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AMERICAN FRUIT GROWER

The Apple Grower's Guide to YOUR BEST CROP YET

AGRO-K®

Science-Driven Nutrition℠

SCIENCE-DRIVEN NUTRITION™ MORE EFFECTIVELY

Maximizes Quality and Yield

PRODUCING A TOP-QUALITY APPLE CROP year after year requires the right mix of experience combined with precision using science based data. Each growing season presents an abundance of new demands and variables challenging apple growers to continually rise to the occasion.

A critical component of cultivating a high-yield, economically viable crop is nutrition. Without this piece of the puzzle, growers are left to play defense against pests, diseases, and mildew problems. Those who focus on apple nutrition have the advantage in a highly competitive marketplace.

Proper nutrition is very technical and it requires a science-driven approach. Each unique farming operation demands different solutions based on a variety of factors, from soil texture to soil fertility and pH. This guide is designed to help growers understand the intricacies of crop nutrition to save them time and money, minimize product waste, and ultimately maximize the quality and yield of their apple harvest.

"When we talk about science-driven nutrition, we're talking about using tools such as soil testing, tissue testing, fruit sampling, and sap analysis to help us understand and guide the nutritional program."

— RICK DE JONG, International Business Development Manager for Agro-K

CASE STUDY:

Overcoming the Prohexadione Calcium Dilemma

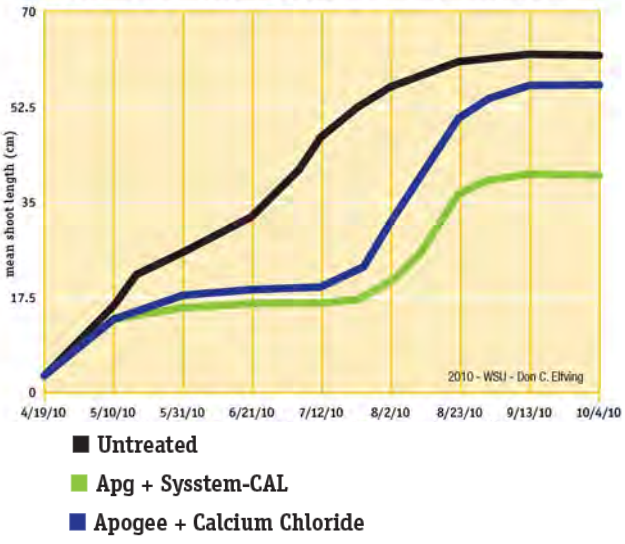
Perhaps the busiest and most stressful time for a horticulturist and apple grower is the bloom and early post bloom period. Fruit thinning applications and plant growth regulator (PGR) sprays like MaxCel®, Promalin®, Apogee® are being applied. These applications improve fruit size, fruit quality, return bloom, all while reducing hand thinning and pruning expenses.

Many products are being applied during peak fruit cell division, which is the most critical time for foliar calcium applications. Calcium can only enter the fruit cell wall during cell division. That's why it's particularly important to be able to apply foliar calcium in a formulation that not only penetrates the cell wall quickly and efficiently, but also won't antagonize or destroy the prohexadione calcium in the PGR sprays.

Unlike many foliar calcium products, Agro-K's Calcium phosphite, the primary active ingredient in Sysstem®-CAL and Blue Cal Rx, will not negatively impact these sprays. This has been proven repeatedly in numerous trials for the past several years. One such trial from Washington State University is demonstrated below.

The work of Dr. Don C. Elfving, Horticulturist and Professor of Tree Fruit Research at Washington State University focused on a vigorous orchard of mature BC2 Fuji/M.7 apple trees planted in 1990. The research included comparisons of tank mixes of Apogee with Sysstem-Cal and Apogee with calcium chloride.

Sysstem-CAL Effect on Apogee and Shoot Growth in Fuji



"Apogee reduced shoot extension for about two months, after which a second growth flush began. When tank-mixed, the proprietary calcium (Sysstem-CAL) did not negate the growth control activity of Apogee, but it appeared as if the tank-mixed calcium chloride did reduce Apogee efficacy," Dr. Elfving reported.

MaxCel and Promalin are registered trademarks of Valent; Apogee is a registered trademark of BASF Ag Products.

Agro-K is a company where Science-Driven Nutrition™ is much more than a tagline. "If we're letting science drive us and we stop guessing, we're going to be more efficient with our fertilizers and what the crop actually needs."

Getting Started with Science-Driven Nutrition

The process of growing top-grade fruit begins with in-depth knowledge about the operation, growing conditions, and the individual orchard blocks. Geographic location, variety, climate and soil conditions all have an impact on the crop plan and management program. Not every nutritional input is right for every grower. Knowing what key nutrients are actually needed during the different growth stages is essential to minimizing waste and reducing costs.

