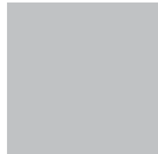
GrowPlus

CALCIUM FOR CROPPING FARMERS P3



MAXIMISING AVOCADO FRUIT QUALITY P4

DIAGNOSING NUTRIENT DEFICIENCIES P7

A HORTICULTURAL NEWSLETTER FROM BALLANCE AGRI-NUTRIENTS LIMITED ISSUE 1

Is ultra-low biuret urea right for your crop?

Nitrogen is a key component of numerous cell constituents, including enzymes, vitamins and chlorophyll. Frequently referred to as the main driver of growth, nitrogen cannot be overlooked in any horticultural venture.

Fertiliser nitrogen comes in three forms – urea, ammonium and nitrate. Urea is a very economic form of nitrogen, but is vulnerable to losses from leaching and volatilisation. Ammonium carries a positive charge, which means it can be adsorbed onto negatively charged clay particles and organic matter, so keeping it in the soil for longer. However, ammonium is also converted to nitrate in the soil, and in this process hydrogen ions are generated. These ions are what makes soil acidic and this in turn can lead to unfavourable conditions for plant growth. Negatively charged nitrate is the form favoured for uptake by most plants, yet this too is vulnerable to leaching. Losses of nitrogen to water systems not only reduce the efficiency of applied fertiliser, they also have the potential to contribute towards environmental damage.

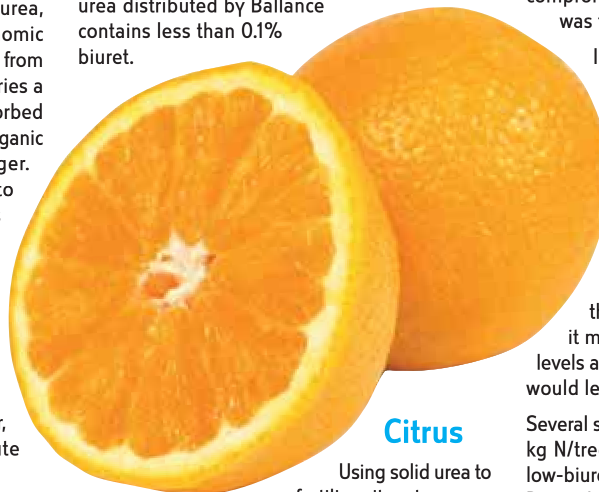
A burning concern

Nitrogen can be applied to horticultural crops by one of three methods: dry applied, fertigation or foliar applications. Of these, foliar nitrogen is least likely to impact on the environment. However, foliar applications of urea can carry a different set of problems, one of which is the impact of biuret.

Biuret, also known as carbamyl urea, is a nitrogenous impurity that is formed in the manufacture of urea. The urea manufactured at Ballance's Kapuni plant has a maximum content of 1.2% biuret and while this will not cause any problems if applied to soil, in some crops there may be a risk of damage if a solution is applied directly to foliage.

Biuret is thought to 'burn' leaves – the first symptom of biuret toxicity is irregular patches of interveinal chlorosis (yellowing) appearing at the leaf tips. As the severity of the problem increases the zone of chlorosis expands until eventually only the midribs and major veins remain green.

For foliar applications to biuret-sensitive crops, therefore, the use of low or ultra-low biuret urea is recommended. The ultra-low biuret urea distributed by Ballance contains less than 0.1% biuret.



Citrus

Using solid urea to fertilise citrus trees can result in nitrogen losses, but foliar-applied urea has been reported as an effective means of supplying this crop with nitrogen. International fertiliser manufacturers Yara recommend that any such applications contain less than 0.4% biuret. When fertiliser nitrogen is applied to the soil, mature citrus trees require between 0.45 and 0.60 kg N/tree annually to ensure fruit productivity and sweetness remain high. For solid fertiliser, this is usually split into three applications during the growing season; if fertigation is employed, the nitrogen applications may be more frequent.

Strategic foliar applications of ultra-low biuret urea, though, may mean that even less nitrogen can be used without sacrificing crop quality or quantity. Research done as long ago as the 1960s showed that Valencia orange trees receiving 0.23 kg N/tree annually as two split foliar applications produced yields equivalent to those from trees receiving 0.91 kg N/tree of soil-applied ammonium nitrate.

In the 1990, research by Carol Lovatt and associates at the University of California looked at ways to reduce the nitrogen loading still further.[1] Lovatt's aim was to see if a single application of 0.16 kg N/tree could be used without compromising productivity or quality. The key, it was felt, was in the timing.

In plant cells, ammonia – a product of urea – can be converted into an amino acid called arginine. This in turn forms the basis of larger proteins called polyamines. Some of these polyamines have a key role in flowering in navel oranges, particularly when soil temperatures are low (less than 15°C). They also promote cell division. Lovatt thought that by applying urea at the critical time, it might be possible to increase polyamine levels and so increase cell division, which in turn would lead to bigger fruit.

Several scenarios were examined. In the first, 0.16 kg N/tree was applied as a 0.5% N solution of low-biuret urea in one of four months (November, December, January or February), remembering that in California, flowering occurs from late February through to mid-May. Control trees received 0.5 kg N/tree as soil-applied urea. The experiment was conducted over three years and the results were impressive:

- a significant increase in yield using foliar applications
- no decrease in fruit size
- an increase in the percentage of commercially valuable fruit
- January foliar applications resulted in a three-year yield increase of 20.6 t/ha more than the control
- February foliar applications resulted in a three-year yield increase of 16.4 t/ha more than the control.

In the second approach, foliar nitrogen was applied when the trees were in full bloom. For

continued on page 2

two years, Washington navel orange trees were treated with foliar nitrogen at 1.3% concentration, delivering 0.16 kg N/tree annually. In a further experiment, the urea treatment was combined with an application of cytokinin. Again, results were favourable:

- total weight and number of fruit per tree increased in the 'on' year in the treated trees
- the cytokinin treatment resulted in a yield increase in the 'off' year as well as the 'on' year
- there was an increase in the number of commercially valuable large-size fruit
- a cumulative yield increase of 7 t/ha was seen over the two years for the foliar urea application and an increase of 11 t/ha was noted for the urea/cytokinin application.

