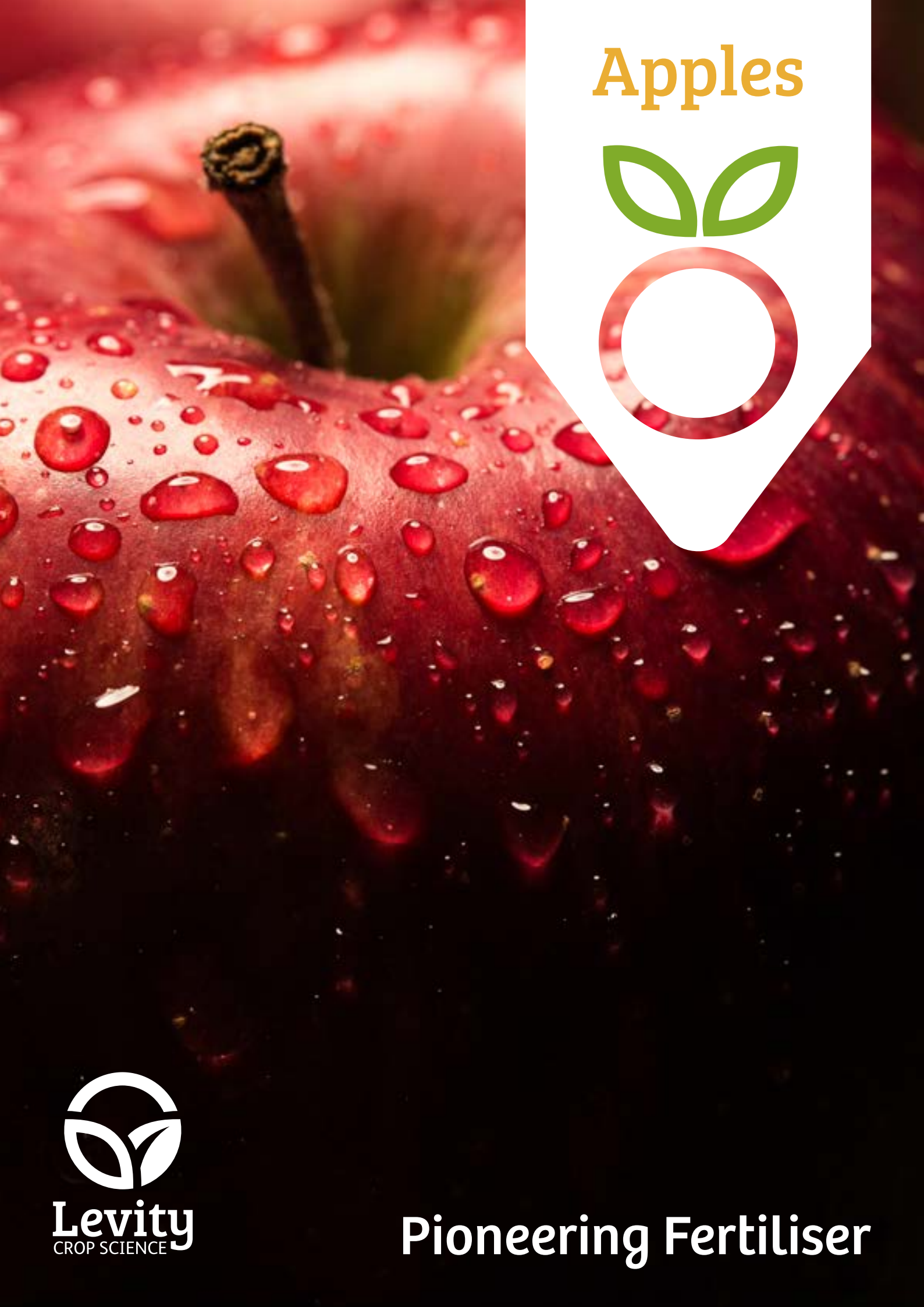


Apples

Levity
CROP SCIENCE

Pioneering Fertiliser

A complete range of fertiliser designed to enhance growth and quality of apples.

Levity are putting crop science at the heart of our product development. Our expertise is in understanding how plants use their food to grow, and then adapting the inputs so that the crop gets better use from it. It allows us to use very low inputs whilst achieving better results.

Our approach is to talk to growers, understand the challenges they face and then go back to the lab and create products that can help them. We consulted with apple growers around the world and identified key challenges that were poorly addressed by the fertiliser and agchem industry: shelf life, increasing yield without reducing quality, stress and management of Bitter pit, russeting and other disorders.

The developed range is the result of several years of intensive development and testing by our team of crop scientists. The products are backed with a huge amount of research and have been proven to be effective in an extensive global field programme.

Our job is to understand how science can help farmers, and deliver easy-to-use products that solve their problems. We are really proud of this range because it takes fertiliser inputs to a new level. By properly taking the time to understand the crop, we have created very low input products that solve problems and allow apple farmers to produce top quality and yield. This is the first time that products for apples have been built from a proper understanding of the crop, and farmers will be very happy with the results.

The 6 biggest issues facing top fruit addressed:

1 Yield:

Fertiliser can often produce vigorous leaf growth rather than fruit and root growth. This in turn can create quality issues and disease pressure. Farmers need ways to fuel fruit growth rather than vegetative.

Lono is a smart fertiliser that focuses the plant's growth on fruit development rather than the vegetative growth stimulated by conventional N fertilisers. Lono increases apple yield, lifting both size and number of fruit. It also helps crops maintain growth during periods of stress, safeguarding yield. The key benefits are increased yields, more even size distribution and less vegetative growth.

2 Quality:

Growers need to ensure that the roots they produce remains firm, and lasts well post- harvest so that fruit does not spoil before it's eaten. They also need to reduce incidence of disorders like Bitter pit and russeting.

Albina is a pioneering new product that improves shelf life and quality. Albina uses Levity's pioneering chemistry to stimulate calcium absorption into fruit at timings that conventional products can't. Albina is proven to reduce the incidence and severity of Bitter Pit, and to positively impact post-harvest storage of apples.

3 Maturity:

Growers need to ensure that fruit has the right colour and brix levels before harvest is possible. This needs to be achieved without sacrificing shelf life so the crop stores well.

Sulis is a pioneering new product that improves colour and brix formation in apples. Albina uses Levity's pioneering 'blush chemistry' to speed up colour and brix in apples allowing better grading and earlier harvest.

4 Grading:

Getting crops to the best size so that the crop achieves the highest possible quality and grading.

Damu can increase size of apples ahead of harvest by increasing the transfer of photosynthates from foliage to the developing fruit.

5 Stress:

The weather and growing conditions are the single largest influence on both yield and quality.

Indra is a product that improves growth and quality of root crops by helping the crop cope with stress caused by heat, cold, salinity, drought and high UV light. Indra can help protect crops from loss of quality and yield.

6 Protection:

Strong plants are more robust and healthy, Levity product improve plant strength and health.

Zeme is Levity's unique silicon fertiliser which strengthens the crop, making it more resilient against pests, disease and stress. Zeme uses Levity's patented SiX chemistry which dramatically improves silicon uptake and distribution allowing lower rates and better results.

The Results:

What to expect from the Levity approach.

Yield - Our products help apples growers achieve better yields, and a more even size distribution. Growers using our products will see less vigorous canopy growth better fruit development leading to improved yields.

Grading - Our products make apples bigger, and more evenly sized.

Maturity - Our products help improve colour and brix, allowing earlier harvest and better grading.

Stress - Our products allow growers to maintain growth and quality when conditions are tough. They help crops cope with heat, cold, salinity, UV and drought, and prevent loss of quality during stress periods.

Quality - Our products make apples firmer and longer lasting, they reduce Bitter pit and russeting and improve appearance.

Protection - Our products make crops stronger and more resilient. Growers using Levity products reduce susceptibility to disease and physiological disorders.

How Lono Improves Apple Yield.

As the primary plant nutrient, apple farms need to supply nitrogen for growth of the crop. However conventional nitrogen fertilisers disproportionately favour vegetative growth, meaning farmers are faced with a difficult balancing act between supplying enough N to achieve a good crop, and pushing out too vigorous shoot growth which detracts from yield and can increase fruit drop.

It is nitrates that drive vegetative growth. Nitrates are processed in leaves, and as they accumulate apple trees increase synthesis of the growth hormone auxin. The more nitrates the tree takes up, the more auxins are produced and the more the tree pushes towards building vegetation rather than supporting fruit development.

Different forms of nitrogen like amine and ammonium do not produce this 'auxin effect' but despite this switching to conventional ammonium and urea nitrogen sources still tends to produce increasingly vegetative growth as supply increases. This is due to the inherent instability of nitrogen fertiliser in the environment.

Regardless of the form applied most N given to apple orchards does not get taken up by the crop, and the majority that does make it into the trees does so in the nitrate form. This is due to bacterial activity that alters nitrogen from the form applied to nitrates, with losses along the way through leaching and volatilisation.

Levity's Solution - Lono

Levity have developed LimiN, a technology that holds nitrogen in the amine form, preventing conversion to nitrates. Our product Lono supplies stabilised amine nitrogen, and this can be used by farmers to help apple trees better allocate growth via a process known as 'growth partitioning'.

When trees are exposed to stabilised amine N via applications of Lono, they allocate growth differently. The crop becomes less 'apical dominant' developing more branching rather than shoot extension, better root development, and greater emphasis on flower and fruit development.

By regularly applying small doses of Lono alongside conventional N inputs, farmers can increase the number and size of apples produced by the tree, reduce fruit drop and improve quality.

Apples

How Albina Reduces Bitter Pit & Russeting.

Although fruit quality in apples is strongly linked with fruit calcium levels, it is rarely the case that the crop as a whole is calcium deficient. Even on crops with high levels of bitter pit there are frequently no signs of calcium deficiency in leaf analysis.

