Soft Fruit

Levity
CROP SCIENCE

Pioneering Fertiliser

Soft Fruit

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

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 soft fruit growers around the world and identified four key challenges that were poorly addressed by the fertiliser and agchem industry: shelf life, maturity, increasing yield without reducing quality, and stress.

The developed range is the result of several years of intensive development and testing by our team of crop scientists. 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 soft fruit problems and allow farmers to produce top quality and yield. This is the first time that products for soft fruit have been built from a proper understanding of the crop, and fruit growers will be very happy with the results.

The 5 biggest issues facing soft fruit addressed:

1 Shelf life:

Growers need to ensure that the fruit they produce remains firm, and lasts well post- harvest so that fruit does not spoil before it's eaten.

Albina is a pioneering new product that improves fruit firmness and shelf life. Albina uses Levity's pioneering chemistry to stimulate calcium absorption into ripening fruit, where conventional products cannot. It will help soft fruit producers get firmness, fruit set and shelf life to higher standards using very low inputs. Another key benefit is the reduced physiological disorders and reduced risk of soft rots.

2 Maturity:

Getting crops to the best level of brix and colour so that fruit achieves the highest possible quality.

Sulis builds maturity (colour and brix) in soft fruit crops. 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's firm. Key benefits are improved colour formation, brix levels and firmness.

3 Yield:

Fertiliser can often produce leggy growth and create quality issues and disease pressure. Farmers need ways to feed crops and maintain quality.

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

4 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 soft fruit 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, and also prevent loss of colour due to UV. The key benefit is crop protection to help prevent loss of quality and yield during poor growing conditions.

5 Protection:

Stronger plants are more robust and healthy, Levity's nutrients 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 and improving post-harvest shelf-life. Zeme uses Levity's patent SiX chemistry which dramatically improves silicon uptake and distribution allowing lower rates and better results.

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The Results:

What to expect from the Levity approach.

Yield - Our products help growers of strawberries, blueberries, raspberries and blackcurrants achieve more plentiful and bigger fruit, and a more even sized crop. Growers using our products will see less leggy shoot growth and more energy going into the fruit.

Maturity - Our products make fruit sweeter and more colourful, with better levels of antioxidants and flavours. Crops can be brought to harvest more quickly, giving growers the best returns.

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.

Quality - Our products make fruit firmer and longer lasting.

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

A complete range of fertiliser solutions designed to enhance and protect soft fruit.

Levity use a unique combination of crop science and agronomy to find better ways to grow crops. Our scientists are researching how plant physiology can improve agricultural inputs to develop products that help farmers produce better yields.

What sets Levity apart is how we approach product development. We bridge academia and industry, taking the very latest in academic research and finding ways to put it to practical use to solve problems for farmers. Our products start on a farm, where our expert agronomists take time to understand the challenges faced by growers. We then go back to the lab and apply crop science in research programmes.
The products that emerge are tested around the world in rigorous independent trial programmes, before we are finally ready to go back to the farm with a new product.

Soft Fruit

Strawberries – How growth partioning increases yield.

When producing strawberries farmers must balance feeding the plant enough nitrogen without getting excessive vegetative growth. Because of this growers have to take care not to give plants too much nitrogen as more growth can mean lower yield and quality.

To understand why nitrogen tends to favour vegetative growth ahead of fruit development we need to consider two factors.

1. **Stability in the environment**
2. **How form affects growth partitioning.**

In this article we will discuss both of these factors, and explore how we can get the crop growing in the right place.

Strawberries waste more nitrogen than they use.

Strawberries are not good at capturing applied nitrogen with some studies showing typical efficiency of between 8 and 20% of applied nitrogen being taken up by the crop in the UK.

The reason so much is lost is due largely to the instability of nitrogen in the environment. Nitrogen is taken up by plants as one of three forms: Amine (NH_2), Ammonium (NH_4) or Nitrate (NO_3), but it does not stay in the form in which it is applied.

