AGRITEC
INTERNATIONAL

# Liquid Calcium

CATALOG 2024 - 2025

www.agritecint.com

BIO-ACTIVATED LIQUID CALCIUM

# INTRODUCTION

## Welcome to AgriTec International - Your Partner in Hay Production

At AgriTec International, we're more than just a company; we're innovators, growers, and steadfast partners committed to revolutionizing the way the world thinks about hay. From the sun-drenched fields to the cutting-edge research labs, our journey is fuelded by a passion for excellence and a relentless pursuit of quality. Our mission extends beyond more production; we're here to transform the economic landscape for farmers, helping them to significantly increase their profits by maximizing revenue while minimizing input costs.

## Our Mission

Our mission is straightforward yet ambitious: to revolutionize agricultural practices through innovation, quality, and sustainability. We aim to empower farmers across the globe by providing them with cutting-edge solutions that enhance soil health, booth crop productivity, and ultimately contribute to a more sustainable and profitable farming future. We deliver products that are both effective and environmentally friendly.

## Innovation Rooted in Tradition

Founded in 1976 as a family owned & operated business, AgriTec International has stood at the forefront of agricultural excellence, blending time-honored farming practices with groundbreaking technological advances. Our journey began with a simple yet ambitious goal: to producce the highest quality of hay that not only nourishes livestock but also supports the sustainability of our planet. Through rigorous trials, exhaustive research, and a deep understanding of the land, we've developed products and methodologies that set new standards in hay production, ensuring our partners can achieve greater economic success with less expenditure.

## Driven by Our Customers' Success

At the heart of AgriTec International lies a commitment to our customers' success. From our trials and research to our carefully curated product range, every aspect of our operation is designed to empower farmers, ranchers, and agricultural professionals to not only thrive but also revolutionize their profit margins. Our customer testimonials stand as a testament to the transformative impact of our products, showcasing real-life success stories and before-and-after scenarios that inspire confidence and demonstrate the financial gains achievable with our innovations.

## Embark on a Journey of Agricultural Excellence

As you flip through the pages of this catalog, you'll discover the fruits of our labor; innovative solutions that promise to elevate the quality of your hay, testimonials from satisfied customers, and striking before-and-after imagery that speaks louder than words. Join us on a journey where tradition meets innovation, quality is paramount, customer satisfaction is guaranteed, and the enhancement of your profitability is our ultimate goal.

Welcome to AgriTec International, where excellence in hay production begins, and your financial success is our priority.

# Calcium in the Soil

Calcium plays a vital role in the soil beyond affecting soil pH. Calcium is one of the main trucker nutrients in the soil. What calcium does is bind to nutrients such as nitrogen and transports and delivers them into the plant. This is known as cation exchange in the soil. Without the proper calcium base saturation of 65 75% nutrients become bound up in the soil, which means lost potential for your production.

What this problem also results in, is lost fertilizer. The University of Iowa research showed that the lower the soil pH is the more fertilizer goes to waste, because it is being bound up in the soil or dissipating. In soils that have a pH of 5.0 half of fertilizer applied goes to waste. That is wasted money and lost revenue. Whereas, in balanced soil with proper pH and calcium levels, fertilizer applied is nearly 100% available and effective. That means getting more out of the money you are putting in, better production and better crops.