Indeed, when we consider the amount of fruit calcium needed to prevent bitter pit, we can see that far too much calcium is used for 'prevention' in terms of calcium required to solve an extremely small problem.

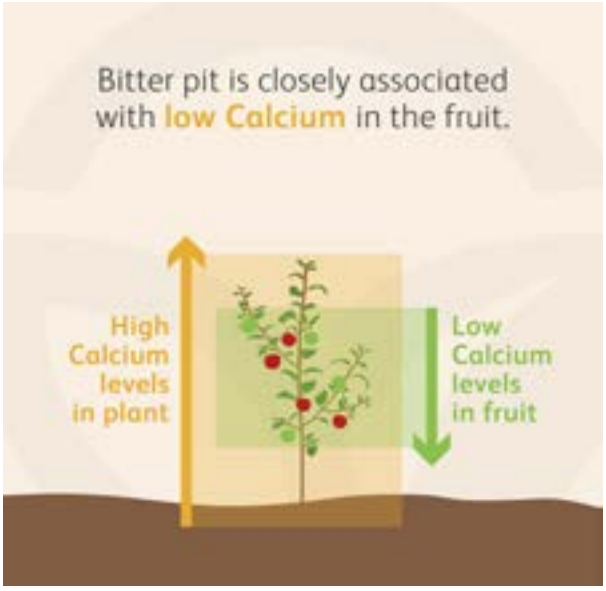
So how much Calcium is needed to prevent Bitter Pit?

Depending on variety and location, fruit calcium levels need to be above 5 – 5.4 mg Ca/100g fresh weight (Terblanche et al, 1980). Most apples are close to this level without any correction, with the difference between calcium level in fruit with and without bitter pit being typically between 2 and 4 ppm.

> **If we look at a crop with 100% bitter pit and do some simple calculations, we can see just how little calcium is needed to make the difference.**

If the crop is 30MT per Ha and every apple has bitter pit, only 2% of every apple is actually affected (the lesions), making a total 600kg of deficient tissue. If the difference in calcium content between the bitter pit affected tissue and the rest of the fruit is 4ppm then this makes the amount of calcium implicated in the problem 2.4g.

This means a 2.4g calcium deficiency created 30MT of crop loss. When we see how small the level of extra calcium needed to prevent bitter pit risk, it raises questions about why we apply so much calcium to prevent it.



Why Does Bitter Pit Occur?

To understand why we get these small areas of calcium deficiency, we need to understand more about how calcium is picked up, moved around and absorbed by plants.

Unlike most other nutrient's calcium is not phloem mobile, instead plants move calcium in the xylem with water. This means calcium moves through the plant in the same direction as water flow, moving through the plant from roots to leaves via transpiration stream.

This makes calcium movement susceptible to water availability and weather conditions, hence bitter pit increases when water flow is restricted by growing conditions. It also makes getting applied calcium to fruit tricky, as fruit is low in transpiration so receives little throughput of calcium when compared to other parts of the plant like leaves.

Absorption of calcium is also linked to presence of the auxin hormone. Tissues high in auxin absorb calcium easily, but tissues low in auxin have difficulty absorbing calcium no matter how much is available. Given that mature apples are naturally low in auxin, this makes absorption of calcium rather than availability of calcium the main driver in bitter pit susceptibility in apple crops.

When we look at the physiology of the fruit, we can learn a little about best timings for reducing bitter pit incidence. Auxin levels are highest in fruits between flowering and when the fruit is 5mm in size, this is the main period of cell division (which is powered by auxins).

As the fruit gets bigger it is focused on increasing the size of cells rather than creating cells, and auxin levels drop making it progressively harder to get calcium into fruit as it increases in size.

Levity's Solution - Albina

To help improve calcium levels in apples Levity have developed LoCal, a chemistry that improves calcium absorption in the absence of auxins. This helps apple fruit (naturally low in auxins) to properly absorb calcium.

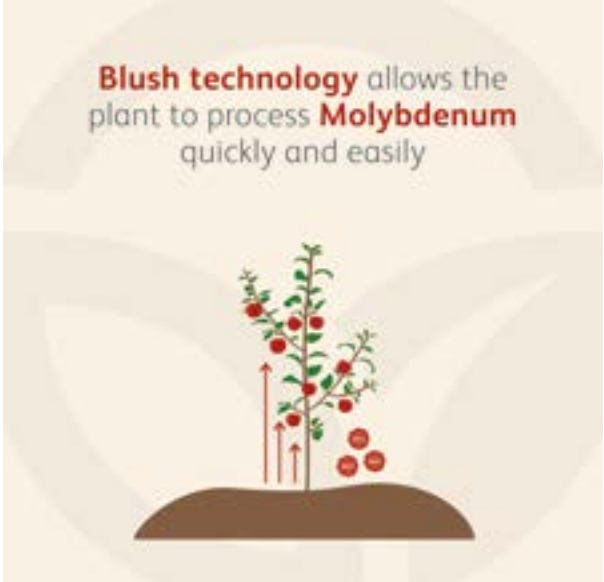
Albina uses LoCal chemistry to deliver calcium into apples, which allows farmers to use lower application rates and less frequent applications than with conventional calcium fertilisers. Albina (and other products using LoCal) have been demonstrated to reduce bitter pit on apples in field trials around the world.

Apples

How Sulis Improves Apple Colour, Brix & Post Harvest Shelf Life.

Sulis builds maturity (colour and brix) in apples. It works by supplying molybdenum and boron in a special formulation that helps the fruit maximise the function of the enzymes responsible for maturation, building better levels of colour and brix to allow earlier picking.

The processes of maturation require molybdenum and boron, but as molybdenum does not produce visible deficiency symptoms, the enzymes are often not adequately functioning, leading to a slow build of colour and sugars. The Blush technology that powers Sulis activates the plant's natural process of maturity, whilst ensuring these key nutrients in the process are available.



Levity's Solution - Sulis

The special formulation of Sulis helps fruit build better levels of colour and brix to allow earlier picking. It promotes the processes of maturation that are normally triggered by the hormone ABA. Importantly, Sulis does this without causing a spike in ethylene, which can retard shelf life and create quality problems.

Sulis also contains cell wall stabilisers, so that whilst colour and sugars build, the developing fruit can also maintain firmness. Normally, there is a trade-off between colour and sugar formation and softening, Sulis is designed to manage this process so that farmers can get the taste they need whilst still picking fruit that stays firm in storage.

Sulis is proven to improve colour and brix and to bring forwards harvest in multiple field trials on a wide range of varieties in both the UK and US.

Apples

Damu helps improve fruit development and size.

Boron is an essential an important nutrient, that has roles to play nitrogen metabolism and in translocation of photosynthates to fruit, flowers, roots and tubers.

However simply supplying enough boron to correct a deficiency is no guarantee that all of these processes will increase. This is because the use of boron is governed by the plants metabolism, not simply by supply of the nutrient.

This means that supplying extra B in conventional forms has limitations, both in terms of what it can achieve and where it will go.

For example, the translocation of sugars from leaves where they are made, to storage organs (beets, carrots, potato tubers) is limited by the speed of incorporation of boron into boron-carbohydrate complexes. Increasing boron supply can act upon leaf deficiency symptoms like whiptail, but does not make much difference to the speed of carbohydrate transport for bulking.

Damu addresses this in two ways. Firstly in incorporates 'Catalyst' a biostimulant developed by Levity, that speeds up the crops metabolism. This allows faster incorporation of the boron applied into complexes so that transport improves.

Secondly Damu contains molecules that are capable directly of transporting Boron via phloem, making immediate phloem mobility possible in plant species that are not capable of transporting boron via phloem.

Levity's Solution - Damu

This technology contained in Damu, makes it the only Boron product available that helps all crops move boron and sugars from leaves to fruits, roots and tubers removing the roadblocks in their physiology.

Damu can therefore be used to increase the size of fruits, and to improve flower set. Damu consistently demonstrates the ability to influence fruit size over and above conventional boron.

How Indra helps reduce stress.

Indra is a product that improves growth and quality of crops by helping them cope with stress caused by heat, cold, salinity, drought and high UV light. Stress causes crops to produce toxins (ROS) that damage cells and reduce quality. Indra promotes the plant's own antioxidant production and supplies the nutrients needed to make their manufacture possible. Indra can help protect crops from loss of quality and yield, improve colour, and reduce susceptibility to disease.

Levity's scientists understand how crops respond to stress; this is helping us find ways to help crops help themselves. Indra has been created to enable farmers to use high salt irrigation water without losing yields, and to help crops carry on growing when hit by stressful growing conditions. Our research shows that stimulating the plant's ability to protect itself from toxins produced when stressed can lift yield and quality in all crops.

UV Light Stress

The whole world relies on plants to use energy from sunlight to make food, but the wrong balance of sunlight can damage crops. In the Southern hemisphere, the ozone layer is thinner and more UVB rays get through the atmosphere and onto crops. Indra can stimulate production of antioxidants to give growers better crops.

Salinity and Drought

In arid and semi-arid parts of the world, overuse of groundwater aquifers is leading to seawater in infiltration. Over time the level of salt in the water fed to crops in many parts of the world is increasing, and it is reducing the yield of the crops it used to. Levity's research shows that by helping plants remove toxins that accumulate when they take in salty water, yield loss can be prevented. Indra helps farmers get higher yields with better quality.

Heat, Cold and Drought

The climate is changing and weather patterns are becoming less predictable. More crops are losing yield due to periods of high or low temperatures. By priming crops to allow them to cope when the weather gets tough, Indra helps farmers to safeguard yields and quality.