In the environment plants compete for nitrogen fertiliser with microorganisms, these microorganisms change the form of nitrogen rapidly from amine to ammonium to nitrate (with various other steps along the way).

Nitrogen changes from non leaching forms to gaseous forms (ammonia gas) which are volatilised, and leachable forms (nitrates) which leach to groundwater.

The crop does not receive all the nitrogen applied and what it does get it takes up mostly in the form of nitrate regardless of what form is applied. The nitrogen not taken up is lost from system via volatilisation, leaching, and competition organisms (weeds, and microorganisms).

> **The result of this is that strawberry plants do not receive much of the fertiliser applied to them, and what they do get they get mostly as nitrate.**

The form of nitrogen alters where strawberry plants allocate growth.

Although nitrate, ammonium and amine nitrogen forms all contain nitrogen and can be used as sources by plants, they are chemically quite different and are processed by the plant differently.

Nitrates are processed in leaves, where the plant converts them into amine nitrogen (what proteins are made from) using nitrate reductase enzymes taking time and energy. As nitrates accumulate in leaves plants start to make more of the growth hormone auxin, leading to increasing emphasis on vegetative growth.

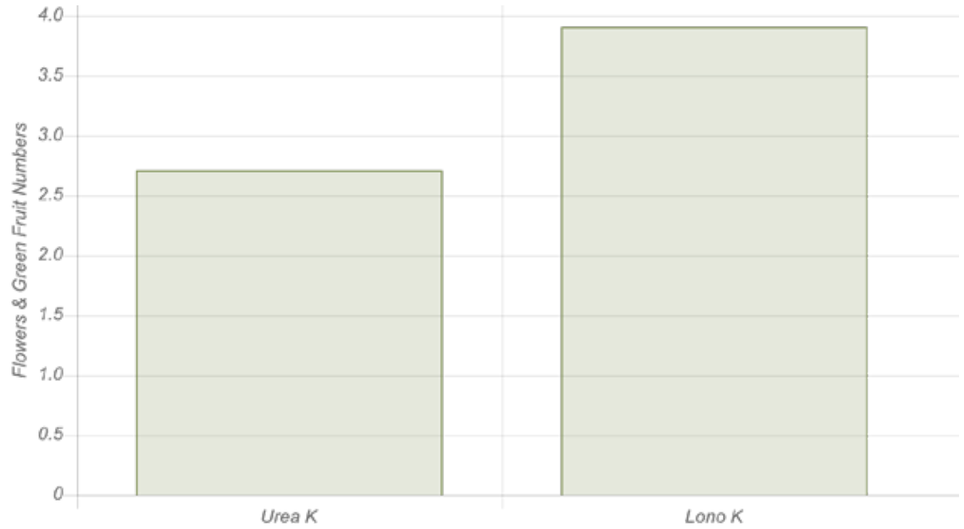
Amine nitrogen is processed in roots and is more quickly and easily converted to proteins requiring less energy to do so. Amine nitrogen accumulation does not lead to increased auxin synthesis, but instead increases production of the cytokinin growth hormone, leading to a greater emphasis on reproductive growth.

Levity have used this understanding of how nitrogen form influences where plants grow to develop more effective ways to feed strawberry crops.

LimiN technology stabilises amine nitrogen, preventing it from changing into other forms after it is applied to the crop. This has two advantages. Firstly far more of it is taken up, rather than lost to the environment. Secondly it encourages the crop to allocate more resource to flower and fruit production rather than vegetative growth.

> **When crops allocate more of the growth from nitrogen to reproductive growth, yields increase. A phenomenon known as 'growth partitioning'.**

Experiments at Levity's Myerscough University College research site show how applying stabilised amine N alters where strawberries grow, compared to the same nutrients without stabilisation.



This graph shows how Lono K (stabilised with Levity's LimiN technology) produced significantly higher flowers and fruit numbers than a conventional formula with identical nutrient analysis.

