3.4 Potassium

For general management guidelines pertinent to all nutrients, see chapter 3.1 'Nutrient budgeting'. Most issues pertinent to K are dealt with in that chapter, but some additional issues specific to K are dealt with here.

Although a significant proportion of Australian soils have adequate natural levels of available K for plant growth, K deficiencies do occur, typically in higher-rainfall areas, on sandy soils and in coastal areas (Gourley 1999). On dairy farms, K typically needs to be applied to soils to maintain adequate levels for crop or pasture maintenance particularly, where hay is exported or grazing is intensive (Hosking 1986).

Dairy effluent contains variable but often significant levels of K (typically as salts), and can be used to supply pasture or crop K requirements (McDonald *et al.* 2005). Significant K loadings may be applied to paddocks in dairy effluent, but although grazing and fodder conservation can export significant amounts of K, soil K levels can still become very high (Kruger *et al.* 1995). Excessive quantities of K in soils can lead to animal health problems, soil nutrient imbalances and detrimental environmental impacts (Wang *et al.* 2004). The K collected through an effluent management system therefore needs to be managed prudently.

Potassium in dairy effluent

Typically, dairy pastures and supplementary feeds contain between 1% and 3% of their total dry matter (DM) as K (Hosking 1986). However, the quantity of K within dairy effluent will vary with location and feed type and quantities (Ebeling *et al.* 2003). Small amounts of K are exported in milk, and the remainder is passed out in excrement. Minimal K is lost throughout collection and conveyance of dairy effluent on the farm, and it can be assumed that most K collected will be available for reuse. The amount of K in dairy effluent storages will vary considerably; see chapters 2.3 'Anaerobic, aerobic and facultative ponds' and 2.8 'Desludging and pond closure' for typical K concentrations in dairy effluent and sludge. Although these chapters can provide a guide, it is more accurate to analyse the dairy effluent in each individual case (Waters 1999).

Adverse potassium impacts

Potassium losses

Excessive quantities of K in soils can lead to K losses off site through leaching into groundwater or surface runoff. Although K is largely retained in soils, it can leach from coarse, sandy, well drained soils, where loadings are excessive or through bypass flow mechanisms (Gourley 1999, Price 2006). K can be removed in surface runoff from rainfall or irrigation, becoming suspended in the water, typically adsorbed to soil particles (McCaskill *et al.* 2003). Higher concentrations of K in surface runoff or leachate are associated with sites with a high use of K fertiliser or effluent application, especially where soil incorporation does not occur (Fleming and Cox 2001, McCaskill *et al.* 2003). To help minimise the risks of K export, careful monitoring of soil and effluent K levels is required, along with responsive management. In addition, surface runoff should flow into drainage lines and recycling ponds so that no contaminated runoff leaves the farm.

Potassium salts

As K can occur in the soil as a salt, high soil K salt contents can contribute to soil salinity, leading to reduced pasture production on highly saline soils (Hosking 1986). Water-soluble K has been implicated in an adverse effect on soil structural stability in a similar way to sodium (Smiles 2006). Smiles (2006) questions the presumption that Australian soils have few structural problems associated with K and suggests that areas with significant levels of K relative to sodium can suffer adverse soil physical consequences resulting from K just as much as from sodium.

Potassium and stock health

Excessive quantities of K in soils can increase the risk of stock health problems, notably calcium deficiency (milk fever or hypocalcaemia) and magnesium deficiency (grass tetany or hypomagnesaemia), typically on grass-dominant pastures (Wang *et al.* 2004). Excessive soil K levels can result in luxury uptake by pasture, thus increasing K intake by animals (Hosking 1986). The high K concentration in pasture suppresses the uptake of calcium and magnesium by stock, leading to low concentrations of each in the cow's bloodstream (Hosking 1986). These stock health disorders can be managed. Dairy cows are most susceptible to high K levels in the diet during the transition period (before calving) and early lactation. Not grazing cows on areas where effluent has been applied during these times, particularly on consecutive days, will minimise the risk of grass tetany. In addition, grazing the pasture when ryegrass has reached the three-leaf stage is recommended, because the concentrations of Ca and Mg will have increased in the plant by that stage. Magnesium oxide can be added to stock feed to reduce the risk of grass tetany. To minimise the risk of grass tetany and milk fever, annual applications of K should not exceed 120 $kg{\cdot}ha^{-1}$, and single applications should not exceed 60 $kg{\cdot}ha^{-1}$ (Gourley 1999, Hosking 1986).

Potassium management

Detailed nutrient budgeting is dealt with in chapter 3.1 'Nutrient budgeting'. Soil analysis for K is a reliable method of assessing soil K requirements. Soil should be analysed before effluent or fertiliser is applied to assist in determination of appropriate K loadings (Gourley 1999, Gourley *et al.* 2007). Gourley *et al.* (2007) found that available K levels for pastures measured by the commonly used Colwell, Skene and exchangeable K soil tests are strongly correlated with one another, and there was no statistical dependence with state, region or cation exchange capacity. The Colwell K test, preferred by Gourley *et al.* (2007), did show significant dependence on soil texture class.

Gourley *et al.* (2007) calculated that the critical soil-available K level to achieve 95% of maximum pasture production was as detailed in Table 1.

Table 1. Critical Colwell K soil test values for four soil texture classes and the equations describing the relationship between Colwell value and percentage of maximum pasture yield (Gourley et al. 2007).

Soil texture	Critical value[1]	Confidence interval[2]	Number of experiments	Equation[3] % maximum yield =
Sand	126	109-142	50	$100 \times (1 - e^{-0.024 \times \text{Colwell K}})$
Sandy loam	139	126-157	122	$100 \times (1 - e^{-0.022 \times \text{Colwell K}})$
Sandy clay loam	143	127-173	75	$100 \times (1 - e^{-0.021 \times \text{Colwell K}})$
Clay loam	161	151-182	194	$100 \times (1 - e^{-0.019 \times \text{Colwell K}})$

1: Soil test value ($mg{\cdot}kg^{-1}$) at 95% of predicted maximum pasture yield.
2: 95% chance that this range covers the critical soil test value.
3: e ≈ 2.71828.

3.4 Potassium

The amount of natural K and the amount of K from effluent or fertiliser which is or becomes available for plants depends on a soils' physical and chemical parameters, including particle size, clay mineralogy, moisture status, organic matter and soil pH (Hosking 1986). The amount of available K can vary greatly across a paddock (Gourley 1999).

Monitoring potassium

Details on monitoring K throughout a dairy effluent management system are provided in chapter 7 'Monitoring and sampling'.

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