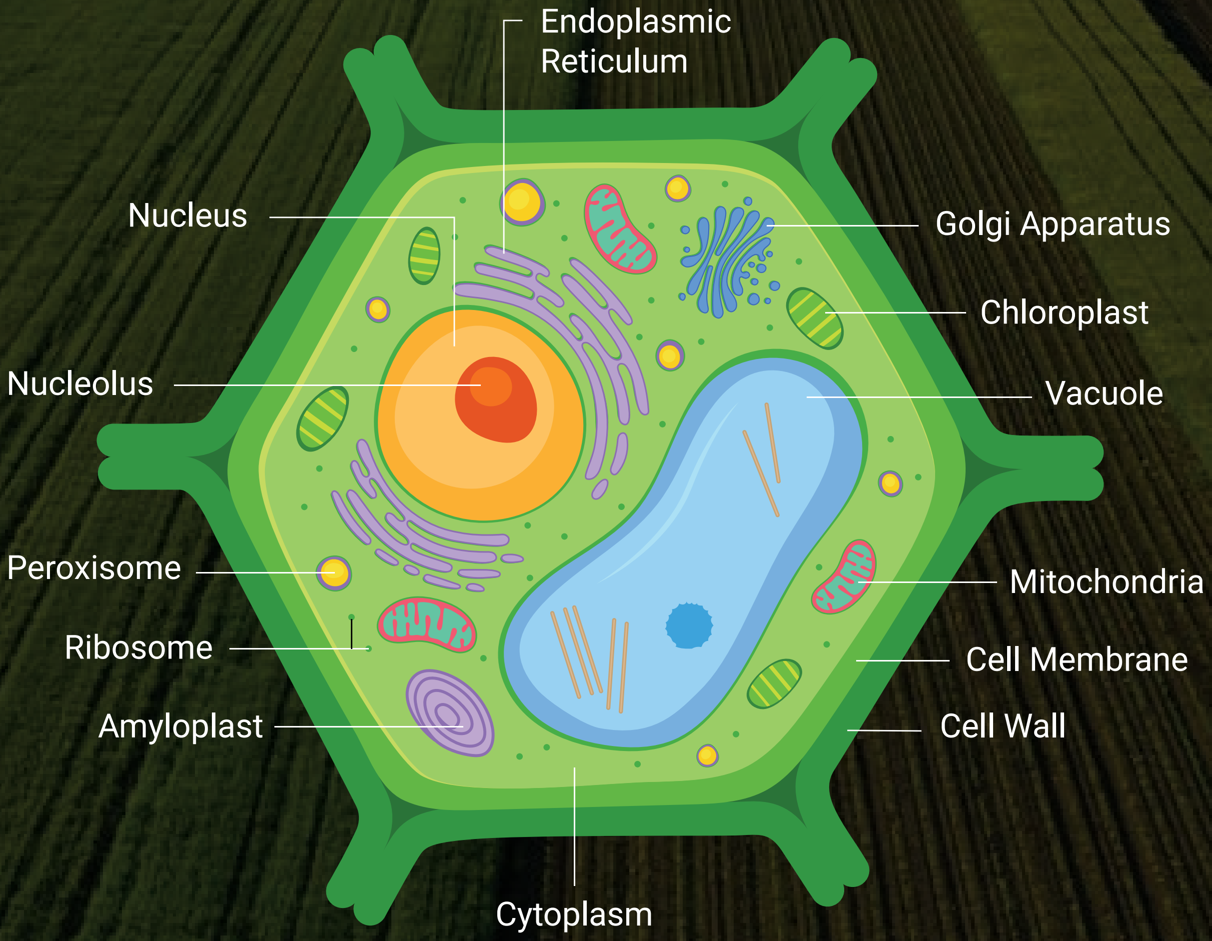
| Soil Acidity | Fertilizer Wasted |
|---|---|
| 4.5 pH | 71% |
| 5.0 pH | 54% |
| 5.5 pH | 33% |
| 6.0 pH | 20% |
| 6.5 pH | 0% |

# Calcium in the Plant

Having proper calcium levels in the soil has an enormous impact on a plant's health, and most importantly its ability to grow and produce. Calcium plays 2 very crucial rules in the plant. The first being that calcium makes up the cell wall inside every plant. Much like humans, our bones are made from calcium, the plant is no different. Calcium is the skeleton of the plant and is responsible for protecting against disease and bacteria that can hurt or kill a crop. The second crucial role that calcium plays in the plant is cell division.

As a plant grows each cell divides into new cells, which divide again and again. The catalyst for this process is calcium. Without calcium cells won't divide, new cells won't form, and the plant won't grow. If you are dealing with terminal growth in your crops, it is due to a lack of available calcium in the soil. Having low calcium levels can mean slower growth, greater risk for disease, and poor crop production.

