CSIRO PLANT INDUSTRY

Acid soils - a ticking time bomb?

In a major breakthrough, CSIRO scientists have collaborated with a Japanese group to isolate genes that protect plants from acid soils. This discovery is boosting prospects for an effective assault on soil acidification, one of the greatest threats to the future productivity of Australian agriculture.

Lost Production

33 million hectares of Australia's farming land currently have highly acidic soils, particularly the productive higher rainfall country in south-eastern and south-western Australia and Queensland.

A further 55 million hectares of moderately acid soils are also at risk of severe degradation.

Soil acidity has been identified by the National Land and Water Audit as the most serious land degradation issue for Australian agriculture, costing close to $1 billion in lost production each year.

Soil acidification is a more serious problem than salinity, in terms of both area affected and cost to the economy.

Farming and acidity

Australia has naturally acid soils. Farming inevitably tends to make soils more acid. Pasture improvement and nitrogen fertilisation of crops have increased the rate of acidification.

The key to maintaining productivity is the application of lime to neutralise the acidity, but on land used for grazing this is generally uneconomic. In contrast, the benefits for broadacre cropping are well established.

Toxic metals

Major production losses occur when acidity increases to the point where toxic elements in the soil, such as aluminium and manganese, dissolve.

Soil acidification is Australia's most serious land degradation issue

The aluminium damages root growth and restricts the ability of plants to take up nutrients.

Although manganese is an essential element for plants, it is only needed in tiny amounts and when present in excess, becomes toxic. Unlike aluminium, the manganese primarily affects shoot growth.

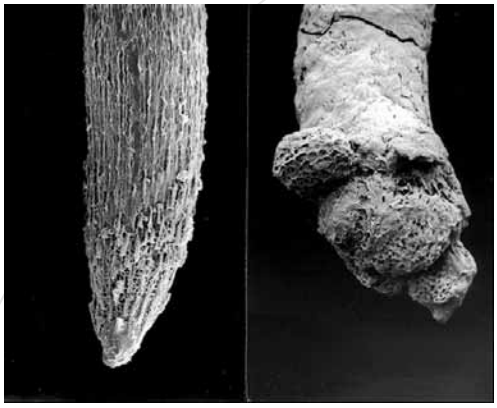
Improved Plants

It is well known that aluminium does much less damage to some wheat cultivars than it does to others. CSIRO scientists have found that tolerant plants were able to keep aluminium out of the sensitive tips of their roots.

Further research showed that the plants did this by excreting malate from the root tips. Malate is a normal constituent of plant cells and when released in the soil binds with aluminium to make it non-toxic.

The gene that controls the release of malate has been isolated, providing the means to enhance the aluminium tolerance of crops and pastures.

This can be achieved by using gene technology to insert the genes into sensitive plants, or by using the gene to more effectively breed for aluminium tolerance.



Aluminium tolerant root tip (left) and sensitive root tip (right)

Manganese Tolerance

In a related project the researchers used yeast as a tool to find genes that protect plants from manganese toxicity.

In many respects yeast cells behave just like plant cells but are much easier to handle in the laboratory. The researchers introduced plant genes into the yeast and then identified yeast colonies that had become tolerant to manganese.

The effect of manganese toxicity on canola (right)

The gene that conferred the tolerance to yeast was then introduced into plants and shown to provide protection from manganese toxicity.

Future prospects

Prospects appear good for producing varieties of lucerne, canola and barley that are tolerant to acid soils.

The researchers expect these new improved plants will be used in conjunction with liming on acid soils. For example, crop yields could be maintained in acidic areas where lime application controls surface soil acidity, but does not reduce acidity levels deeper in the soil profile.

The aluminium-sensitive varieties cannot produce maximum yields under these conditions, but the roots of the new aluminium-tolerant cultivars will be able to penetrate the deeper acid soil layers and use the water there to produce yields that are close to their potential.

For pastures, the use of aluminium-tolerant, deep-rooted perennial plants instead of shallow-rooted annuals will lower rates of acidification by reducing the leaching of nutrients. This will result in more effective management of acid soils to ensure optimal yields.

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