In a further experiment, the time of maximum peel thickness was determined and foliar urea applied just prior to this (0.16 kg N/tree as a 1.5% solution of N). The time of maximum peel thickness is the point at which cell division ends for navel oranges. It was thought that applying foliar urea at this time might increase cell division and so lead to larger fruits. The treatment did result in a significant increase in commercially valuable large-size fruit, but did not produce an increase in overall yield.

Lovatt's work shows that strategic applications of low-biuret urea can be used to increase the productivity of citrus trees. In some areas, this may also reduce the impact of nitrate leaching on local groundwater supplies.

Apples

New Zealand apple crops are susceptible to black spot, caused by the fungus *Venturia inaequalis*. One relatively easy way to minimise the damage caused by this fungus is to reduce levels of its spores in the environment. This can be done by spraying apple trees with urea at leaf fall.

However, this practice can itself cause losses in production as it may encourage excessive vegetative growth, cause stem-end splitting and colour suppression in fruit and increase the death rate of flower buds in spring.

As biuret has been associated with phytotoxic effects in a number of fruit crops, scientists at HortResearch investigated the practice of using urea as an agent for black spot control in apples and looked at the impact of both high and low biuret content.[2]

An early June application of urea was sprayed on Royal Gala and Braeburn trees – at the time this was done the Galas were at 80% leaf fall and the Braeburns at 10%. Two types of urea were used: the low-biuret urea contained 0.35% biuret and the high-biuret urea contained 0.9% urea. Each was applied at four different concentrations – 2, 5, 10 and 20% urea; the low-biuret urea was also applied at 40%. Three months after application the percentage of dead buds in each treatment was assessed.

Gala, already well-progressed with leaf fall by the time of urea application, showed no significant effect from the high- versus low-biuret urea. Percentage of dead buds was similar for both treatments. In the Braeburn, however, the high-biuret urea caused greater bud death, most notably at the 20% urea concentration. In both cultivars the percentage of dead buds increased with the concentration of urea, with urea at 5% or less causing very little bud death.

From this, the authors suggested that it is the concentration of urea that plays the most important part in determining bud death in this treatment. However, the University of Florida Institute of Food and Agricultural Sciences recommends that foliar sprays contain no more than 0.25% biuret. This is lower than the low-biuret content used in the HortResearch work (0.35%). While spraying high concentrations (40%) of urea undoubtedly does have a deleterious effect on crops, it may be that at the lower concentrations (5%), ultra-low biuret urea will do less damage than low- or high-biuret urea. The degree of natural variation in horticultural systems means that these differences may not show up as being statistically significant, yet to the grower they may still result in an improved crop in the coming year.

Avocado

The role of boron in improving fruit set and yield in avocado crops has been widely reported recently, but there is also some evidence that low-biuret urea can have a similar effect. To investigate the impact of foliar applications of low-biuret urea, Lovatt and colleagues conducted a three-year study on Hass avocados in southern California.[1]

Trees were treated with a 20% N solution of low (0.1%) biuret urea so that each tree received 0.16 kg N. Boron-treated trees received a foliar application of 6 g boron each. In southern California, mature leaves of Hass avocados do not take up urea, so to overcome this the trees were sprayed during the cauliflower stage of inflorescence development.

On examining the number of pollen tubes that penetrated the ovule, Lovatt found that all treatments improved this event, with the strongest effect shown by boron (see Figure 1). In contrast, the viability of the ovules was most markedly increased by the urea treatment (see Figure 2).

It would be logical to assume that since each of these treatments appears to enhance the reproductive potential of the tree, yield increases would follow. Figure 3 shows that this is the case, with boron or urea treatments resulting in a significant improvement in cumulative yield. Interestingly, the dual application of boron and urea did not improve yield. The mechanism behind this growth is uncertain: in the first year of the experiment the urea-treated trees showed a yield increase; in the second year it was the boron-treated trees that yielded more fruit. In the third year no treatment produced significantly more fruit, though the yield from the urea-treated trees was slightly higher than the others.

This work highlights the complexity of plant nutrient issues. While the addition of a single nutrient to the system can result in a positive outcome for the grower, it does not necessarily follow that adding two nutrients will produce an even better result. In addition, the inherent variability of plant systems means that the best results are likely to be achieved if growers maintain accurate records of crop inputs and performance over the years and work with their Ballance horticultural specialist to develop a plant nutrient regime tailored for their specific demands.

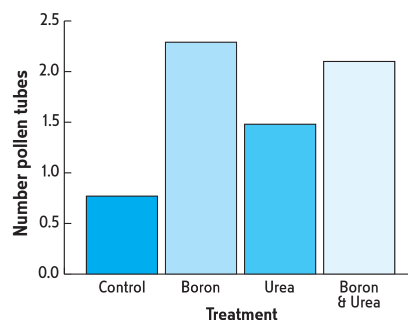


Figure 1: The effect of boron and/or urea applications on the number of pollen tubes penetrating the ovule of Hass avocado trees.

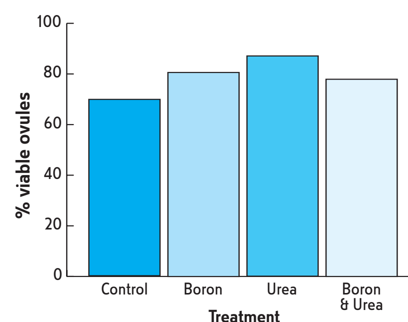


Figure 2: The effect of boron and/or urea applications on the percentage of viable ovules.

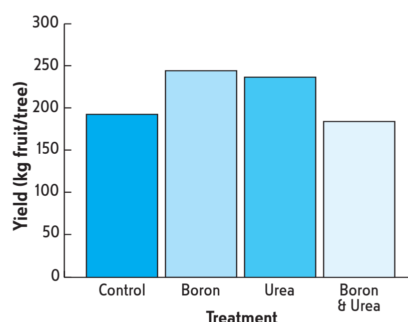


Figure 3: The effect of boron and/or urea applications on the cumulative yield per tree of Hass avocados (presented as the combined yield from three years' fruit).