Reducing disease susceptibility

Stress weakens plant cells and increases the level and severity of disease. Indra reduces the impact of stress producing stronger crops that are better able to resist disease. Levity's research is demonstrating that managing stress can significantly reduce incidence of many fungal diseases.

Levity's Solution - Indra

To help growers with this Levity have developed Indra, a fertiliser that can reduce the effects of stress and help plants produce higher levels of antioxidants. Indra can help improve yield and quality in apple crops where UV leads to poor colour retention. It can also help protect yield from other kinds of crop stress including salinity, drought and high temperatures.

Apples

How Zeme improves strength, health and vigour of crops and protects against stress

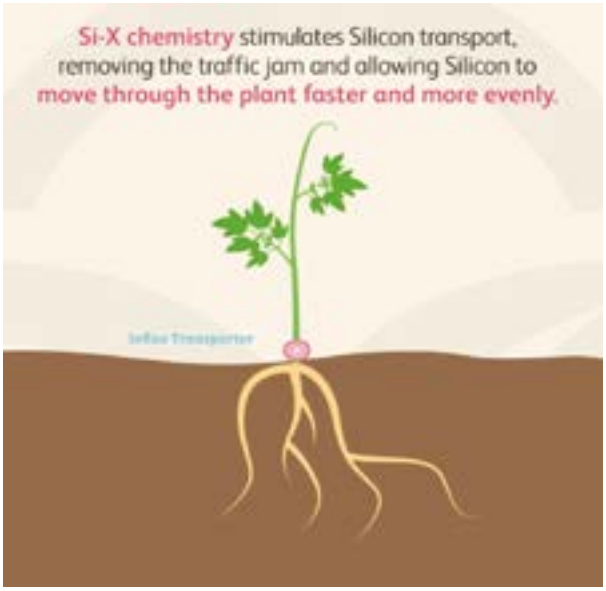
Zeme is a pioneering new product that improves strength, health and vigour of crops and protects against stress. Zeme uses Si-X technology to help plants transport and distribute silicon, a nutrient that can improve quality but is poorly taken up and distributed by plants.

Silicon has the potential to improve growth, strengthen and protect crops but problems in uptake and distribution of silicon have limited the potential of silicon fertilizers to improve crops. Soils contain as much as 50% silicon, and the small soluble fraction that is available should be more than enough to provide good levels to crops. However for most crops this is not the case with large differences in silicon uptake leading to huge variations in content between crops, with some species like rice containing as much as 15% silicon, but most other cereal crops only 1-3% and most dicots (fruits, vegetables and potatoes) only 0.1-0.5%. Indeed the vast majority of silicon released into soil water leaches into the sea without ever being taken up by plants.

> **So why do plants take up so little of the silicon available to them, and can this teach us how to improve it?.**

Silicon is not phloem mobile, so like other non-mobile elements (calcium and boron) plants move it through xylem with water. This means silicon transport moves up and through the plant from roots and is not evenly distributed. This is made worse by limitations in xylem loading. To get into and out of xylem silicon has to pass through a surrounding layer called the 'Casperian strip' which is impervious to silicon. Plants 'pump' silicon into xylem in the roots, and back out into leaves, shoots and fruit using influx and efflux transporters.

Although all crops use the same transporters, some do it more efficiently than others. This is why crops like rice can accumulate up to 15% silicon, whilst many fruit and vegetable crops can have as little as 0.1% silicon. The lack of transport leads to a traffic jam in the roots, and providing more silicon does little to improve uptake.



Better transport and distribution of silicon

To help make silicon more effective, Levity have developed Si-X technology (patent applied), which stimulates influx and efflux of silicon from xylem. This Si-X technology used in Zeme ensures that plants can efficiently take up and distribute silicon making it work far more effectively.

Because the silicon in Zeme is more mobile in the plant it can be applied at low levels (1L/Ha) and less frequently than conventional silicon fertilisers.

More metabolically active silicon

Another limitation of silicon application to crops is the fast conversion to inert forms. When silicon is deposited in leaves (or applied to leaves in a foliar spray) it rapidly forms opals, thin layers of silica gel. These opals give the plant a degree of physical toughness and protection, but are chemically inert. Once they are formed the silicon can no longer be redistributed and can no longer have any growth stimulant or anti-stress effects.

The Si-X technology used in Zeme slows down the process of silica gel formation, which when combined with improved transport allows a more long lasting and greater growth stimulation and anti-stress effect. Levity's research demonstrates superior growth response when compared to conventional silicon applications.

Accelerates growth

Zeme makes metabolically active silicon rapidly available, in strong healthy growth. Research shows Zeme improves flower / grain development, stem thickness and height, and produces a stronger more upright crop.

Strengthens crops against damage

Silicon gives plant tissue physical toughness that helps plants resist damage. The Si-X technology used in Zeme improves the distribution of silicon, giving better and more long-lasting strength to the crop.

Improves growth during stressful growing conditions

Silicon elicits a strong anti stress response in crops, but only when metabolically active. The Si-X technology used in Zeme keeps silicon metabolically active for longer stimulating a powerful anti-stress effect.

How to Reduce Bitter Pit in Apples

Whilst bitter pit is linked with localised low levels of calcium it is characterised as a physiological disorder, and not a calcium deficiency. There is a reason for this distinction and it should inform best agronomic practice on how to reduce bitter pit in apples.

What is Bitter Pit?

Bitter Pit is a physiological disorder of apples which results in dark spots on the skin. The spots are strongly associated with low calcium levels which lead to collapsed tissue in the lesions where it occurs. Bitter pit symptoms are most severe when crops suffer from stressful growing conditions.

What causes Bitter Pit in apples?

Bitter Pit is caused by poor cell division in developing fruit. When cell division is weak calcium cannot be properly absorbed leading to local calcium deficiency in the characteristic spots. Although symptoms appear when the fruit starts to reach full size, they are caused during the early stage of development becoming visible later.

Although Bitter Pit is more prevalent in parts of fruit with lower levels of calcium, however it is rarely the case that the crop as a whole is calcium deficient even on crops with high levels of bitter pit. There are frequently no signs of calcium deficiency in leaf analysis, or even in most parts of the fruit with bitter pit lesions.

> **Indeed when we consider the amount of fruit calcium needed to prevent bitter pit we can see that far too much calcium is used for 'prevention' of what is in terms of calcium required an extremely small problem.**

So how much Ca is needed to prevent the disorder? Depending on variety and location fruit calcium levels need to be above 5 – 5.4 mg Ca/100g fresh weight (Terblanche et al, 1980). Most apples are close to this without any correction, with the difference between calcium level in fruit with and without bitter pit being typically between 2 and 4 ppm.

If we look at a crop with 100% bitter pit and do some simple calculations we can see just how little calcium is needed to make the difference. If the crop is 30MT per Ha, and all the fruit has bitter pit lesions only part of that fruit has bitter pit lesions (2%), making 600 Kg of deficient tissue. If the difference in calcium content between the bitter pit affected tissue and the rest of the fruit is 4ppm then this makes the amount of calcium implicated in the problem 2.4g.

> **This means a 2.4g calcium deficiency created 30MT of crop loss. When we see how small the level of extra calcium needed to prevent bitter pit risk, it raises questions about why we apply so much calcium to prevent it.**

To understand why we get these small areas of calcium deficiency, we need to understand more about how calcium is picked up, moved around and absorbed by plants.

Unlike most other nutrients Calcium is not phloem mobile, this means plants move it in xylem with water with calcium moving through the plant is in the direction of water flow, moving through the plant from roots to leaves via transpiration stream.

This makes calcium movement susceptible to water availability, and weather conditions hence bitter pit increases when water flow is restricted by growing conditions. It also makes getting applied calcium to fruit tricky, as fruit is low in transpiration so receives little throughput of calcium when compared to other parts of the plant like leaves.

> **Absorption of calcium is linked to presence of the auxin hormone. Tissues high in auxin absorb calcium easily, but tissues low in calcium have difficulty absorbing calcium no matter how much is available. This makes absorption of calcium rather than availability of calcium the main driver in bitter pit susceptibility in apple crops.**

When we look at the physiology of the fruit, we can learn a little about best timings for reducing bitter pit incidence. Auxin levels are highest in fruits between flowering and when the fruit is 5mm in size, this is the main period of cell division (which is powered by auxins).

As the fruit gets bigger it is focused on increasing the size of cells rather than creating cells, and auxin levels drop making it progressively harder to get calcium into fruit as it increases in size.

Given the physiology of apples the best way to reduce bitter pit is to focus on timing, placement and absorption rather than quantity and frequency of application.

How to reduce bitter pit in apples.

- Use foliar applications of Calcium (rather than soil) with emphasis on getting good coverage so as to hit as much of the fruit / flowers as possible.
- Primarily time applications of Calcium between king bud and when the fruit is 5mm in size. Applications are more efficacious in this time as smaller fruit is more able to absorb calcium.
- Use Albina fertiliser with LoCal Chemistry. LoCal Chemistry improves fruit calcium absorption in the absence of auxins.

Improving Colour Formation in Apples

As an apple crop gets closer to harvest it can be a frustrating time for farmers watching crops hit the right size but not form enough colour and sugars to be picked. Often early harvest is where a grower can get the best price in the market, and of course the longer the time to get the whole crop off the orchard the higher the labour costs involved.

> **Here we look at the role of molybdenum in fruit maturation, and showcase how Sulis a product developed by Levity Crop Science has been helping growers in the UK and US improve colour in apples.**

Ethylene does not directly produce colour in apples

Ethylene is the hormone most associated with fruit maturity in apples, and many of the methods and products used to encourage maturity focus on either applying ethylene or stressing the trees to encourage its production.