While apple growers have an impressive base of knowledge about their crop and its unique needs, it's important to test, not guess, before diving into a crop nutrition plan. When issues arise, the exact cause isn't always clear. The solution is in the science. Before the season starts and pre-harvest, it's important to conduct several tests.

"For apples and other tree fruit, the pre-harvest fruit analysis will be the most revealing, as it indicates the nutritional levels within the actual fruit," says Kenneth Dart, Agro-K National Technical Manager. "Soil, tissue, and sap testing also help to guide the nutritional program. Combined, these tests give the report card of what's working and the roadmap of where to improve."

By taking an analytical approach to plant nutrition, growers are empowered to measure key metrics and consequently manage their crop more effectively and profitably.

The **Right** nutrient at the **Right** time in the **Right** form in the

PRODUCT FOCUS 1:

Blue Cal Rx™—Fertilizer and Fungicide in One Product

Apple growers are busy. When a particular product can do double the work while saving half the cost, it tends to be an easy choice. Blue Cal Rx, a calcium enhanced fungicide with fertility benefits.

This unique, low-pH calcium phosphite complex improves tree health while providing another mode of action for crop protection and integrated pest management programs. Here are some of the things Blue Cal Rx can do for your apple crop:

- This phosphite formulation is a great source of systemic calcium without the antagonism of potassium or inhibiting prohexadione calcium products.
- While the product is a good tank mix partner, it also works as a fungicide to improve tree health and help mitigate bitter pit, fireblight, mildews, and other common disease problems.
- Blue Cal Rx phosphite formulation helps improve nutrient uptake and increase efficacy of ground applied products via the natural root exudate process.
- The nutrient content in Blue Cal Rx can improve the total calcium level within apples and leaves creating thicker and stronger cells for a more robust and disease resistant crop.

THE FIVE Rs OF PLANT NUTRITION

Every season growers have the opportunity to provide their trees and fruit with essential nutrition. Proper integration of a science-based fertility program can be achieved by following Agro-K's 5 R's of plant nutrition.

Nutrient applications are more precise when following the 5 R's. By using the Right nutrient at the Right time in the Right form in the Right mix targeting the Right location in the plant, growers achieve the very best results. The most efficient and effective product applications take all five points in to consideration. Those applications that don't are less effective at best and will negatively impact crops at worst.

"The more we understand the Five Rs of plant nutrition, the more efficiently we can apply those Five Rs and the better the outcomes at the farm," de Jong says. "The better the crop is going to be from a quality perspective and a yield perspective. And the better return on investment because we aren't guessing about what we think we need."

How can growers know that they're investing in the right tools for their crop? The first two R's are covered by testing and managing the crop timings.

"One of the most common mishaps occurs when growers apply nutrients outside of the plant's peak demand," Dart says. "The more accurate the timing, the more impactful the nutrient."

Foliar and soil-based products are responsible for delivering on the last three: right form, mix, and location. Outside of right time, the other R that tree fruit producers commonly struggle with is "right form." Making the wrong choice is often like taking one step forward and two steps back. That is because the wrong formulations are either useless to the plant or aggravate other nutrition-related challenges.

With foliar calcium on apples, for example, the right formulation will safely lower the fruit's potassium-to-calcium and nitrogen-to-calcium ratios. Correct nutrient ratios yields fruit that avoids disorders like bitter pit and internal breakdown. Not all calcium products are created equal.

When it comes to the right mix, it's important to take advantage of synergies while avoiding antagonisms. For example, during fruit cell division potassium applications inhibit the movement of calcium in to the fruit and thus should be avoided if at all possible. By applying boron and calcium together the uptake of both nutrients can be enhanced. In addition, selecting tank mix friendly products such as those manufactured by Agro-K can help minimize the number of passes through the orchard. Making sure each pass of the sprayer through the orchard is optimized just makes sense.

Targeting the right location in the plant is essential, too. If foliar products simply coat the outside of the plant or focus on the leaves, at best only a small part of the apple tree will receive the nutritional benefits. A foliar nutrient application can achieve maximum value if it moves into the plant completely and quickly gets to the right place where it is needed. Products that move quickly and thoroughly into the root structures as well as the apple leaves and fruit ensure nutrients are distributed throughout the tree.

A crop is truly optimized when the science-driven nutrition plan follows all five Rs. Growers who understand this are positioned to make the best choices with the best results; minimizing waste and increasing economic returns.

Right mix targeting the **Right** location in the plant

AGRO-K
Science-Driven Nutrition™

Understanding the Essential Crop Timing

Apple growers have limited windows of opportunity to positively impact their crop. During the season, there are four essential crop timings where the right science-driven nutrition program can make a difference in apple color, size, weight, sugar content, pack out, and uniform maturity at harvest. Learn more about each one in the sections below:

1 Tight Cluster to Pink

During this period, Science-Driven Nutrition is crucial for maximizing the yield of high-quality fruit at harvest. The ideal time to begin a foliar nutrition program is at tight cluster. Up until tight cluster spur leaf development has largely been driven by the plant's nutritional reserves from the previous year. A proactive approach to nutrition will make all the difference to a grower's pack out.