This increase in fruit and flower production is partly due to more of the nutrients being taken up, and partly due to a process known as 'growth partitioning' whereby the plant has invested more in reproductive growth.

> **Field trials in California confirm the effect on farm, demonstrating significant increases in yield when used alongside standard fertiliser programmes.**

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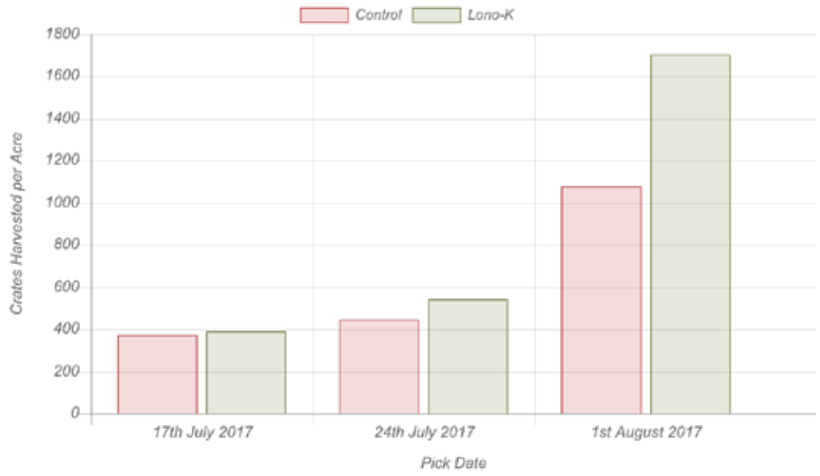
Here we present some results from a trial in California where Lono-K (Marketed as SizeN-K in the USA) was used 3 times at 1 gallon per acre in addition to a standard fertiliser programme.

Pick Date	Crates Harvested per Hectare	
	Control	Lono-K
17 July 17	373	391
24 July 17	448	540
1 August 17	1080	1703



Lono-K gave progressively higher yield increases as the crop invested more in growing in the right place. Indeed the trial ended early as the farmer turned the whole crop over to the treatment.

Trial conducted by Omex USA (Levity's US distribution partner), with Nutrien-Salinas.

The effect of calcium on strawberry quality is erratic - Levity technology can improve performance.

Calcium can improve firmness and quality but is poorly absorbed by maturing soft fruit. Most growers know that calcium is important for soft fruit, as it can improve cell wall strength which has a positive effect on shelf life, firmness and ability to withstand diseases. However when you look at the scientific evidence it becomes clear that the calcium applied to crops like strawberries does not always end up in the fruit. Calcium is poorly observed by maturing strawberry fruit therefore a lot of the calcium farmers apply to their crops is wasted as ripening fruit are not able to absorb it.

So why is it the case that calcium absorption is so erratic? Calcium absorption in strawberry fruit is strongly linked to the transport of auxin, a plant hormone. In strawberries auxins in the achene (the seed) are transported into the developing fruit, allowing the fruit to absorb calcium. However ripening is triggered by cessation of auxin transport into the fruit, so as the fruit starts to turn red the ability to absorb calcium rapidly declines.

Red strawberries have very little auxin, and can not absorb any calcium that is applied to them. So when crops are sprayed with foliar calcium, the leaves and green fruit will absorb it, but maturing fruits will not. Usually it is exactly the fruit that can not absorb the calcium that farmers are targeting, in order to improve firmness and post harvest shelf life. This is why results from conventional calcium fertilisers are so erratic, sometimes the fruit can't absorb calcium into fruit and the input is wasted.

When you understand what causes problems with firmness (inability to absorb calcium) then you can develop smarter ways of supplying it.