> **However ethylene is not the only ripening hormone, and its effects on colour and brix levels are not direct. Ethylene's role in the ripening of apples is primarily that of fruit softening.**

Ethylene stimulates cell wall hydrolase genes to produce polygalacturonase (Tacken et al, 2010). This is why use of ethylene promoters to stimulate colour and brix are associated with loss of fruit firmness. Ethylene also stimulates removal of calcium from cell walls, which is why apples have higher incidence of bitter pit both pre and post harvest when there are stressful growing conditions.

ABA is the primary hormone involved in colour formation in apples

It is not however ethylene that is responsible for triggering colour and brix formation in apples, that process is stimulated by a different hormone ABA (Sata et al 2018).

> **When ethylene is produced or applied to a crop the trees also start to produce ABA, which then stimulates the enzyme activity that produces maturation.**

What is the link between molybdenum and maturation of apples?

Mo deficiencies are not only transient and short-lived, but virtually impossible to detect: quite different from copper or sulfur deficiencies, for example, where the leaves tell the whole story.

> **Molybdenum is a limiting factor in synthesis of ABA, to make it plants must have adequate levels. However simply upping levels of moly in the crop is not enough to ensure the plant can make enough ABA to improve fruit maturation.**

Sulis can help improve colour in apple crops

Levity have developed Sulis, a product that gives the plant the molybdenum it needs to power ABA production, alongside 'Blush' a biostimulant that ensures rapid uptake and utilisation by the crop and switches on the enzyme systems that power maturation.

Importantly Sulis achieves this without also triggering a reduction in fruit firmness as it contains cell wall stabilisers that counter the effects of ethylene and prevent loss of calcium from fruit.

Sulis

To stimulate colour and brix ahead of harvest, apply Sulis at 2L/Ha as soon as fruit starts maturation, repeating the application at 7-10 day intervals.

Photo-Oxidative stress and fruit colour.

Farmers in the Southern hemisphere growing soft and top fruit crops have to work harder to get colour, and shelf-life and to reduce physiological disorders. In this article we will discuss the role light plays in this, its effects on plant physiology and what farmers can do agronomically to deal with it.

UV radiation from the sun is necessary for all life on earth, and put to good use by plants during photosynthesis, but too much of a good thing can be dangerous. UV levels and UVA / UVB balance are not uniformly distributed around the earth, and the Southern hemisphere nations of Peru, Argentina Bolivia, Chile, New Zealand and South Africa all receive heightened levels of UV with a higher UVB levels due to the ozone layer being thinner there.

So why does this matter to fruit growers? Photo-oxidative stress generated by UV balance causes heightened production of toxic reactive oxygen species (ROS) during photosynthesis. ROS damage plant cells, ultimately leading to cell death if they build up in plant tissue, therefore plants have mechanisms to deal with them. Namely production of anti-oxidants such as anthocyanins and carotenoids and enzymes such as superoxide dismutase (SOD).

For crops to grow well where there is a high UV level, plants must use anti-oxidants in order to protect themselves. These antioxidants are the main source of colour in fruit crops, with yellow, orange and red pigments coming from carotenoids and red, blue and purple pigments coming from flavonoids. From a practical agronomic point of view this means that colours and flavours that come from anti-oxidants are metabolised by the fruit as they are used to prevent damage from ROS. This means that it can be harder to hold colour in crops like table grapes, cherries, apples, pears and soft fruits.

So what can we do about this? Firstly we need to understand that the problem is not caused by the plant not producing colour, rather it is due to the colour being metabolised. Anything a grower can do to reduce stress will improve the situation (most kinds of stress induce ROS increases, not just UV), so paying attention to minimising stress in general can help.

Secondly we can try and stimulate production of antioxidants. Thirdly we can pay attention to the enzyme systems (superoxide dismutases), which require sufficient levels of enzyme co-factors (copper, manganese and zinc) to properly function. To help growers with this Levity have developed Indra, a fertiliser that can help plants produce higher levels of antioxidants, and ensure proper functioning of antioxidant enzyme systems.

Another approach is to encourage the plant to boost up the functioning of hormones involved in maturation (ABA). ABA levels dictate the timing and speed of synthesis of the colours and sugars produced as fruits ripen. Often the speed of synthesis of colours and sugars is slowed by lack of availability of molybdenum, a nutrient vital for processing of ABA. Because molybdenum deficiencies do not show leaf symptoms growers are often not aware of them.

To help growers stimulate maturation of colour and brix Levity have developed Sulis, a product that can help the plant stimulate maturity processes and help the plant produce better levels of colour and sugar.

To summarise. In many southern hemisphere nations, colour is harder to achieve and maintain in fruit crops, due to high UV causing photo-oxidative stress. If we understand what is causing the problem, we can adjust our agronomy and support the plant by developing products that work with the crop to help them improve production and protection of pigments.

Levity's science team have developed products to help, Indra to stimulate antioxidants and SOD, and Sulis to stimulate maturity processes. When farmers use these products they can reliably achieve good colour and brix levels.

Photo-oxidative stress and fruit calcium

The Southern hemisphere nations of Peru, Argentina Bolivia, Chile, New Zealand and South Africa all receive heightened levels of UV with a higher UVB levels due to the ozone layer being thinner there.

So why does this matter to fruit growers? Farmers in high UV regions also have a harder time correcting physiological disorders. Lets discuss why photo-oxidative stress can affect this.

Stress (any stress) including UV stress triggers movement of calcium from the cell wall into the interior of the cell where it is involved in triggering production of the stress hormone ethylene, this is sometimes termed 'second messenger'. This means that fruit grown where there is high UV has a higher metabolism of calcium. It moves away from cell walls and must be replaced more often if cell wall strength is to be maintained.

This is nicely illustrated by looking at research the level of tissue calcium needed to prevent physiological disorders. Studies on apples show that in the same apple variety (Cox) the level of tissue calcium needed to prevent bitter pit is higher in South Africa (where UV is high) than the UK. This difference is due to the higher metabolism of calcium in fruit crops grown in the Southern Hemisphere.

The take home message from this research is that you need higher calcium levels to prevent physiological disorders like bitter pit in apples and cracking in cherries in countries with high UV. It is also the case that other factors affected by calcium levels such as shelf life and firmness in soft fruit require higher levels of calcium, as metabolism is faster.

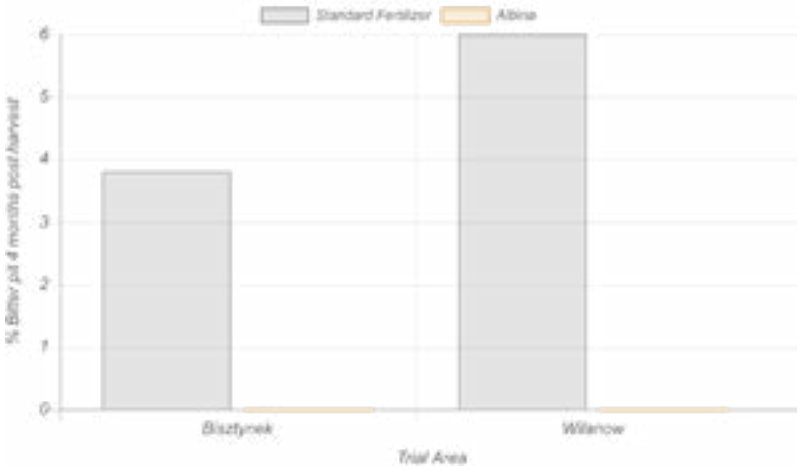
Unfortunately the effect of UV on calcium depletion in fruit crops are most apparent late season as the calcium gradually depletes. This is the time when fruit is least able to replace calcium as there is no active cell division, and the main driver for transport (auxin produced in the seed) is small, meaning transport of calcium into fruit from foliar sprays is relatively inefficient with much of the calcium applied unable to get to where it is needed.

So what can growers do to help?

- Early sprays of foliar calcium on young developing fruit, this is the best time to load the level of fruit calcium up using conventional products.
- Levity's scientists have developed Albina, a product that can help maintain quality even in late season applications. This is a good way of holding quality in crops grown under high UV in South America, New Zealand and South Africa.

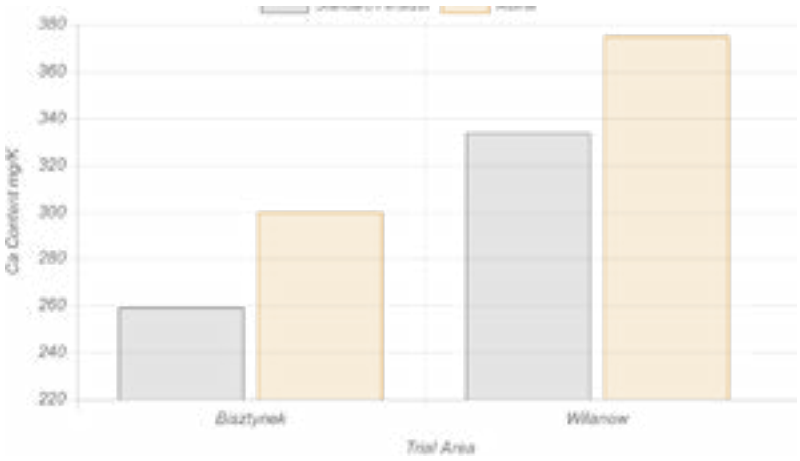
Trial: Poland (2009)
Fertiliser: Albina
Apple Variety: Szampion

Studies were carried out in Poland Warsaw Agricultural university 2009. The trials looked at the comparison between Standard Calcium fertilizer and Levity's Albina Fertilizer with LoCal technology on apple variety Szampion. The standard Calcium was applied in greater volumes at 9 applications of 5 litres per hectare and Albina was applied at 3 applications of 1.5 litres per hectare.



