommended that low cadmium fertilisers are used. The impact of this on reducing tuber cadmium levels at sites with a long phosphate fertiliser history is only likely to occur over the medium to long term.

Your supplier will be able to advise you on the cadmium content of fertilisers. Look for products of less than 150 mg cadmium per kg of phosphorus. Such products are commercially available. Where repeated high applications of phosphorus (that is greater than 100 kg per crop) are anticipated, fertilisers of less than 100 mg cadmium per kg of phosphorus are desirable.

Where a paddock has adequate soil phosphorus levels for potatoes (for critical levels consult your local agronomist) phosphorus rates can be reduced as yield response will be limited, and further cadmium will be added through the fertiliser application.

Maintain or increase soil organic matter

There is good evidence that organic matter helps to reduce cadmium availability to plants.

Soil organic matter is generally built up by:

- the retention of crop residues after harvest
- use of green manure crops
- pasture phases in crop rotations
- significantly reducing the number of crop cultivations

The build-up or breakdown of soil organic matter is a slow process and significant changes only occur in the medium to long term, unless organic matter is introduced from external sources such as manures.

Avoid use of irrigation water with high chloride levels

Field experiments have shown that increased chloride content in the topsoil will increase tuber cadmium levels.

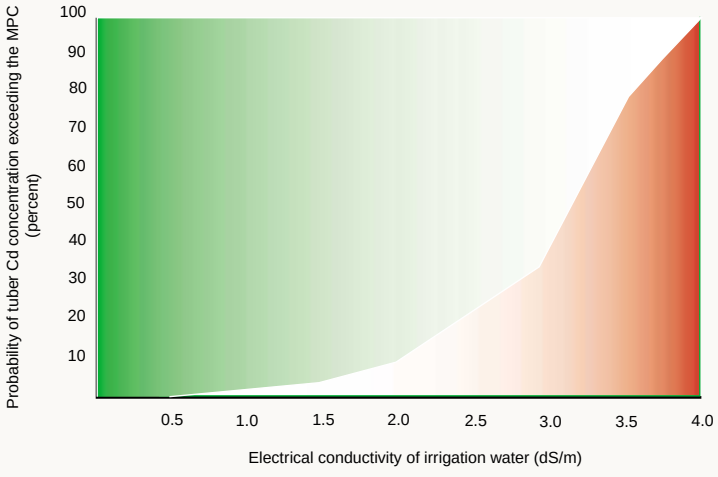
A major source of chloride is likely to be saline irrigation water. Experiments have confirmed increases in tuber cadmium levels with increasing chloride in irrigation water. This effect is less in a highly alkaline soil, that is pH (water) is greater than 8.0 or pH (calcium chloride) is greater than 7.3.

High soil chloride may also occur in areas subject to increasing dryland salinisation, due to rising groundwater levels.

The figure below shows that the probability of cadmium concentrations in tubers reaching the MPC is low when using irrigation water with a conductivity less than 2.0 dS/m. The probability then rapidly increases to above 50% as the salinity of the irrigation water increases above 3.0 dS/m.

Note: 1 dS/m = 100 mS/m = 1 mS/cm

Growers are advised to use water with a conductivity of less then 2.0 dS/m.



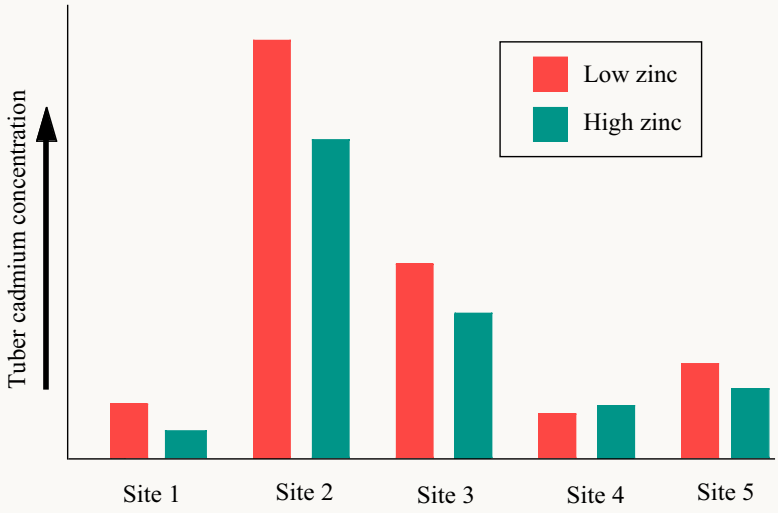
Probabilities of tuber cadmium levels at the MPC with varying levels of salinity of irrigation water

Testing of irrigation water for salinity is recommended - see brochure 'Cadmium in potatoes - managing the risk from saline irrigation water' CRCSLM/CTT01/99 available from your state contact.