1. Lovatt, C.J. (1999), Timing citrus and avocado foliar nutrient applications to increase fruit set and size. *HortTechnology*, 9 (4): 607-612

2. Wood, P.N. and Beresford, R.M. (2000), Avoiding apple bud damage from autumn-applied urea for black spot (*Venturia inaequalis*) control. *New Zealand Plant Protection*, 53: 382-386

Calcium for cropping farmers

Cropping farmers have specific fertiliser requirements that differ from pastoral farmers' needs. To meet these nutrient requirements a range of horticultural fertilisers has been developed.

One of the key vegetable crops grown is potato. Statistics New Zealand reports that for the year ending 30 June 2003 some 10,930 hectares of the country were planted in potatoes. This land was fairly evenly divided between the North and South Islands, with the majority of planting occurring in the Canterbury, Waikato and Manawatu districts. Potatoes have particularly high nutrient requirements, which is why the best crops are often grown following high-fertility pasture.

One nutrient that plays a key role in the yield and quality of potatoes is calcium (Ca). Improved tolerance to cold and heat stress, and also to disease, is seen in potato crops that have adequate levels of Ca. In addition, Ca improves resistance to specific diseases, such as *Erwinia* infections, internal rust spot and internal brown spot. The overall skin finish is also improved when Ca levels are optimal.

If we analyse Ca levels in a potato, we can see that there is much more Ca present in the peel than in the tuber itself – peel Ca is usually three to five times higher than tuber Ca. It is this abundance of Ca in the peel that helps confer disease resistance. When testing potato Ca levels the peel is sampled at two depths; levels of Ca in the tuber are not usually measured. A minimum level of 0.15% Ca is needed in potato peel (in the first, outermost, sample), though 0.2% is better for conferring disease tolerance.

As well as helping potatoes resist disease, adding Ca to soil with suboptimal Ca levels will increase crop yields. A study at the University of Wisconsin found that adding Ca to a Ca-depleted soil resulted in yields of 1.0 kg tuber per potato plant, compared to the control soil, without added Ca, where yields were only 0.7 kg tuber per plant. This is effectively a 43% yield increase.

Crop yield is also influenced by plant stress (e.g. from water stress or cold stress). Adding fertiliser Ca along with fertiliser nitrogen (N) has been shown to help overcome the yield reductions in these situations, as shown in Figure 1.

For growers looking to achieve maximum yield from their potato crops, then Ca is clearly an important nutrient, and if stress is an issue then N (widely recognised as a key driver of growth) plays an equally vital role. So how best to supply your crop with the N and Ca needed to maximise yield and tuber quality? The two key factors are the form of the fertiliser and the timing of application.

Nitrate is generally regarded as the preferred form of N for cropping situations, since there are no losses from volatilisation (a potential problem with ammonium forms of N), soil acidification is minimised (ammonium fertilisers are quite acidifying), and the nitrate is readily available for plant uptake. In addition, nitrate N promotes plant uptake of cations such as Ca, conferring an advantage in terms of plant health.

In order to be taken up by plants, Ca needs to be present as a cation (Ca^{2+}). To attain this state it needs to be dissolved in water. Ca added in the form of lime or dolomite is largely water-insoluble and as such is only slowly made available to plants. On the other hand, Ca added in the form of calcium nitrate is already in the water-soluble form, so can instantly be taken up by plants.

The timing of application is particularly critical for Ca, since this must be present when plant cells are being formed. If Ca is added later, when cell expansion is taking place, it will have no effect since it cannot enter the cells. Plant cells that don't receive sufficient Ca while they are forming will later collapse and die, and this will show up as visible Ca disorders in tubers and leaves.

For potatoes, the crucial time for applying Ca is during tuber initiation, when the potatoes themselves are no more than 20 mm in diameter. It's important to remember that Ca enters the tubers via the stolon, not the roots. Placement of fertiliser should reflect this.

Ballance carries several fertilisers that are suitable for use on a wide range of crops, including potatoes. For soils – or crops – that require higher levels of Ca **tropi-cote**, which contains 15.5% N (mainly in the nitrate form) and 19.2% Ca (in the water-soluble form), is an ideal solution.

However, one other nutrient – boron (B) –has been implicated in the uptake and utilisation of Ca. Studies have indicated that boron may assist in the movement of Ca through the plant, ensuring it reaches the growing cells.

Free-draining, sandy soils have a tendency to be B-deficient, as B leaches easily. B itself is involved in a number of crucial plant processes, including the movement of sugars around the plant. However, excessive levels of B can cause toxicity symptoms to appear, so advice should be sought before applying any boronated fertiliser. One product that is suitable for use on boron-deficient soils is **nitrabor**, which contains 15.5% N, 19.2% Ca and 0.3% B, all in readily soluble forms. Your Ballance horticultural specialist will be able to advise which of **tropi-cote** or **nitrabor** is most suited to your cropping situation.

Ca, heat stress and potatoes

Potatoes prefer cool temperatures, and warm weather will reduce yields. Trials at the University of Wisconsin examined the effect of heat stress on Russet Burbank potatoes grown in a loamy sand soil. Relative humidity was held at 60% over the 16-week experiment but day and night temperature varied. Daytime temperature was held at 20°C for the first three weeks, then raised to 25°C for five weeks; during this time the night temperature was held at 15°C. The plants were then exposed to heat stress for four weeks, with daytime temperatures of 30°C and night temperatures of 25°C. For the remaining four weeks night temperatures were kept at 15°C and day temperatures at 25°C (two weeks) and 20°C (the final two weeks).

Crops were treated with one of three protocols:

- all N before the heat stress period
- half N before and half N during heat stress period
- half N before and half N during heat stress, plus Ca during heat stress

Yield was significantly better when N and Ca were applied to the plant during heat stress.