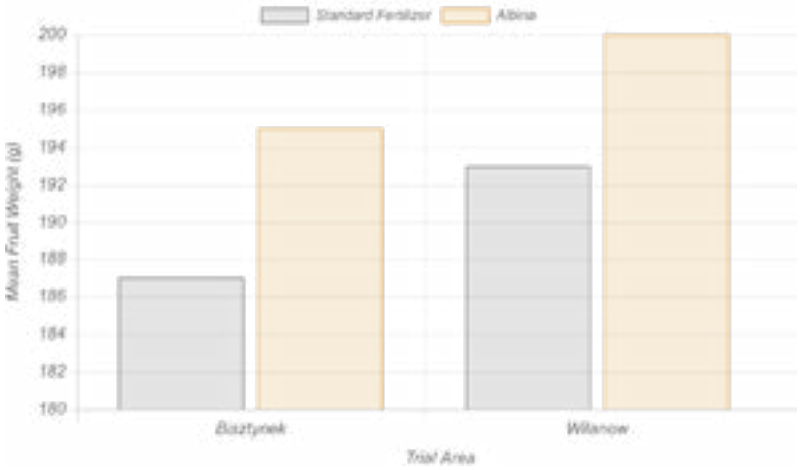
Bitter Pit

The study showed that 3 x 1.5 L/ha Albina completely corrected Bitter Pit, whereas 9 x 5 L/ha of conventional calcium fertiliser did not. This is because Albina can be absorbed by the fruit.



Calcium Content

Calcium content was much higher in the Albina treated apples when compared to the industry standard fertilizer. This is important for quality, shelf life and prevention of disease.



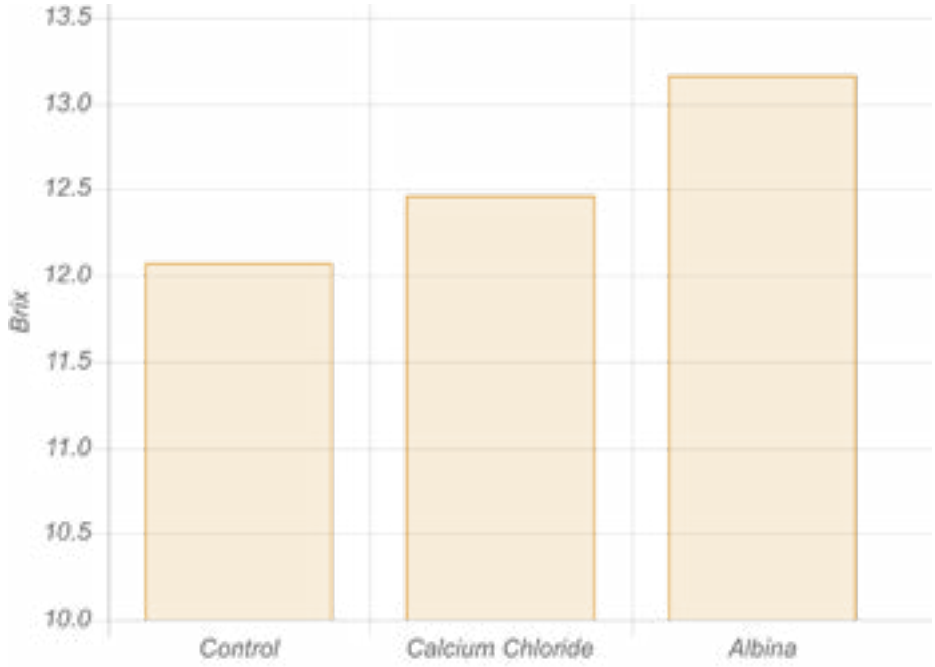
Mean Fruit Weight

The Albina treated apples were also exhibited a higher average weight than those treated with industry standard fertilizer.

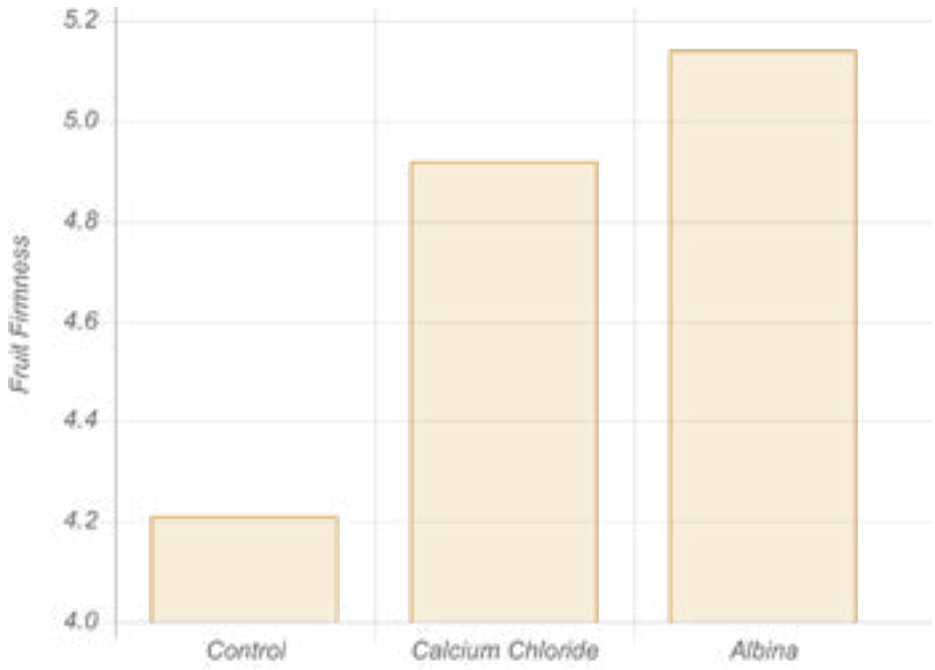
Trial: Kent, UK (2011)
Fertiliser: Albina
Apple Variety: Cox

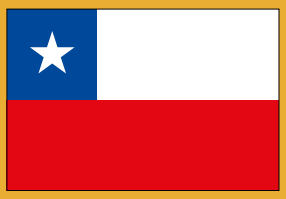
This Independent UK trial conducted in Kent in 2011 compared Albina at 1L per Ha with Calcium chloride at 10L per Ha used at the same timings. Albina outperformed conventional calcium application with significantly better fruit firmness and brix even at 1/10th the application rate.

Brix



Fruit Firmness

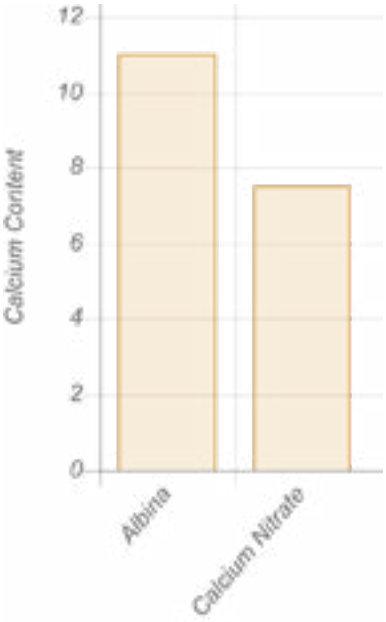




Trial: Chile (2012)
Fertiliser: Albina
Apple Variety: Golden Delicious

In this study conducted in Chile Albina applied at 1L/Ha was compared with 5L/Ha of calcium nitrate applied at the same timings. The Albina treatment had significantly higher levels of calcium in fruit and also improved the level of all other nutrients tested.

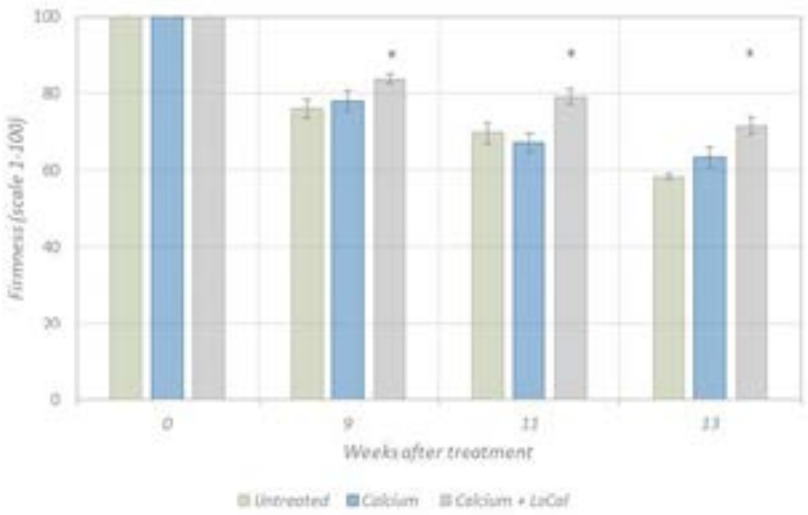
Calcium



Post harvest fruit firmness has improved with Albina.

Fruit firmness (a key shelf life indicator) was assessed for 13 weeks after harvest. Standard calcium applications were not effective at improving firmness,

but Albina significantly improved fruit firmness for the full 13 week period tested during storage.