"During tight cluster, it's important to support leaf development and function," de Jong says. "This means having the right mix of magnesium, iron and zinc. Magnesium builds chlorophyll, the driving factor behind photosynthesis, while iron supports the chlorophyll development process. Zinc helps to develop the vascular tissue, leading to larger leaves. Bigger leaves mean increased sugar production and ultimately, vibrant fruit color at harvest."

At pink, growers turn their attention toward optimizing the bloom window. There is a short period to get calcium into the apples in time for fruit cell division. It's important to note that if calcium is not adequately applied from bloom until four-to-six week's post-petal fall, the opportunity is lost and fruit quality can suffer.

Any calcium applications beyond this point act as nutrient maintenance and are essential to maintaining fruit calcium levels for fruit quality and shelf-life. Boron, which ensures pollen viability, pollen production, and flower health, is also at peak demand at pink timing. When applied together, calcium and boron synergize to increase the uptake of both nutrients.

2 Bloom to Post Petal Fall

While the ideal time to begin a foliar nutrition program is at tight cluster, the bloom-to-post-petal-fall window is equally important. At fruit set the crop begins to enter fruit cell division, which demands the right mix of nutrients to support and energize this process.

"Because this is the part of the season when growers have a significant number of products in the tank, there's potential for a considerable number of issues," de Jong says. "The right nutrition program ensures growers only apply the nutrients necessary to produce consistently high-quality apples. Using sap analysis, growers quickly learn what their crop needs to perform its best, ultimately saving time and money."

Certain nutrients are critical at this time. Boron is essential for pollen

viability, pollen production and flower health. As mentioned previously, fruit cell division is the key time to move calcium in to the fruit to optimize fruit firmness and maximize pack out at the end of the season. Effectively applying foliar calcium requires growers to appreciate the limited timeframe for getting the nutrient into the fruit. After cell division ends, calcium applications help to maintain the crop's nutrient levels from depleting but do not increase fruit calcium concentrations.

The post petal-fall window is a time of growth, where new wood and new leaf structures are forming. Phosphorus will help energize the crop and maximize new growth, while zinc supports leaf and vascular tissue development. Magnesium and iron positively impact chlorophyll production. Manganese, which is responsible for driving photosynthesis, a process that creates the sugars the crop needs later in the season, is applied during this time, as well.

3 Apple Bulking

Apple bulking, when fruit cells expand and the apple increases in size and weight, is an important opportunity to impact fruit development. Growers who base their nutrition decisions on science can better influence optimal growth and an enhanced marketable yield.

A proper nutrition plan ensures cohesiveness throughout the growing season. Bulking is the period of time when growers must focus on leaf function and facilitating the movement of sugar into the fruit. Calcium maintenance applications are required to support fruit firmness.

In addition to supplemental calcium, the apple tree requires magnesium, manganese, sulfur and iron to maximize chlorophyll production.

"Potassium, which helps to move sugars throughout the plant and regulates plant moisture through the opening and closing of the stomata, is one of the most important nutrients during this time," de Jong says. "The apple crop's potassium needs increase exponentially during the summer months. Fruit color, weight and uniform maturity at harvest all hinge on maintaining proper potassium levels during cell bulking. Excessive nitrogen, an inhibitor to fruit color, must also be limited during this crop window."

4 Apple Coloring to Post-Harvest

The time from apple coloring to post-harvest is a grower's final opportunity to impact the crop's nutritional needs each season. Fruit color is the direct result of optimizing leaf development and function starting as early as tight cluster.

Zinc is a primary nutrient for growing the bigger leaves that drive apple sugar production. In turn, those sugars—assisted by potassium and phosphorous—boost the production of anthocyanins, the pigment that gives apples their deep red. A deficiency in either nutrient can negatively impact fruit color.

Growers that applied seaweed products earlier in the season will want to reduce their usage. Unless they are actively attempting to delay maturity, seaweeds inhibit ethylene production and slow the ripening and color process.

"After the harvest, zinc and boron support bud overwintering and new bud health," de Jong says. "Magnesium helps to set the stage for early leaf function in the spring, jumpstarting the growth cycle again next season."

OVERCOMING COMMON CROP PROBLEMS WITH NUTRITION

Proper nutrition is more than a means of maximizing apple appearance, quality, and yield — it helps the tree better tolerate fire blight and powdery mildew, while battling against bitter pit, by ensuring nitrogen is metabolized. A grower's best defense against these problems is boosting the crop's overall viability.