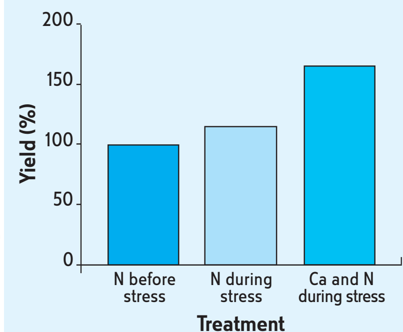
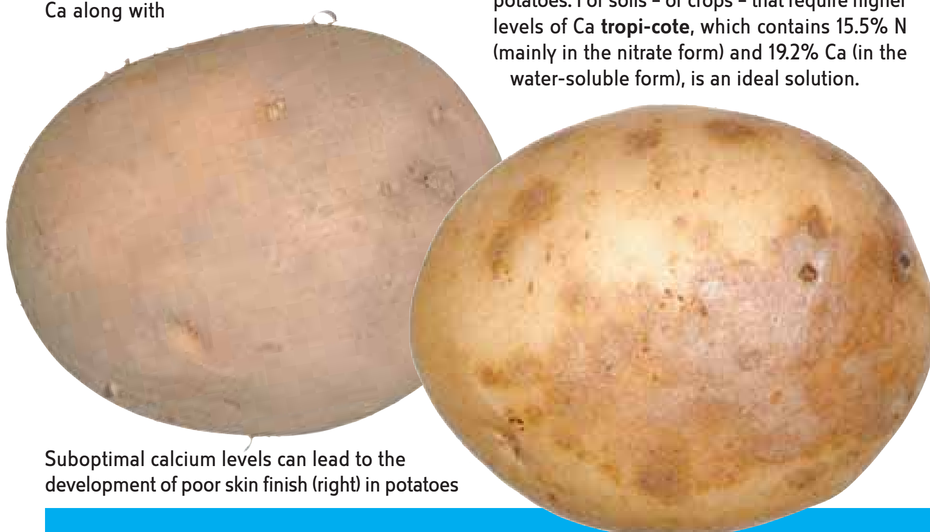


Figure 1: Effect of fertiliser treatment on yield of heat-stressed potato crops



Suboptimal calcium levels can lead to the development of poor skin finish (right) in potatoes

Maximising avocado fruit quality

Although by no means the world's largest producer, New Zealand still has a significant avocado industry. In the 2002/2003 season, in excess of 14,000,000 kg of avocados were grown here commercially and this looks set to rise in the future. Statistics New Zealand reported large increases in the amount of land planted in avocados in 2002, and in 2003 there was a further 4 percent increase in land used for avocado production throughout the country.

Avocados are not a particularly voracious crop when it comes to macro-nutrients. An indication of the quantities of nutrients involved can be seen in Figure 1, which shows nutrient removal for a typical 10 tonne/ha crop. However, nutrient balance is important and a poor fertiliser regime will result in a less-than-optimal outcome. In terms of fruit yield, the nutrient that has the greatest influence is nitrogen (N), while calcium (Ca) and boron (B), both have a strong effect on fruit quality.

The pre-harvest status of avocados is important, since there are few post-harvest techniques that will improve fruit quality. As Ca plays such a key role in fruit quality, this is one of the nutrients worthy of growers' attention.

The role of Ca in plant nutrition and health in general is widely recognised. Ca improves the integral strength of cell walls, regulates the movement of nutrients across cell membranes and helps plants resist attack from bacterial and fungal enzymes. In avocados, low levels of Ca are associated with a number of negative states, including susceptibility to chilling injury, rapid ripening of fruit after harvest, flesh discolouration, pulp spot, vascular browning and vulnerability to anthracnose.

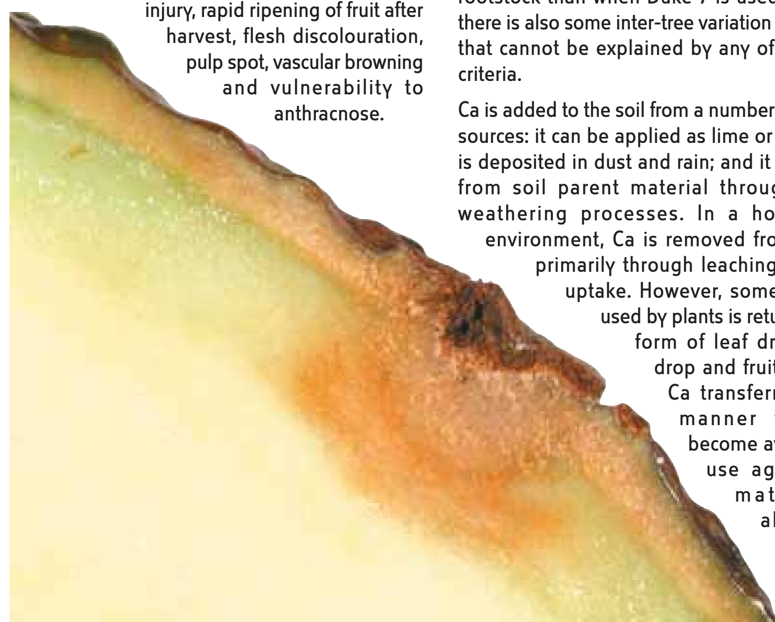
Unlike some other nutrients, Ca is relatively immobile within plant tissue. If there is an insufficient supply of Ca during fruit set, for instance, the plant cannot simply meet its needs by moving Ca from the leaves, roots or branches. In contrast, nutrients such as potassium, magnesium and iron can be transferred in this manner.

The effect of this poor mobility is further compounded by the way in which Ca is taken up by plants. There is no active transport system involved in this process; rather, Ca enters plants passively through the root tips in transpirational water flow. That means that any damage to plant roots will have a negative impact on plant Ca levels.

One practical consequence of the behaviour of Ca is that the plant requires a continuous supply of this nutrient during its growing season. The level of Ca in the soil must always be sufficient to meet the needs of the plant. If growers are looking to maximise fruit quality, then having adequate supplies of Ca at fruit set is essential. The critical time period extends out for the first eleven weeks after fruit set, as this is when the cells of the fruit are multiplying. If Ca is not available to be incorporated into these new cells when they are formed, the cells will remain Ca deficient. Ca cannot be taken in to mature cells.