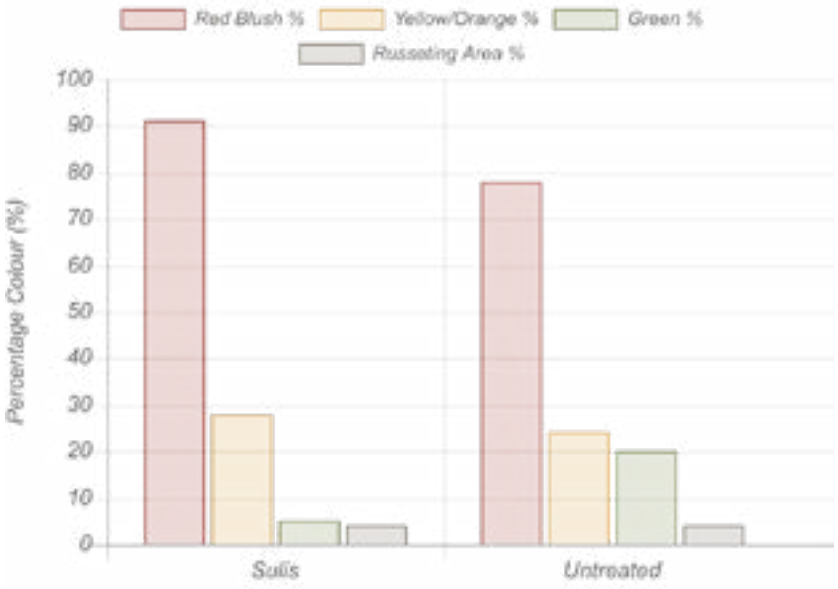


Trial: Kent, UK (2017)
Fertiliser: Sulis
Apple Variety: Gala

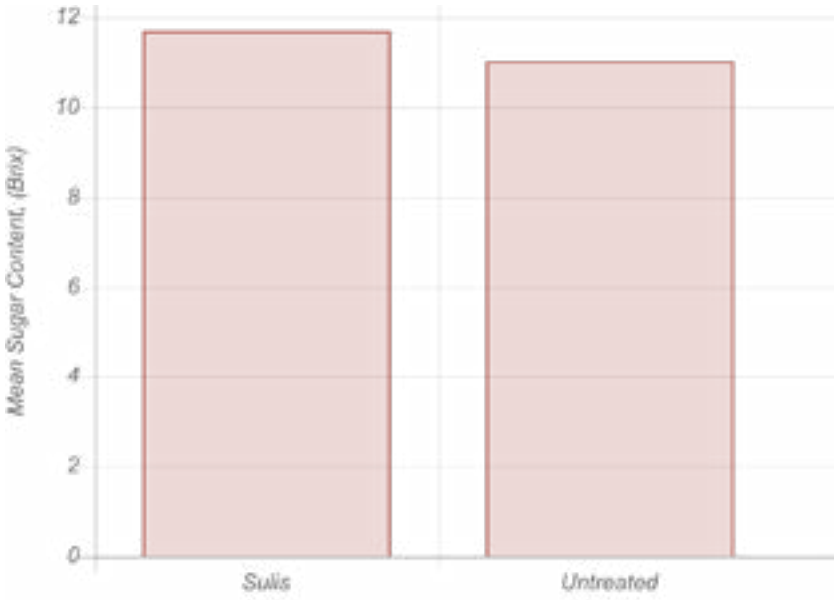
Independent studies were carried out in Kent, UK studying the effects of Sulis on Gala apples colour and brix, where Sulis was applied at 2 litres per hectare.

The studies showed that Sulis significantly increased the number of red apples and the increased the sugar content.

Mean Colouration of Apples



Sugar Content (Brix)



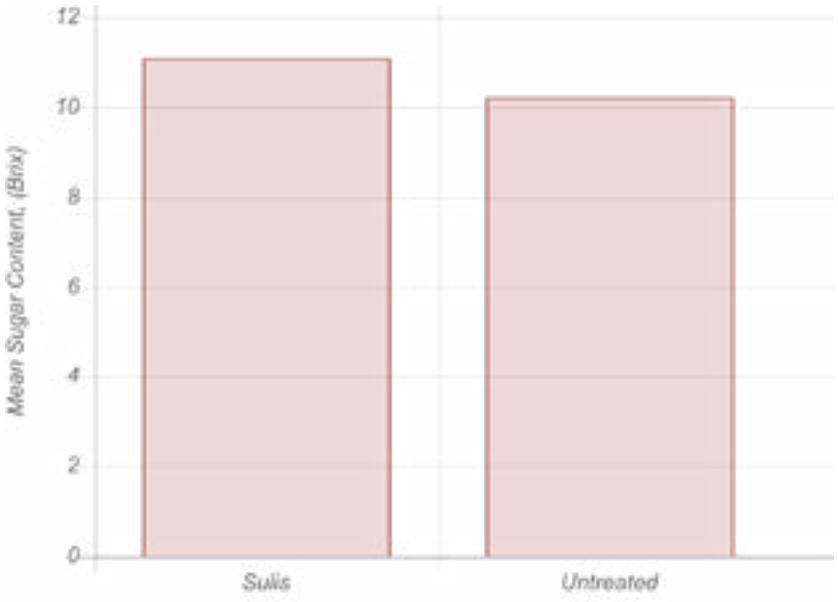
Trial: Kent, UK (2017)
Fertiliser: Sulis
Apple Variety: Braeburn

Independent trials were conducted in Kent (2017) studying the effect of Sulis on apple variety Braeburn. The trials studied the how well Sulis improved maturity (colour) in the Braeburn apples, as well as sugar levels (brix). Sulis was applied at 2 litres per hectare and the results can be seen below.

These trials showed that sulis gave a significant improvement in both maturity and brix.

Mean Colouration of Apples

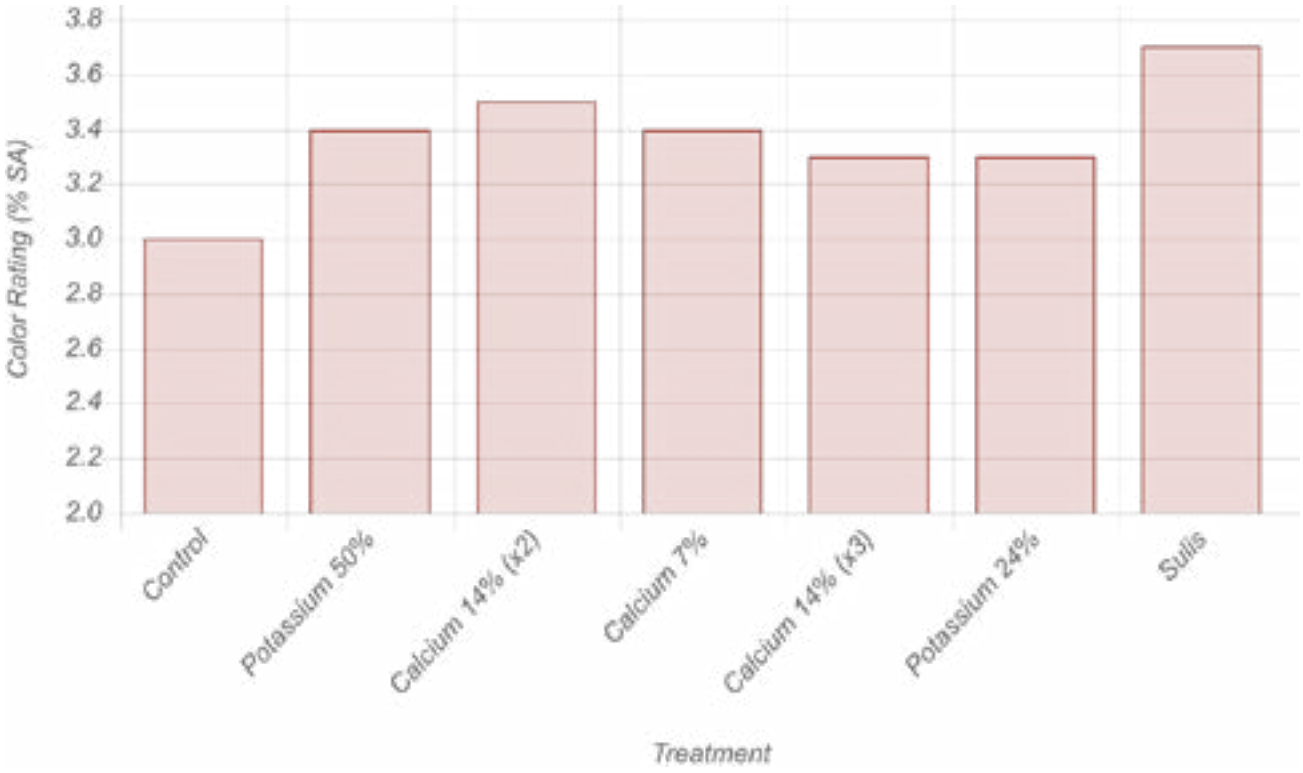
Sugar Content (Brix)



Trial: Washington State, USA (2020)
Fertiliser: Sulis
Apple Variety: Gala

Independent studies were carried out in Washington state, USA studying the effects of Sulis on Gala apples colour, where Sulis was applied at 2 litres per hectare. The studies showed that Sulis worked better at improving colour than other treatments, significantly enhancing colour formation. The trial confirmed the performance seen in European trials.