Levity have been developing chemistry that helps calcium absorption for many years, the more we study the better we get at improving it. Our research focusses on understanding the link between polar auxin transport, and calcium absorption. By stimulating the pumps that are normally triggered by polar auxin transport, calcium can be absorbed by fruit in the absence of auxins. We use this science to make better calcium fertilisers at Levity and partner companies (Omex).

Recommendations

Albina

Albina, Levity's new product for improving fruit firmness uses Levity's pioneering chemistry, to stimulate calcium absorption into ripening fruit, where conventional products cannot. It can help soft fruit producers get firmness, fruit set, shelf-life to higher standards using very low inputs.

To develop fertilisers that work better we must first understand what farmers need, then look at the crop and understand what is causing the problem, finally we can then apply science to produce technology that provides solutions for farmers. When growers use Albina they will see good improvements over conventional products.

Soft Fruit

Understanding Plant Physiology – The Key to improving Calcium levels in Blueberry.

It is well known that good calcium levels in blueberry fruit can improve quality and shelf life, but results from calcium fertiliser can be erratic. Here David Marks of Levity Crop Science discusses why it is the crops physiology that limits calcium in fruit rather than lack of availability and discusses how growers can adapt agronomy to this.

Three rules of Calcium

To understand why calcium applications to blueberry are inefficient we need to understand three basic rules on plant calcium metabolism, and then apply them to blueberry. This can then inform how to improve agronomy.

1. **Capacity – Plant cells have a limited capacity to hold calcium.**
2. **Transport – Calcium cannot move against transpiration flow.**
3. **Absorption – Calcium can only be absorbed where auxin is present.**

Capacity

Unlike other nutrients like potassium, plants cannot store excess calcium. Indeed having too much calcium in cells is detrimental. When the holding sites for Ca in cell walls are full plants precipitate out any extra Ca being absorbed as calcium oxalate. Often times plants that are deficient in fruit are still precipitating out calcium from leaves.

Transport

Calcium is not phloem mobile, meaning that for plants to transport calcium it must move through the plant with water. Water movement in plants is governed by transpiration and moves in one direction from roots towards shoots, with the areas of most water loss receiving the biggest flow of water and therefore the biggest supply of calcium.

Absorption

Not all parts of plants can absorb calcium to the same level, this is why we see local deficiencies in fruit crops. Calcium absorption in plant cells is linked to 'polar auxin transport' therefore parts of plants high in auxin absorb calcium easily (if available) and parts of plants low in auxin absorb calcium sparingly (no matter mow much is supplied).

Lets look at the physiology of blueberries and see how the three rules of calcium interact with it.

In common with most crops, blueberries struggle to get good calcium levels in the fruit. This is due to the fruit being a low auxin tissue and therefore a poor sink for calcium. When the fruit is young and small (<2mm) it is in the cell division stage where the new cells that will become the fruit are being created and at this point auxin levels are good, however as the fruit starts to increase in size cell division is no longer occurring the cells are instead expanding and auxin levels are lower. This means as fruit increase in size the ability to absorb calcium decreases.

Blueberries lack the capacity of other plants to process nitrate so leaf build-up is rapid following soil nitrogen application (whatever the form applied). This leads to excessive auxin hormone production in leaves. It is this build up of auxins that lead to growth flushes.

> **During growth flushes strong calcium sinks form in the shoots and leaves, which is are also the main destination for water transport. This means that it is the shoots that have both the highest throughput of calcium (moving with water towards shoots) and the highest absorption of calcium (due to high polar auxin transport). The capacity however is limited, and during growth flushes calcium will be precipitated out of leaves even if fruit is deficient.**

During growth flushes blueberry fruit receive limited calcium throughput and have limited calcium absorption ability that makes getting calcium into fruit tricky.

Calcium problems in blueberry are driven by physiology.

Once we understand the physiology of calcium in blueberry it becomes clear that low calcium in fruit has little to do with fertiliser, and a lot to do with the crop itself.