Ca uptake in avocados is also influenced by the rootstock. Research has shown that, all other things being equal, Ca levels in fruits are generally higher when avocados are grown on Velvick rootstock than when Duke 7 is used. However, there is also some inter-tree variation in Ca levels that cannot be explained by any of the above criteria.

Ca is added to the soil from a number of different sources: it can be applied as lime or fertiliser; it is deposited in dust and rain; and it is released from soil parent material through natural weathering processes. In a horticultural environment, Ca is removed from the soil primarily through leaching and plant uptake. However, some of the Ca used by plants is returned in the form of leaf drop, flower drop and fruit drop. The Ca transferred in this manner will only become available for use again if the material is allowed to fully decay in situ.



Low levels of calcium increase the likelihood of avocados developing anthracnose

Whatever the source of Ca, it is only the water-soluble form that can be taken up by plants. Many traditional sources of Ca, such as limestone and dolomite, primarily contain insoluble Ca. This Ca becomes slowly plant available, but the rate at which this occurs is insufficient to meet the peak needs of avocados at fruit set.

Specific horticultural fertilisers containing high levels of water-soluble Ca have been developed to meet industry needs. One such product is **nitrabor**, which contains 19.2% Ca in the water-soluble form.

nitrabor also contains 0.3% B, again in its water-soluble state. This is important, because not only does B play a key role in pollination and the development of the fruitlet, it's also thought to mediate the uptake and utilisation of Ca. Studies have shown that B can assist in the movement of Ca through the plant, ensuring it reaches the growing cells. By supplying water-soluble B and Ca in the one dose, **nitrabor** helps ensure that pre-harvest fruit quality reaches its potential.

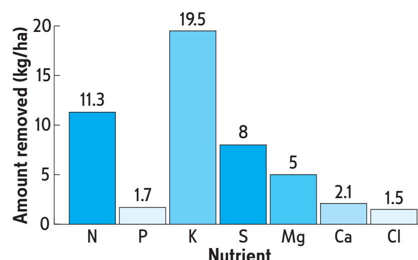


Figure 1: Amounts of nutrients removed in an avocado crop of 10 tonne/ha

Too much or too little?

Boron is one of a number of micronutrients that can cause both deficiency and toxicity symptoms in plants. If avocado leaf B levels fall below 25 ppm, growers can expect to see the following deficiency symptoms:

- yellowing and deformation of leaves
- reduced pollen viability
- smaller and deformed fruits
- reduced root growth
- lesions on branches and trunk
- thickening of the nodal regions of branches

On the other hand, should leaf B levels start to exceed 100 ppm, toxicity symptoms can start to appear:

- interveinal chlorosis
- necrotic spots
- reduction in vegetative growth

A question of acid

Many factors influence the growth of horticultural crops and some of them – such as day length and soil temperature – cannot be controlled in an outdoor environment. However, one important factor that can be manipulated is soil pH.

The pH of a soil refers to the acidity or alkalinity of the soil solution and it impacts on many different aspects of plant growth, affecting the chemical availability of plant nutrients, influencing the activity of soil organisms (bacteria, fungi and earthworms) and also directly impacting on the plants themselves.

The pH of any substance – soil, orange juice, wine – is a measure of the ratio of hydrogen ions (H^+) to hydroxyl ions (OH^-) in solution. Hydrogen ions are acid-forming, while hydroxyl ions drive the pH in the other direction, making the solution more alkaline. The pH range is from 1 to 14, with anything below 7 indicating acidity and numbers greater than 7 representing alkalinity. A pH of 7 is neutral, and it means that there is an equal concentration of hydrogen and hydroxyl ions in the solution. The smaller the number below 7, the more acid a solution; the greater the number above 7, the more alkaline.

Pushing the pH

The pH of a soil falls as a result of natural biological and chemical processes. Soils tend to become more acidic with time as a result of leaching and weathering activities. How fast these changes occur depends on individual soil types.

Leaching removes the cation forms of calcium, magnesium and potassium. The rain that prompts the leaching brings in hydrogen ions and these replace some of the lost cations, so causing the pH to fall (see Figure 1). Weathering causes the release of minerals that can be taken up by plants, but that also impact on the pH of the soil.

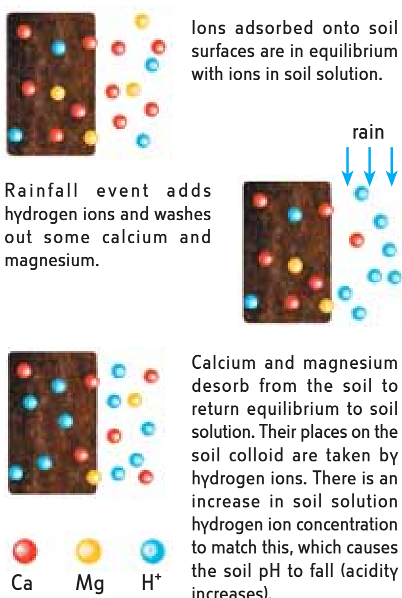


Figure 1: Leaching triggered by rainfall can cause soil to become more acidic.

Biological processes also tend to make the soil more acidic. Respiration by plant roots and microorganisms produces carbon dioxide, which in turn combines with water to form carbonic acid and when this dissociates (breaks up) it produces hydrogen ions. Bacteria also help make the soil more acidic in other ways: they break down organic matter and release acids as a result; they are involved in the conversion of ammonia to nitrate, which again releases hydrogen ions; and they also convert elemental sulphur into sulphate, which creates a more acidic soil environment.

The simple act of a plant taking up soil nutrients can also add to soil acidity, as when the plant takes up a positively charged nutrient, such as magnesium, it needs to expel hydrogen ions in order to keep its internal electrical balance stable.

Chemical reactions in the soil also affect pH, as hydrogen ions are released from soil colloids and especially as aluminium reacts with soil water. The addition of fertiliser to the soil can either increase or decrease soil acidity. Fertilisers containing ammonium are very acidifying, as is elemental sulphur. Some phosphate fertilisers can create quite a drop in pH around the individual granules, but this is generally just temporary.