Gala Colour Rating



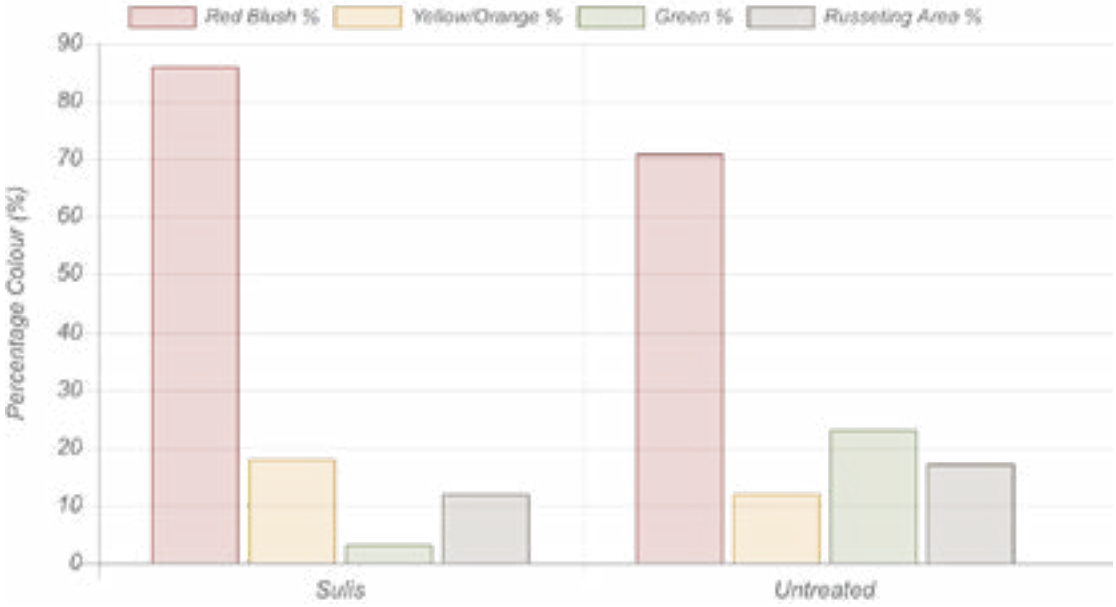
Trial: UK (2017)
Fertiliser: Sulis
Apple Variety: Zari

This large scale replicated trial was carried out in Frittenden UK with 2400 trees treated with 1 2L application of Sulis and 5600 trees untreated. All other fertilization was standard across the trial.

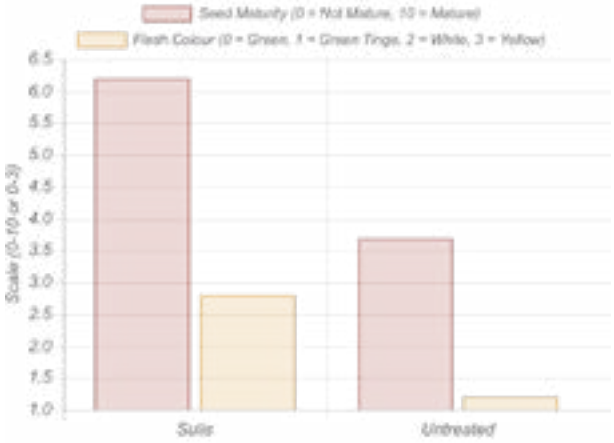
The data here shows that ripeness, colour and sugar were all significantly improved in the Sulis treated trees. However, the main benefit was the reduced number of picks required in the treated blocks. The Sulis treated blocks were fully harvested in the first two picks, with the untreated blocks requiring 4 picks to fully harvest the fruit.

This trial demonstrated that Sulis not only improved colour, taste and brix on this variety, it also brought forwards harvest allowing large savings in labour costs on farm.

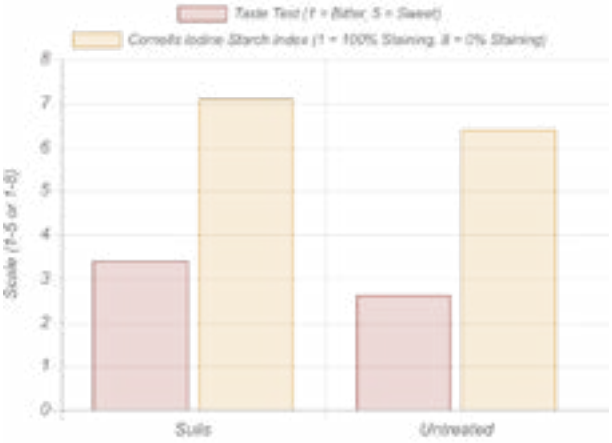
Zari Colour

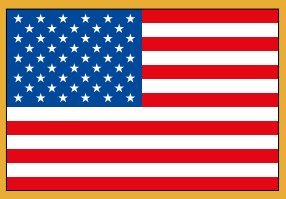


Apple Ripeness Indicators



Apple Ripeness Indicators





Trial: Washington State, USA (2020)
Fertiliser: Sulis
Apple Variety: Honeycrisp

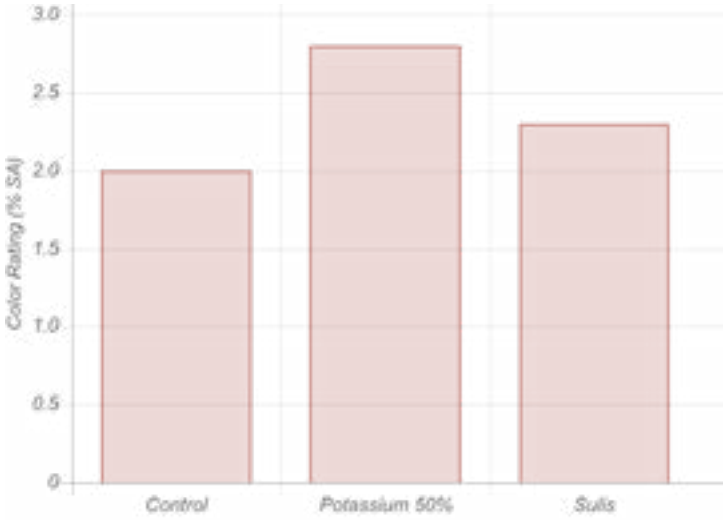
Honeycrisp is a variety that is highly susceptible to bitter pit and promoting better colour the fruit can have the undesirable side effect of increasing incidence of bitter pit.

This Independent trial in Washington State USA show two benefits from applications of Sulis. When compared with potassium used at higher rates Sulis still gave good improvements in colour compared to untreated control plots.

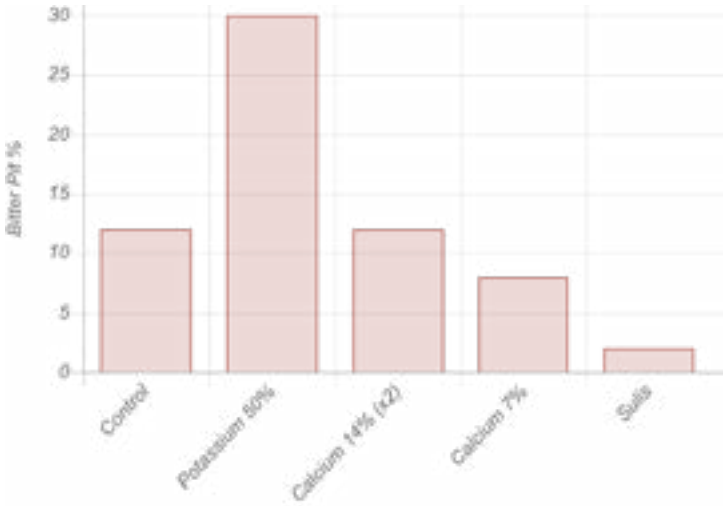
When measuring bitter pit incidence post-harvest, the K treatment showed a threefold increase in bitter pit, whilst Sulis actually gave a reduction in bitter pit greater than standard calcium treatments.

This trial demonstrates how well Sulis can improve maturity without compromising post-harvest fruit quality.

Honeycrisp colour rating



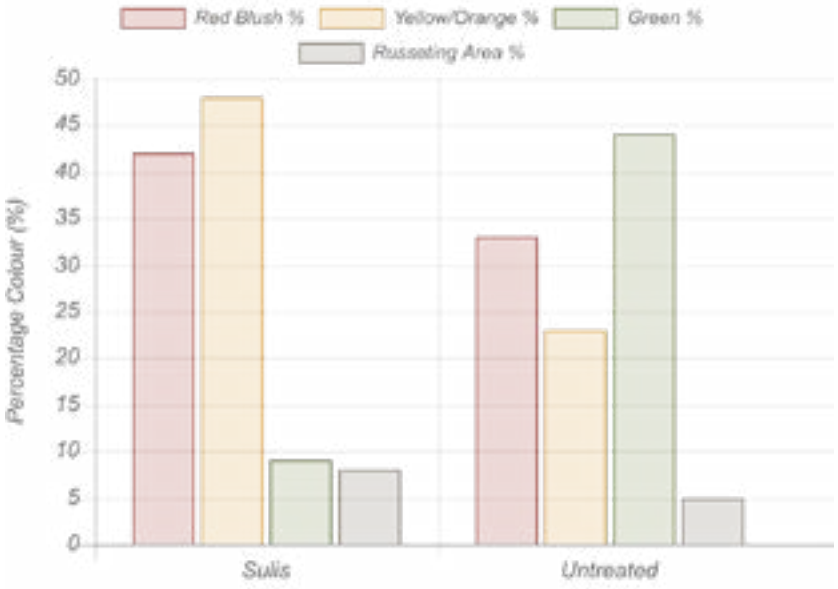
Honeycrisp Post Harvest Bitterpit %



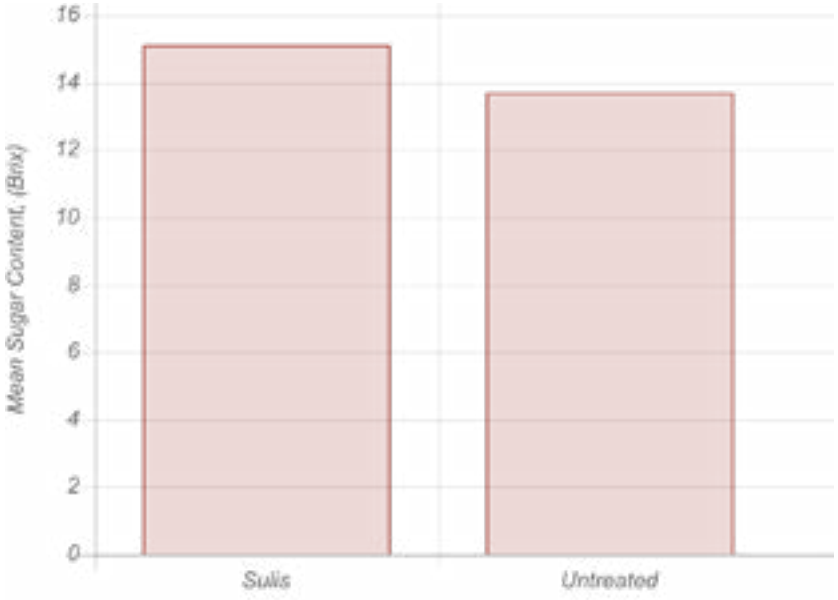
Trial: Herefordshire, UK (2017)
Fertiliser: Sulis
Apple Variety: Tentation

This independent replicated trial was conducted in Herefordshire UK in 2017. A single application of Sulis was applied at 2L/Ha and significant improvements were achieved in earliness, colour and brix.