Management practices to minimise cadmium levels

Selection of nitrogen and potassium fertilisers to minimise cadmium uptake

Glasshouse and field experiments have shown that changing nitrogen fertiliser has little impact on tuber cadmium concentrations. Changing from potassium chloride to potassium sulphate has decreased tuber cadmium by up to 30% in areas where chloride in soil and irrigation water is low. However potassium sulphate costs more.



Effect of zinc on tuber cadmium

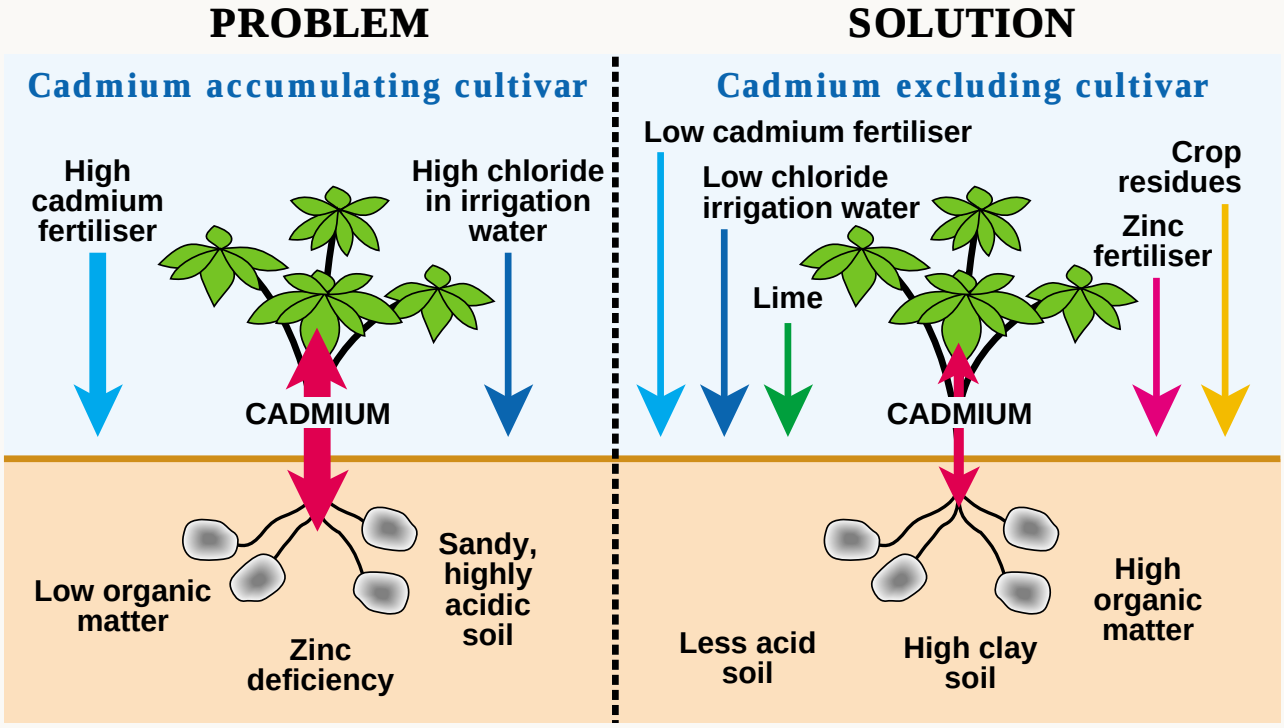
Addition of zinc

Banding 50-100 kg zinc/ha as zinc sulphate at planting has significantly reduced tuber cadmium concentrations at some trial sites. These rates are more than is usually applied to treat zinc deficiency in potatoes.

Zinc broadcast and incorporated into the soil is suggested as a trial where the concentration of EDTA zinc in the soil is less than 6 mg/kg. Rates of 30-100 kg zinc sulphate/ha could be used (consult your agronomist).