Strong, healthy trees are less susceptible to pests, diseases, and damaging nutritional deficiencies. Overcoming potential problems requires a holistic approach. Read on for best practices when tackling common problems that require full season control.

FIRE BLIGHT

Successfully managing and preventing fire blight requires growers to think beyond nitrogen. Growers that pour on the nitrogen forget that proper nutrition is a balancing act. Cobalt and copper are two micro nutrients that can have a positive impact by ensuring nitrogen is metabolized. Additionally, an apple crop will benefit from potassium, phosphorous, and other supporting micro nutrients, such as molybdenum. The right mix of micro nutrients ensure the plant can use the available macro nutrients to improve tolerance against this highly contagious disease through balanced nutrition.

BITTER PIT

While a lot of the focus on bitter pit has centered on calcium, there's more to the equation than this one secondary nutrient. Calcium supports healthy cells, but the cells need to be well developed before they can be improved. This means growers also need phosphorous to support cell division at the right time. Then, zinc can be used to support vascular tissue. The right products come into play here as well: It's one thing to get calcium on to the tree and apple. It's another to get it into the tree and apple where it can get properly distributed throughout the apple's vascular tissues.

POWDERY MILDEW

When it comes to tackling powdery mildew, having a product with a combination of fertility and fungicidal properties is the one-two punch growers need. Blue Cal Rx, while not a stand-alone product, can be used in combination with other crop protection materials to help prevent the Podosphaera leucotricha fungus from taking hold while also supporting the ongoing demand of calcium for thicker cell wall structure. This calcium-enhanced fungicide provides the unique mix of nutrition and a fungicidal mode of action for top-notch crop protection against powdery mildew.


AGRO-K'S PRODUCT LINES
support the 5 R's of Science-Driven Nutrition™

For 45 years, Agro-K has been an innovator in the agricultural industry worldwide. For decades Agro-K has continually invested in the agricultural industry through academic research and fields trials. Using a science driven approach, Agro-K has been focused on improving the return on investment for our growers. Our approach has led to the engineering and development of truly unique product lines that support our 5 R's of Science-Driven Nutrition™.

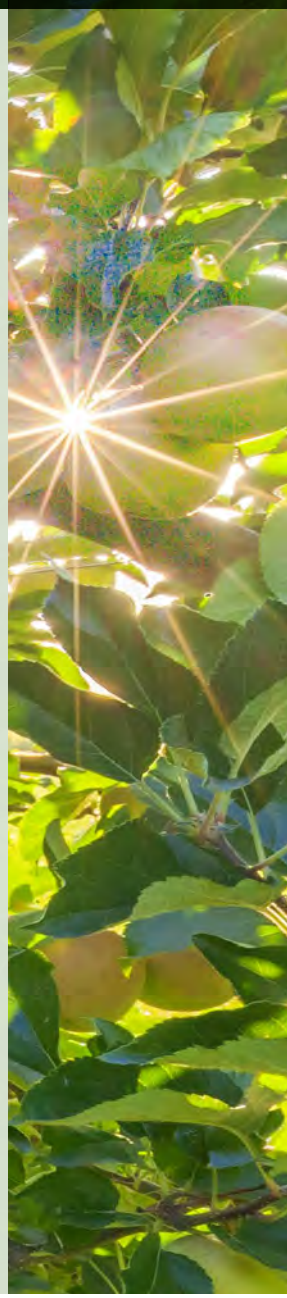
BioMax:
Agro-K's soil biological input is designed as a soil amendment to feed the existing soil biology so those microbes work harder to create a better root zone environment for improved root growth, plant health and increased soil nutrient availability/efficiency. BioMax targets the aerobic bacteria (vs. anaerobic) and beneficial fungi, such as mycorrhizae. It contains specific food sources, micronutrients and enzymes that support and help increase beneficial bacteria and fungal activity.

Sysstem Series:
Agro-K's line of low pH, phosphite complexes are designed to rapidly deliver essential nutrients in systemic forms during key windows of opportunity to enhance crop production and crop quality. Sysstem Series products leverage the unique properties of phosphites to rapidly penetrate plant tissue and move nutrients throughout the plants vascular system.

Dextro-Lac and Vigor:
Dextro-Lac products are made using two biologically important carbohydrate molecules – dextrose and lactose – as complexing agents to deliver nutrients that absorb readily and metabolize easily, requiring minimal plant energy. The exclusive Vigor process adds additional value and performance using a proprietary biological finishing technique to ensure safe foliar applications and improve performance.

AgroBest:
Agro-K's line of N-P-K liquid plant food fertilizers are specifically designed for foliar applications, where product purity is critical.

CLEAN:
This organic line of foliar crop inputs includes macronutrient and micronutrient formulations that meet strict National Organic Program (NOP) standards. With Agro-K's CLEAN organic product lineup organic growers now have a full selection of foliar fertilizers to meet the various nutrient needs through the growing season. No more compromises!



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