Mean Colouration of Tentation Apples



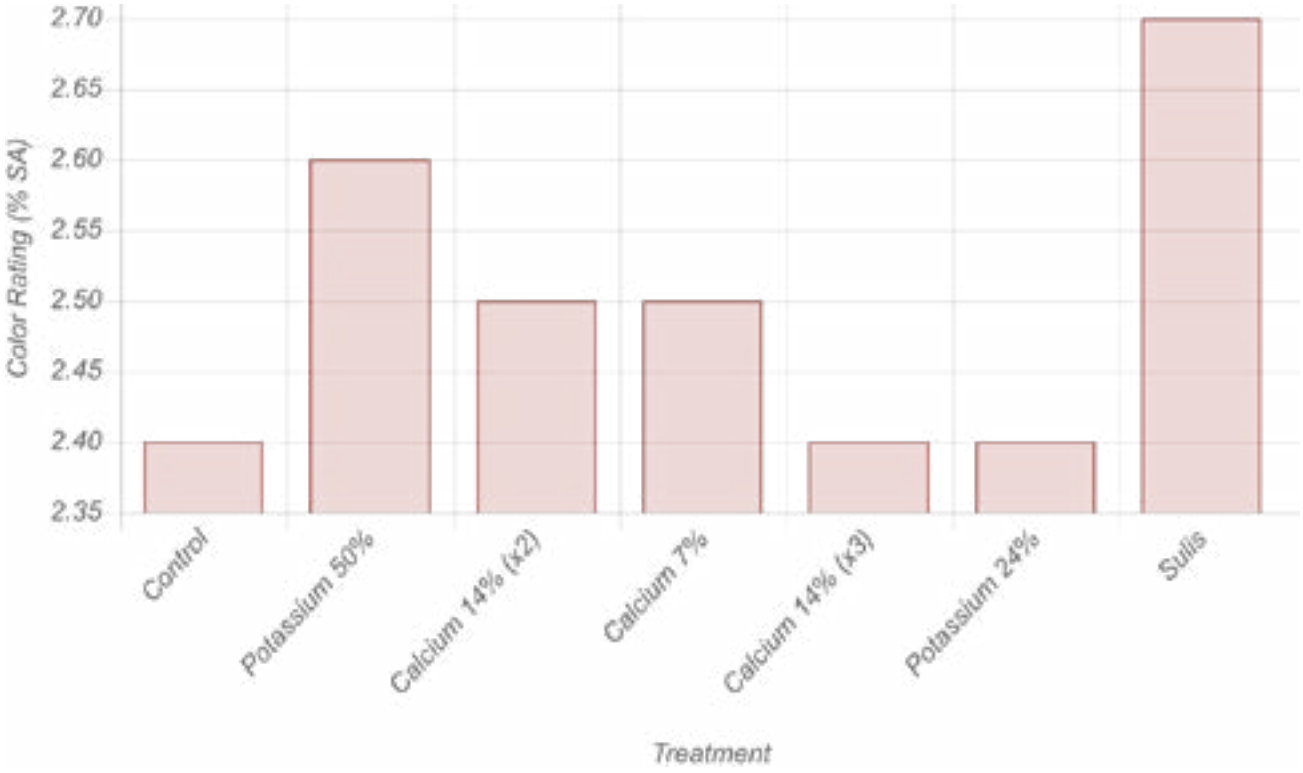
Mean Sugar Content (Brix)



Trial: Washington State, USA (2020)
Fertiliser: Sulis
Apple Variety: Envy

This trial looked at a range of commonly used calcium and potassium based foliar fertilizers and Levity's Sulis on the variety Envy. Sulis gave the best results for colour significantly improving fruit maturity when compared to the control and all other treatments.

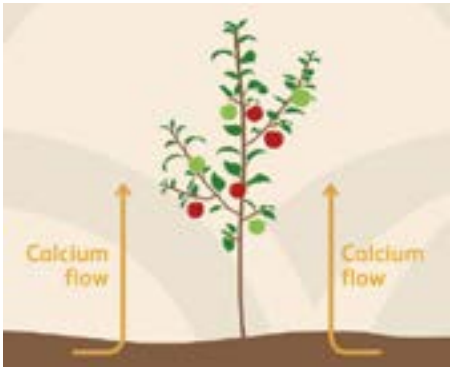
Envy Colour Rating (% SA)



Trial: New Zealand (2022)
Fertiliser: Albina
Apple Variety: Braeburn

Control of bitter pit in apple achieved with reduced calcium inputs.

ISHS Postharvest Unlimited Conference, Wageningen University, Netherlands.



Apple and calcium

- Calcium is an essential nutrient that also acts as a messenger, so it is strongly regulated by plants
- Calcium has a structural role in cell walls and for membrane stability
- Calcium is transported from the roots to the shoots via the xylem
- Mass flow of calcium is towards mature leaves rather than young leaves or fruit

(Demidchik et al., 2018; Thor, 2019; White & Broadley, 2003)

- Auxin mediates transport of calcium across cell membranes
- In apples, once cells have stopped dividing, auxin levels reduce
- To ensure that calcium is transported into cells efficiently, calcium transport stimulants (MCAS) need to be used
- The calcium fertiliser Albina (Levity Crop Science, UK) contains the MCAS LoCal

(Marks et al., 2019)

Aim and methods

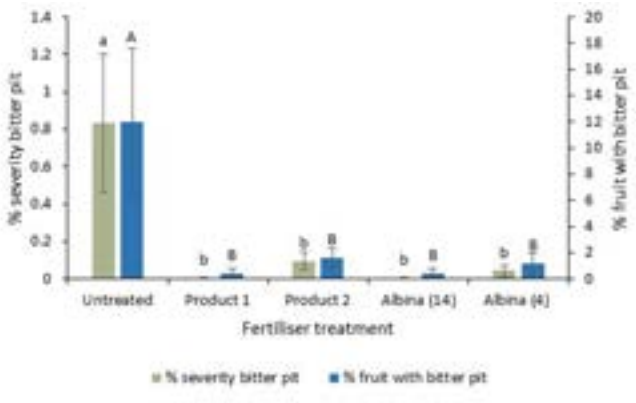
- To compare the use of Albina (containing LoCal, Levity Crop Science, UK) to two industry standard calcium fertilisers on apple comparing quality parameters, firmness and bitter pit
- Conducted in Hawke's Bay region of New Zealand on Braeburn apples
- Randomised block design with five replicates and one tree per plot

All management followed grower standard practices apart from calcium application.

- Untreated – no calcium applied
- Industry standard product 1 - 1750 grams Ca/ha/application for 14 applications
- Industry standard product 2 - 1600 grams Ca/ha/application for 14 applications
- Albina (14) - 120 grams Ca/ha/application for 14 applications
- Albina (4) - 120 grams Ca/ha/application for 4 applications
- Crop phytotoxicity and russeting visually assessed throughout experiment
- Mineral analysis conducted for calcium, magnesium and potassium
- 21 and 42 days after harvest (DAH) flesh firmness and bitter pit assessed

Severity bitter pit and fruit with bitter pit in Braeburn apples.

Sig. dif. between treatments (severity bitter pit – lowercase letters, fruit with bitter pit – capital letters) at $p<0.05$, ANOVA with Duncan's New Multi Range Test.



Conclusions

Per application Albina contained less than 10% of the calcium in the two industry standard products.

Albina when applied either 14 or only four times per season resulted in bitter pit levels that were the same as the two industry standard products and significantly less than the untreated apples.

Albina contained the MCAS LoCal so was able to get the calcium to where it was needed even through much lower levels of calcium were applied.

The calcium use efficiency was greatly improved, thereby saving growers the costs associated with the increased number of applications if they were using the current industry standard products.

Application Rates:

Lono

Application	Amount	Frequency	Impact
Soil or Foliar	5-10L Per Ha	Every 2-4 weeks throughout season	Higher Yield
Dormant spray	1% solution as a spray to wood during dormancy	Once during dormant period	Stronger and earlier bud break

Albina

Application	Amount	Frequency	Impact
Foliar apply	1L Per Ha	At flowering and then 2 further applications (7-14 day intervals)	Reduce physiological disorders

Sulis

Application	Amount	Frequency	Impact
Foliar apply	1-2L Per Ha	Apply as fruit starts maturation and repeat after 7-10 days	Accelerates colour and Brix

Damu

Application	Amount	Frequency	Impact
Foliar spray	2L Per Ha	2-4 week intervals following flowering. Apply in 400 – 800L/ha of water.	Improved size, homogeneity and colour

Indra

Application	Amount	Frequency	Impact
Foliar apply	1L Per Ha	Every 4-6 weeks during periods of stress	Protects from stress, better growth, increased yield, and improved quality

Zeme

Application	Amount	Frequency	Impact
Foliar apply	1L Per Ha	Every 3-4 weeks	Reduced bruising, better fruit firmness, stronger plants.

Notes:

Potato | Root Veg | Soft Fruit | Top Fruit | Brassicas | Leafy Veg | Protected | Cereals | Bulbs

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