FACTSHEET

Hill Country Futures: Aluminium toxicity

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Aluminium (Al) is a naturally occurring element in soils that is not required by plants. However, it can be toxic to plants in its soluble forms.

Key messages

- Where soil pH is less than 5.5, Al in the soil becomes soluble and and can restrict root growth, thus reducing water access, gas exchange and nutrient uptake by plants.
- The most effective strategies to reduce soil Al levels are to:
  - Apply lime and increase soil pH
  - Where lime application is uneconomic, an alternative is to sow an Al-tolerant legume, such as Caucasian clover or perennial lupins.

New Zealand's acidic soils

Nearly all soils in New Zealand are naturally acidic (i.e. below soil pH 7.0). This acidity is caused by a lack of natural limestone and the acidifying effect of leaves from native tree species, such as beech.

Acid soil can:

- Reduce the effectiveness of soil rhizobia to fix nitrogen (N) (where pH <5.5)
- Decrease the activity of the macro- and meso-fauna and the ability of microorganisms to mineralise organic N
- Lower the availability of soil phosphorous (P) and molybdenum (Mo).

Measuring soil Al levels

There are two common methods for measuring soil Al levels: Soil solution and cation exchange sites.

Method	Al toxicity occurs at:	Corresponding soil pH level
Soil solution	3-5 ppm	5.5-5.7
Cation exchange sites	1-2 me/100g	5.5-5.7

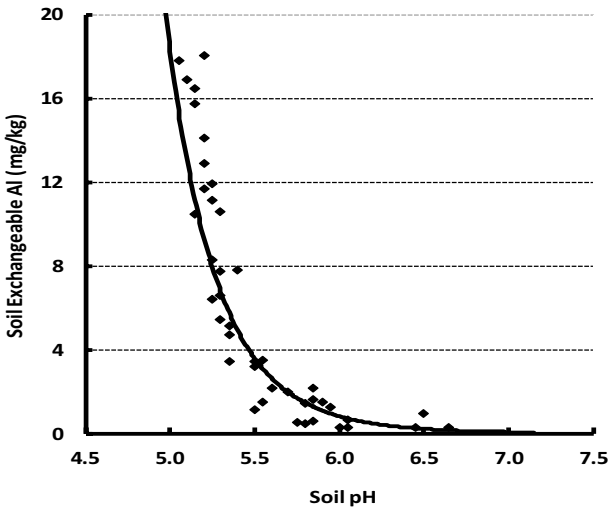
When to measure soil Al

There are two instances where it is sensible to test soil Al levels:

1) On undeveloped and/or un-limed soils, where the soil pH is less than 5.5, and
2) When sowing species that are sensitive to Al toxicity (e.g. white and red clover, lucerne and ryegrass).

Relationship between soil pH and Al

Soil Al decreases as soil pH increases. See graph.



Impact of liming on soil Al levels

The graph overleaf shows that, at a soil pH of 5.5, the soil Al level is 3 ppm, which is at the lower end of the toxicity range. Therefore, the most effective way to alleviate Al toxicity is to focus on increasing the soil pH to at least 5.5.

As a rough rule, apply lime at 1 tonne for each 0.1 pH unit increase you want to gain.

Soil depth and Al levels

Al toxicity can increase with soil depth. In this scenario, plants' root systems avoid growing vertically down into the Al toxic soil layers. Instead, roots spread laterally which reduces their ability to seek moisture. Therefore it may be necessary to test for Al to greater depths than the traditional 0-7.5 cm. If you aim to establish a deep rooted legume, such as lucerne, soil test at 0-15 cm, 15-30 cm, 30-50 cm and up to 1.0 m (50-100 cm).

Al toxicity can be reduced by:

- Incorporation of lime into the soil during cultivation –usually to ~20 cm.
- Surface-applied lime can be transported to lower soil depths by earthworms if present. This can be a slow process, particularly in areas with <1000 mm rainfall, so may be uneconomic.

Ground vs aerial application of lime

Ground application can be a cost-effective method of reducing soil Al toxicity.

Aerial application of lime is more expensive. However, it is worth considering for specific areas. For instance, legumes grow and persist on shady aspects and respond more to lime – so consider aerial application to these areas.

In either case – ground vs aerial – the rate of lime depends on the initial soil pH and transport costs from quarry to farm.

Legume species more tolerant to Al toxicity

Tolerant	Partly tolerant	Sensitive	Very sensitive
• Caucasian clover • *Lotus pedunculatus* • Persian and gland clovers • Lupins	• Subterranean clover	• White clover • Red clover	• Lucerne

Conclusion

Soil Al toxicity is one of the mechanisms by which soil acidity reduces plant growth. It can be remedied by lime application. Choosing tolerant legume species is another option, particularly when liming is uneconomic.

Further reading

This factsheet is part of the Hill Country Futures soil and fertiliser series. The full series can be found at www.hillcountryfutures.co.nz/resources/soil-and-fertiliser-series

"Fertiliser use on New Zealand sheep and beef farms" booklet, produced the Fertiliser Association of New Zealand booklet. Download at: www.fertiliser.org.nz/Site/resources/booklets.aspx

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