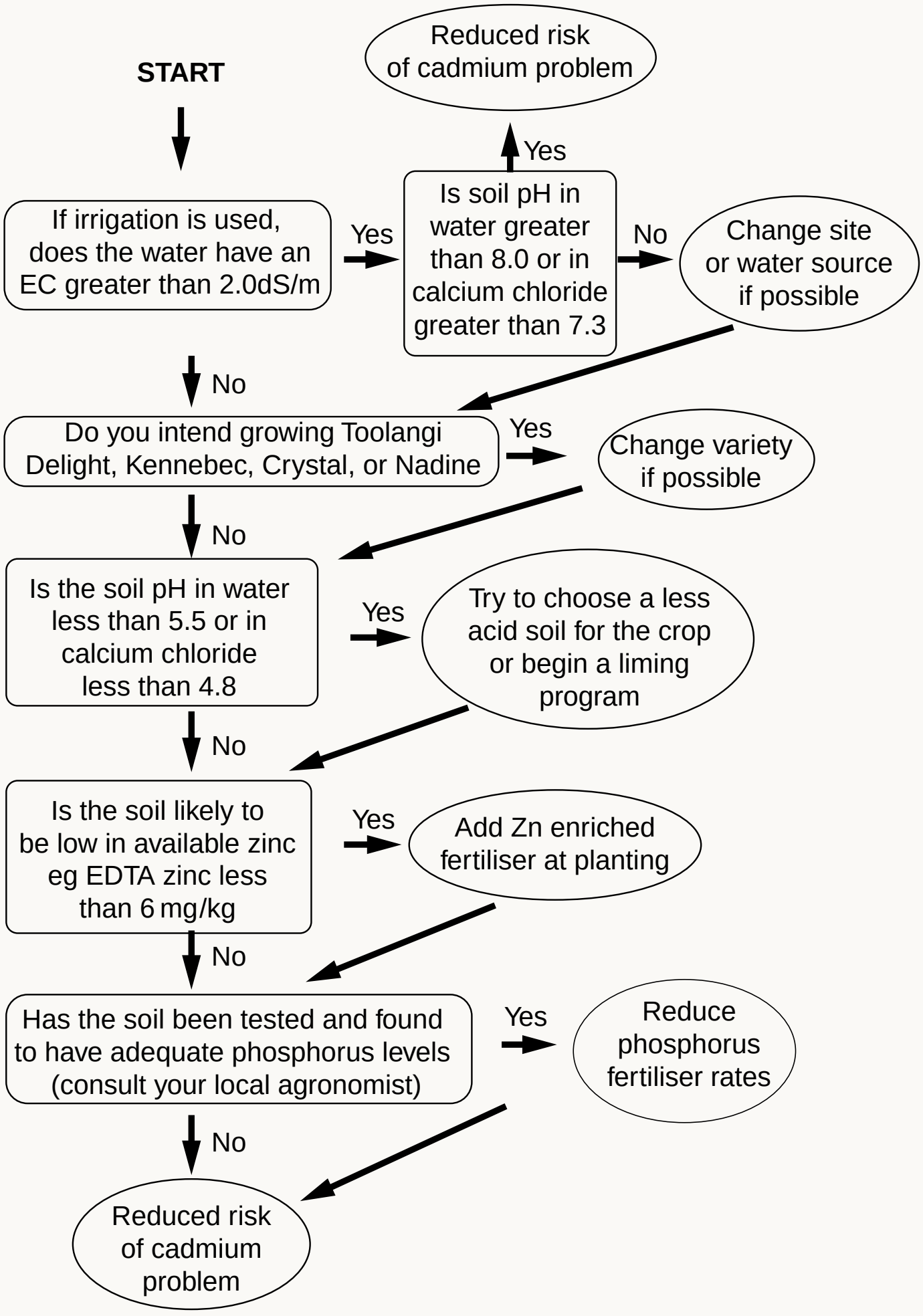
Zinc deficiency has not been widely observed in Australia, so it is unlikely that the zinc will increase potato yields. Any effect of zinc on tuber cadmium should last several years.

Cadmium content of the zinc fertiliser should be checked before using, as the cadmium content of trace element products is normally higher than standard NPK fertilisers.



Managing cadmium effectively means implementing a range of practices as a total system. In paddocks where tuber cadmium concentrations are already high, the impact may be small in the short term, but sound management will be essential to assist control of long term cadmium levels.

Grower checks if tuber cadmium levels are high



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