> **If we apply calcium to the soil it will largely bypass the fruit, instead moving mostly towards foliage, where there is higher transpiration and (particularly during growth flushes) higher capacity to absorb. Rather than move excess calcium supply to the fruit leaves just precipitate it out. Fruit calcium is not a whole plant deficiency.**

If we apply foliar calcium this may get calcium to the fruit, but apart from a short period when young the capacity to absorb it is low and most of the calcium applied will not get in.

A lot of focus has been placed on calcium form in blueberry (nitrate vs chloride etc) but this is largely a red herring as the form has no influence on absorption. The level of calcium that makes the difference between good quality fruit and fruit with poor shelf life is very small (2-3 ppm or 2-3g per MT of fruit), but the quantity of calcium applied to improve the fruit is very high relative to the need. Fruit farmers apply far more calcium than is required to fix the problem, but most is wasted as the plant can not use it where it is needed.

So how can we improve calcium in the fruit?

There are a few things growers can do that will help. Firstly we can place emphasis on creating a good and constantly growing root system. This will ensure that transport of calcium is maximised and help to reduce the impact of growth flushes (roots are the site of synthesis of cytokinins, and improving plant production of them helps to balance auxin influenced growth).

Secondly we can time and place calcium applications to best effect. Fruit absorb calcium best if it is applied directly between flowering and 2-3mm fruit size, so foliar applications made during this period will be more effective than applications made later in the season.

Thirdly we can use technology that improves calcium absorption. LoCal is a technology developed by Levity that allows calcium absorption in the absence of auxin, allowing fruit to absorb calcium during growth stages and growing conditions where applications of conventional calcium fertiliser would be ineffective.

> **Albina contains LoCal technology and can be used to get calcium into fruit where the natural ability to absorb is low. Giving farmers a low dose tool to improve fruit quality and firmness.**

Recommendations

Lono

To give good root growth and better growth habit apply Lono at 5L per Ha, commencing at bud break and making three more applications at three week intervals. This will keep roots actively growing, encourage a good growth habit, and ensure the plant focuses on fruit production.

Albina

To improve fruit calcium levels consider using a calcium that the fruit can absorb properly, like Albina. Albina applied at 1L per Ha at flowering, with a couple of follow up applications will be more effective than more frequent applications of standard formulations.

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Getting Nitrogen right – the key to good blueberry production.

All crops have their own peculiarities, but none more so than blueberry, a crop that has both metabolic and physiological differences that influence nitrogen use and its effect on growth habit. Here David Marks of Levity Crop Science discusses how this impacts the way blueberry pants process and respond to nitrogen, and what lessons we can learn from this for better production.

Blueberry roots are different.

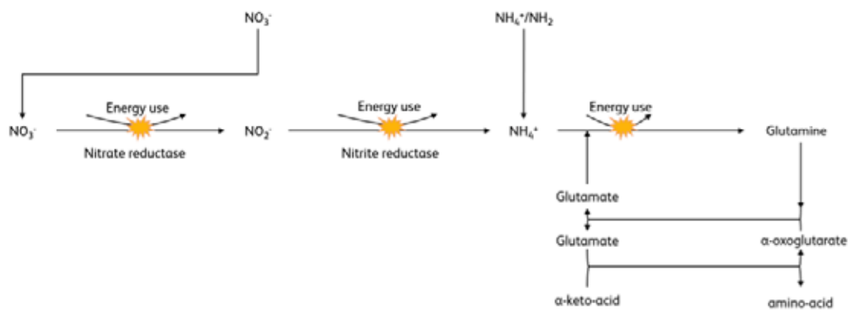
Blueberry and other ericaceous crops (including cranberry) do not produce root hairs. This is unusual and impacts upon their physiology and the best practice for agronomy.

The root systems of blueberry are shallow, the larger diameter roots serve mainly to anchor the plant and transport water, whilst the finer 'feeder roots' do most of the work regards taking up and transporting nutrients. These feeder roots are short lived, typically having a lifespan of less than 130 days.