To neutralise all this acidity, lime or similar calcium-containing products can be added to the soil. The calcium essentially soaks up hydrogen ions, combining with them to form complexes which then degrade to carbon dioxide and water. It is the removal of the hydrogen ions, rather than the addition of hydroxyl ions, that causes the soil pH to rise.

Metal madness

Different crops have particular pH preferences, but in general most crops thrive within the pH range 6.0 to 7.0. For instance, HortResearch states that the optimum pH range for potatoes is 5.4 to 6.0, whereas for cauliflower it is 6.0 to 7.0. Few crops tolerate a pH of less than 5.0 and most prefer a pH below 7.5. One factor that undoubtedly influences plant growth in the more extreme conditions is the impact of acidity or alkalinity on plant nutrient availability.

At low pH, three metals – iron, aluminium and manganese – become strong determinants of nutrient availability. In acid soils the availability of these three elements increases as they are released from the surface of clay minerals. Once in soil solution, they function very much like a battalion of soldiers on a mission to capture enemy troops. Essentially, these metals 'lock up' other nutrients, removing them from the 'battlefield'. Their targets include one of the most important soil minerals – phosphate.

In acidic soils, especially when pH drops below 5.0, aluminium, manganese and iron bind strongly with phosphate. The resulting complexes are insoluble and they precipitate out of solution, meaning that plants no longer have access to this phosphate. In essence, the phosphate is a prisoner of the metal. This captured phosphate can be released again, but only if conditions change.

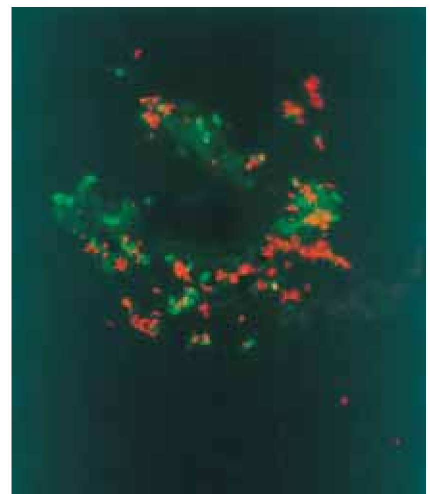
The other target of note for these acid-dominant metals is molybdenum. The availability of this important micronutrient drops off sharply as soil pH falls below 6.5. When soil pH is less than 5.5 molybdenum deficiency symptoms are more common. The reason is the prevalence of aluminium and iron in these situations, and the tendency of these metals to bind molybdenum into insoluble complexes.

Selecting neutral

As mentioned above, acid soils can be modified by the addition of lime, which will increase the alkalinity of the soil solution. As long as this is not carried to excess, it can increase the availability of essential plant nutrients. Phosphate availability is maximised between pH 6.0 and 7.0, with the optimum being around pH 6.5. Similarly, calcium and magnesium levels increase with pH, as does molybdenum availability. Importantly, as pH increases, the trio of aluminium, iron and manganese return to their military base, adsorbed on to clay particles and so unable to wreak havoc amongst other plant nutrients.

A secondary, yet no less important consequence of reducing soil acidity is the benefit that it confers on earthworm and microbial activity. Though fungi can tolerate a wide range of environmental conditions, worms and bacteria are much more sensitive. When the soil pH is raised from 5.5 to 6.0 it can result in the release of 20 to 25 kg N/ha from the microbial decomposition of soil organic matter. This is free nitrogen and well worth utilising.

In summary, soil pH has a number of effects on crop growth: it can influence the level of specific nutrients, either directly or indirectly. Soil pH drops naturally over time and this can be accelerated by the use of some fertilisers. By keeping the soil within the pH range that favours each particular crop, growers can help enhance the productivity of their land.



Naturally occuring soil bacteria affect soil pH.

Boron – just another trace element?

Like many micronutrients, boron (B) is one of the unsung heroes of the plant world. Needed only in minute amounts, B nonetheless plays a crucial role in the healthy development of plants – and it's not just involved in one aspect of plant growth, either. B has several key functions, each of which is important if plants are to reach their economic potential.

One role of B is to help stabilise cell walls and cell membranes. There is some evidence that this activity is closely linked with calcium, in that adequate levels of B enhance the uptake of calcium by plants. An intact cellular structure is important for two main reasons. First, strong cell walls give the plant structural integrity, allowing it to develop properly. In a way, the cell walls can be compared to the framework of a building. Imagine a skyscraper where some of the framework was understrength – the entire building would be at risk of damage. Second, a correctly built cell membrane provides an ideal internal environment for cellular functions. Again, we can use a building analogy. Imagine living in a house with no internal walls – noise levels would rise, organisation would break down and daily life would quickly become much less efficient.

Boron is also associated with the movement of sugars around the plant and, crucially, with the development of fruits and seeds. Insufficient B has multiple impacts on the reproductive potential of the plant. First, too little B means the viability of pollen grains decreases. Second, B-deficient plants exhibit irregularities in pollen germination and pollen tube growth. These reproductive functions appear to be much more sensitive to levels of B than does vegetative growth.

The consequences of insufficient B are dramatic – cell membranes become leaky and the contents ooze out into the surrounding area, creating the visible damage associated with disorders such as internal cork of apples and brown heart of swedes and turnips. Bud and flower drop increases, and so the productivity of fruit, nut and seed crops declines. Not only does crop quantity decline, though, but so too does quality, meaning there is significant potential for economic damage.

How much is needed?

Defining a B deficiency in plants can be surprisingly difficult. It might seem sensible that one could look for deficiency symptoms, check B levels with a soil or herbage test, then add an appropriate level of B as either a solid or foliar application. Unfortunately, it is not that simple. If B deficiency is only marginal, then the only symptom may be a reduction in growth rate. As the deficiency becomes more acute, symptoms appear, but by this stage the yield potential of the plant may already have been compromised and adding remedial fertiliser will not reverse this.