So how does this impact on the crop? Well the roots die off quickly, so for good crops it is of paramount importance that the crop is managed for maximum root growth, and that root growth is continuous throughout the growing season. Secondly and maybe less well understood is the effect on plant growth hormone production. The main site of biosynthesis of the cytokinin hormone in plants is root hair. Blueberry (and cranberry) do not have root hairs, this makes them less capable of cytokinin synthesis than most plants. Cytokinin synthesis has a big effect on plant growth habit (more on this later).

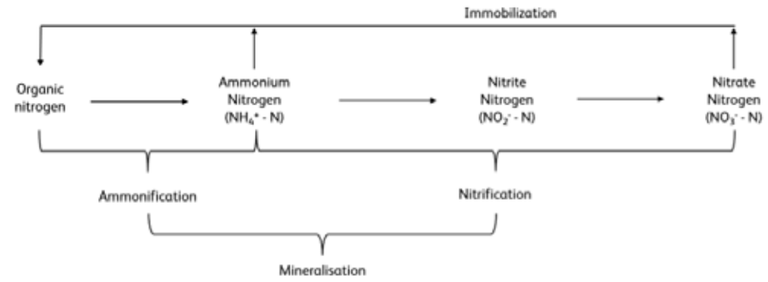
Blueberry nitrogen metabolism is different.

Blueberry plants are less capable of processing nitrates than other plant species due to an inability to efficiently utilise the nitrate reductase enzyme system that plants use to convert nitrate N into protein in order to grow. This is a function of having evolved to be adapted to a low nitrate environment. This makes use of conventional fertilisers highly inefficient.



Here we see the mechanism plants use to metabolise nitrogen, nitrate N is converted to protein using a nitrate reductase enzyme system. Blueberry and other ericaceous plants have a low capability to operate this enzyme system and therefore if they take up nitrates they can accumulate faster than they can be processed.

This is the reason that blueberry growers are often advised to avoid the use of nitrate fertiliser, and instead to use ammonium or ureic N sources. However this does not solve the problem as nitrogen is not environmentally stable. Nitrogen uptake by crops bears little resemblance to nitrogen inputs as it changes between application and uptake.



In most cases crops a. Only take up between 30 and 50% of the nitrogen that is applied (with the rest ending up in the environment), and b. Take up the majority of nitrogen applied in the nitrate form (regardless of what form it was applied as).

In the field then if blueberry farmers apply N in non-nitrate forms, the reality is that the plants are still receiving more of that N as nitrate than any other form, limiting the efficacy of nitrogen fertiliser on blueberry farms.

What are the consequences of excess nitrate on blueberry?

The effect of excess N on blueberry is well known, but is perhaps not well understood. Once we understand that the non-nitrate N applied to blueberry is mostly taken up as nitrate we can better understand why excess N is problematic.

Nitrates are taken up by roots, but have to be processed into protein in leaves. After uptake plants use transporter proteins to move them to the leaf, and nitrate reductase enzymes to convert to protein. In all plants growth hormone synthesis is strongly linked to nitrogen metabolism. The synthesis of the growth hormone auxin is increased when nitrate concentrations in leaves increases.

> **Blueberries lack the capacity of other plants to process nitrate, so leaf build-up is rapid following soil nitrogen application (whatever the form applied). This leads to excessive nitrate hormone production. This excess auxin encourages flushes of growth which can be detrimental to the crop.**

Blueberry physiology can create a high Auxin:Cytokinin ratio

Earlier we explored the unique root structure of blueberries, which do not produce root hairs. Roots are the main site of synthesis for the cytokinin hormone, and due to this lack of root hair blueberries have a reduced capacity to produce cytokinins compared with most plant species.