Taking routine herbage samples may also seem a sensible move. These are definitely valuable, but the process is fraught with complications. Clearly, tissue selection is important – sampling old, mature leaves reveals little about the immediate B status of the plant. US Borax, one of the world's largest boron suppliers, recommends sampling the most recently matured leaves. Sampling time is important, too – taking a sample before the plant enters the reproductive phase will allow B deficiencies to be identified and corrected prior to this critical event. Post-flowering samples may well reveal that there is a problem, but the information will come too late to be of any practical use.

Target levels of B in some New Zealand crops are shown in Table 1. However, even though herbage tests may indicate that plants have sufficient B, an additional application of B is quite often beneficial.

Crop	Boron sufficiency range (ppm)
Avocado	45-100
Apple	20-50
Blueberry	30-70
Grapes	31-50
Broccoli	25-60
Celery	30-60
Carrot	30-60
Cauliflower	25-60
Kiwi fruit	30-60
Peach	20-60
Tomato	30-60

Table 1: Normal range of boron in some New Zealand crops, as reported by Hill Laboratories, 1998.

Boron applications

Boron levels in plants can be ameliorated either by soil applications of solid fertiliser, or by foliar sprays. If soil tests reveal low B levels, then the addition of B is highly recommended. The best way to approach this depends on the crop. For root crops, incorporation into the soil with the base fertiliser is usually the most appropriate technique. In other circumstances, though, simply broadcasting the fertiliser on the soil without any incorporation is more helpful. When solid B fertiliser is incorporated into the soil, the B binds to soil organic matter and to clay particles. This B is not lost to the plant, but will only become slowly available as it is released by normal soil processes. If B is broadcast, it enters the soil system slowly, so is made available to plants over an extended period of time.

Where a soil B deficiency exists, it may well be advisable to use a foliar application as well as solid fertiliser. The ideal time for foliar applications is just as flowers are starting to emerge. This will help ensure that pollen is not B deficient, so that germination and fertilisation efficiencies are not hindered. A light pre-bloom spray of B will be rapidly absorbed and should meet the plant's B requirements throughout the flowering, fertilisation and fruit or seed set stages.

A higher function?

Not only is boron needed for the healthy development of crops, there is some evidence that it also plays a role in human nutrition. Traditional wisdom has it that B is not needed by animals, but recent research indicates that dietary B may not only be an essential nutrient for humans, but that it may also help promote health. Early in 2001 the United States Food and Nutrition Board set an upper intake level for boron of 20 milligrams a day, which is similar to levels determined by European organisations and the World Health Organisation. This is the level that it is considered safe for people to consume as part of a balanced diet without harming their health.

Recent research has indicated that people in the United States consume on average 1 to 3 milligrams of B per day, with key sources being fruit, vegetables, nuts and seeds, along with coffee and wine. One of the interesting pieces of information to come out of this research was that people with low B intakes were more likely to suffer from arthritis and prostate cancer than people with higher B intakes. In Israel, where soil B levels are high, arthritis is virtually unknown, whereas in Jamaica, soil B is low and arthritis is rife. The evidence is only circumstantial, but it does appear that B plays a part in protecting people against this crippling disease.

These developments are bound to spark further research, and it may well be in the future that high-B fruit and vegetables come to be seen as functional foods, able to help us stave off the debilitating effects of chronic ailments such as arthritis, osteoporosis and the dark demon of cancer.

Diagnosing nutrient deficiencies

Nutrient deficiencies are a major concern to growers, as they can severely affect the yield and quality of horticultural crops. If any crop is to achieve its potential, it needs to be supplied with all the nutrients it needs, in the amounts required, in a form that can be used and at a time when they are needed. Failure to meet any one of these criteria can lead to a nutrient deficiency.

Plants have a certain amount of tolerance for the amount of a particular nutrient they require, so desirable levels in tissue are normally expressed as a sufficiency range. In other words, if the plant tissue concentration of a given nutrient falls within this range, it should not suffer any ill-effects related to that nutrient. Below this sufficiency range, the plant is said to be deficient; above it, the plant may display toxicity symptoms.

The precise needs of a plant change during its lifecycle. Germination and seedling growth, vegetative growth, and the fruit- and flower-set phase of a plant all have different nutritive needs. In the early growth stages it is important to have the full complement of plant nutrients available so that development can occur at the optimum pace for the plant. An undersupply of a key nutrient will retard growth, and as a result plants may never meet their full potential. During the vegetative phase of growth, nitrogen takes on increasing importance, and during fruit, flower and seed formation, boron plays a critical role. A deficiency of any nutrient can occur during any stage of growth, but the degree of impact that has on the plant's productivity will depend on how critical that nutrient is at the time it is deficient.

It's not straightforward

Diagnosing a nutrient deficiency in the field is not always simple. There are six factors that need to be considered:

1. The effect of field conditions on plant appearance
2. The effect of multiple deficiencies
3. Look-alike symptoms caused by non-nutrient factors
4. The effect of sub-clinical deficiencies
5. The effect of species or cultivar on nutrient deficiency tolerance
6. The similarity in appearance of some nutrient deficiency symptoms

Reference books and horticultural web sites contain numerous photos of plants showing classic nutrient deficiency symptoms. However, in many cases these symptoms have been produced under controlled conditions, using plants grown in a laboratory or greenhouse environment. These plants are likely to have had ideal growth conditions, with the exception of the one nutrient that they are lacking. Plants grown like this will exhibit clear-cut symptoms of the nutrient deficiency as they are not subject to any other stresses. Out in the field, though, plant life isn't so easy. Transient nutrient deficiencies, strong winds, water stresses, competition from other plants and even harsh sunlight can affect the health of the plant. As a result, nutrient deficiencies in field-grown plants may differ from classically described symptoms.

Plants in the field may be subject to multiple nutrient deficiencies, which can result in a confusing collection of symptoms. In addition, an excess of one nutrient may induce a deficiency in another; for example, too much potassium can result in the appearance of magnesium deficiency. Some environmental factors may produce symptoms that mimic nutrient deficiencies; for example, cold stress can discolour leaves, wind and sun can scorch, insect or microbial infestation can deform or discolour.