The speed at which plants grow is a function of total growth hormone production, but where plants allocate that growth (growth partitioning) is a function of the relative abundance of two hormones (auxin and cytokinin). If auxin production is high compared to cytokinin plants allocate more growth to shoot development or 'vegetative growth'. Conversely if plants have a better cytokinin to auxin ratio they allocate growth differently, with more emphasis on reproductive growth (fruit development).

> **Blueberries have a problem. Due to lack of root hairs they synthesis relatively little cytokinins, and due to inability to process nitrate they are susceptible to excess auxin production when exposed to nitrates. This physiological 'double whammy' makes presents unique challenges to growers of blueberry. As getting nitrogen wrong makes them vulnerable to excess vegetative growth and a drop in yield.**

All plants react to nitrogen form in the same way, if nitrates predominate they get increasingly leggy and more resource goes into vegetation than grain/ fruit/ tuber development. Blueberries however are particularly susceptible to this effect, and this is why N recommendations are low, best practice is 'little an often' (reduces the fraction taken up as nitrate), and timing is important. However if no N is used yield go down, so getting the balance better is a clear path to better yield.

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So how can we use this understanding to improve production?

Blueberries respond badly to nitrate, but applying urea or ammonium sulphate is just a different way of applying nitrate (the crop wastes most of it, and takes up the rest as mostly nitrate). So switching out nitrate for conventional non-nitrate fertiliser is not the answer.

However there are ways we can improve, by using more advanced stabilised amine nitrogen we can give blueberry the right balance of N for best growth and yield. Levity Crop Science are the world leaders in Stabilised Amine Nitrogen fertiliser development, their LimiN technology is used to provide amine nitrogen that stays in that form.

Lono products supply stabilised amine N and have been scientifically proven to change growth partitioning (where plants allocate growth) in many crops. Lono applied in small doses either foliar or via drip changes the growth habit of crops, giving shorter plants with more branching, root development and investment in flower and fruit production rather than the classic nitrate driven N response.

This approach is perfect for blueberries, as it allows growers to produce better root growth (vital in blueberry), more lateral branching (lateral shoots give more fruit than upward shoots), and encourage fruit development rather than extra 'leaf flush'. Furthermore small amounts can be used, as all nitrogen is taken up and used unlike conventional nitrogen applications.

Use of stabilised amine as a nutrient source for blueberry crops gives a far more favourable growth habit, encouraging shorter plants with active root production and a higher yield potential.

Summary

Blueberry growers have a tough job, as the crop has a unique physiology. Blueberry plants do not produce root hairs, and can't process nitrates effectively making them poor producers of cytokinin, and over producers of auxin if exposed to excess nitrogen in conventional formulations.

This physiology makes blueberries prone to 'flushes of growth', and limits potential for improving fruit yield via fertilisation. Growers have been avoiding application of nitrate on blueberry for good reason, but switching to urea or ammonium sources have provided nitrate anyway due to poor environmental stability.

Lono offers a way to get the most out of this tricky crop, supplying nitrogen in a form that puts the growth in the right place, producing plants with a good growth habit (better lateral branching, with thicker shorter stems that support better fruit capacity) and focusing the crops resource on fruit development.

Recommendations

Lono

Apply Lono at 5L per Ha foliar or drip, commencing at bud break and making further applications at three week intervals. This will keep roots actively growing, encourage a good growth habit, and ensure the plant focuses on fruit production.

Application Rates:

Albina

Application	Amount	Frequency	Impact
Foliar apply	1L Per Ha	Every 1-2 weeks throughout flowering	Improve shelf life and reduce physiological disorders

Sulis

Application	Amount	Frequency	Impact
Foliar apply	1-2L Per Ha	Every 2 weeks throughout harvest period	Accelerates colour and Brix

Lono

Application	Amount	Frequency	Impact
Drip Irrigation	5-10L Per Ha	Monthly throughout growing season	Higher Yield

Indra

Application	Amount	Frequency	Impact
Foliar apply	1L Per Ha	Every 4 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	More resilient, healthy and stronger plants

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

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