Plants can also suffer from nutrient hunger in the field. This condition is essentially a low-grade deficiency. There may be no overt symptoms as a result, but growth rate may be reduced and the plant may become more vulnerable to other stresses as a result of its nutrient deficiency. Some cultivars and species exhibit a greater sensitivity to nutrient deficits than others, which can further complicate the field diagnosis of nutrient deficiencies.

The final factor that needs to be considered when making a visual assessment of the nutrient status of plants is the similarity in appearance of some deficiencies. Interveinal chlorosis is a symptom of magnesium deficiency, and also appears on plants suffering from zinc, manganese and iron deficits. Generalised chlorosis is seen in plants with nitrogen, molybdenum, potassium, chloride, sulphur and copper deficiencies. Observation of the type of leaf involved and any additional symptoms shown can give a clue to the exact nature of the deficiency.

Overcoming the odds

The best way to confirm a suspected nutrient deficiency is to have leaf samples analysed by a laboratory. In order to get long-term benefit out of this, the data generated could be combined with other growing information, such as the area the problem occurred, plant species and cultivar affected, time of the year, fertiliser treatments, soil test results, planting density, spray regime, weather conditions and a photographic record of the symptoms. Building up a personalised library of relevant information may help to develop a greater understanding of the factors affecting nutrient deficiencies in plants and by linking this to yields and quality may also be of benefit in assessing overall crop productivity.

The above photo of a potato plant is a good example of the difficulties that can be encountered when trying to diagnose nutrient deficiencies in the field by visual methods alone. The chlorosis (yellowing) of the leaves tends to indicate nitrogen deficiency. However, many of the leaves are still quite dark green, which casts uncertainty on this diagnosis. Iron deficiency may also produce these symptoms, as can a magnesium deficit. However, the most likely reason for the chlorotic appearance of these leaves is cold weather stress.

In the photo below, the greening around the calyx is most likely to be a result of potassium deficiency, but it could also be due to a lack of nitrogen, which can cause blotchy ripening of the fruit. On the other hand, it may be the effect of a chemical spray or insufficient sunlight reaching the fruit. The poor skin finish may be due to a calcium deficiency or an additional symptom of either a nitrogen or potassium deficit.

Ballance Agri-Nutrients horticultural specialists

Ballance Agri-Nutrients has a strong team of technical representatives throughout the country. Yet with approximately a hundred times more land in New Zealand being given over to pastoral farming than horticultural use, it's not surprising that most Ballance technical reps have to focus on sheep, beef and dairy issues. The horticultural industry, though small in area, is of great importance to the economy and products such as kiwifruit, apples and wine grapes have helped reaffirm New Zealand's standing on the international stage.

To help support this industry, Ballance has two horticultural specialists on its team. Peter Buckingham, who has been with the company since 1999, is based in Pukekohe, and Jo Honey, who joined Ballance in 2005, is based in Mount Maunganui.

Peter has a Bachelor of Commerce (Horticulture) and extensive experience, having spent over ten years working in the fertiliser industry before joining Ballance. Although his main focus is vegetables, particularly onions and potatoes, Peter is also well qualified to provide advice on other crops.

Jo has a Bachelor of Resource Studies and has spent time developing and implementing sustainable land management schemes. She was brought up in a farming environment, including the family avocado and kiwifruit orchards.

Both Peter and Jo take an active interest in research developments in their respective fields and in this they benefit from contact with scientists from Yara, which supplies many of the specialist horticultural fertilisers recommended by Ballance. Their wide experience means both are able to assist with plant nutrient requirements for a range of horticultural crops.

Contact details

Peter Buckingham
Ballance Agri-Nutrients
Hart Road
PO Box 260
Pukekohe
Phone: 027 479 5861
Free phone: 0800 222 090
Email: pbuckingham@ballance.co.nz

Jo Honey
Ballance Agri-Nutrients
Hull Road
Mt Maunganui
Phone 027 444 4083
Free phone: 08000 222 090
Email: jhoney@ballance.co.nz

Peter Buckingham

Jo Honey

Specialist horticultural products

Horticultural crops are particularly nutrient sensitive; to get the maximum yield growers need to have access to high-quality fertilisers containing a balanced ratio of nutrients. To meet this need Ballance sources most of its specialist horticultural products from Yara, the world's leading supplier of plant nutrients.

One of the most popular products in this range is **hydro complex**. Formulated into hard, even-sized prills, **hydro complex** delivers not only the major plant nutrients but also a selection of key trace elements. It also contains two forms of nitrogen and phosphate; plants get an immediate boost from nitrate nitrogen and water-soluble phosphate and later benefit from the sustained delivery of nutrients in the form of ammonium nitrogen and slowly available phosphate. Ideal for use on chloride-sensitive crops, **hydro complex** can be applied as a base dressing before, during or after sowing and is suitable for broadcasting and drilling.

The nutrient needs of plants vary with the stage of growth, and side-dressings of products such as **tropi-cote, nitrabor** and **yara can** are ideal for meeting these transient demands. All three products supply nitrogen, a key growth driver, and calcium, important for cell wall strength, disease resistance and crop firmness. In addition, **nitrabor** contains boron, which needs to be in good supply to ensure high rates of fruit and seed set.

For crops grown in soils with a potassium or sulphur deficiency, Ballance offers sulphate of potash, which can be used as either a base dressing or for side-dressing. With its low salt index and low chloride level, sulphate of potash is one of the best fertilisers for restoring the balance of these two essential soil nutrients.

For more information on these and other Ballance fertilisers, contact your horticultural specialist listed above.

Product	N	P	K	S	Mg	Ca	B	Fe	Zn	Mn
	%						ppm			
hydro complex	12.4	5.0	15.0	8.0	1.7	3	150	350	200	200
tropi-cote	15.5	-	-	-	-	19.2	-			
nitrabor	15.5	-	-	-	-	19.2	3000			
CAN	27.0	-	-	-	2.0	4.0	-			
SOP	0.0	0.0	42.0	17.5	-	-	-			