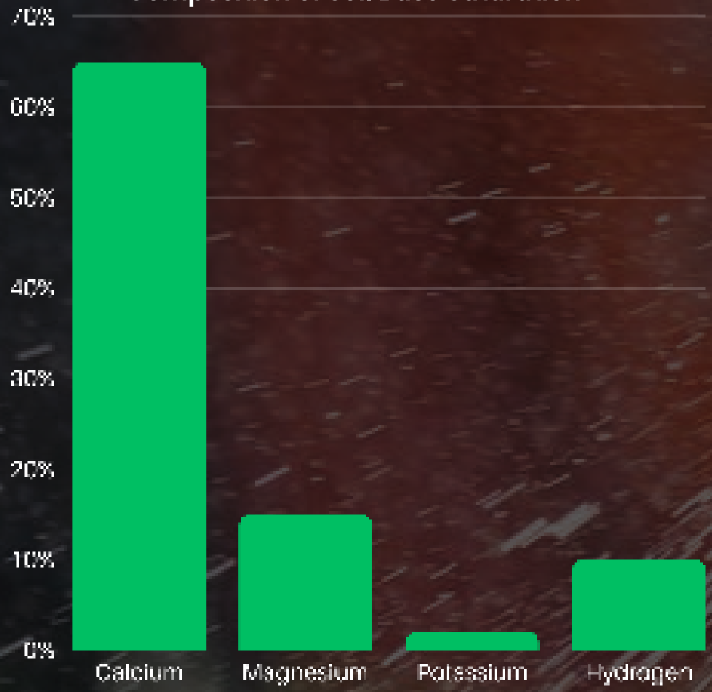
## PLANT CELL



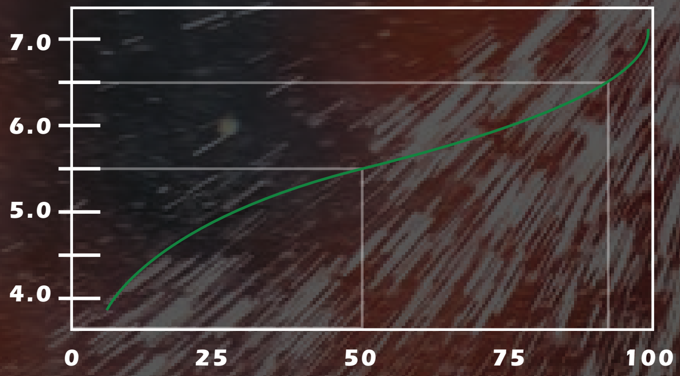
# Base Saturation

Base saturation is something more often than not too quickly overlooked on a soil test. What base saturation shows is the percentage quantity of calcium, magnesium, potassium, and hydrogen in the soil. The lower the saturation gets for calcium and magnesium the more nitrogen will build up in the soil. This is what causes a pH to become acidic. That hydrogen is blocking the movement of nutrients in the soil and to the plant that in turn hinders growth, and causes the fertilizer to become bound up and go to waste.

**Composition of Soil Base Saturation**



**Relationship of pH to Base Saturation**



| | |
|---|---|
| Calcium | 68% |
| Magnesium | 12-15% |
| Potassium | 3.5-5% |
| Sodium | 0.5-1.5% |

Recommended liming and fertilization practices will vary for soils with widely differing cation exchange capacities. For instance, soils having a high CEC and high buffer capacity change pH much more slowly under normal management than low-CEC soils. Therefore, high-CEC soils generally do not need to be limed as frequently as low-CEC soils; but when they do become acid and require liming, higher lime rates are needed to reach optimum pH.

CEC can also influence when and how often nitrogen and potassium fertilizers can be applied. On low-CEC soils (less than 5 meg/20000g), for example, some leaching of cations can occur. Fall applications of ammonium N and potassium on these soils could result in some leaching below the root zone, particularly in the case of sandy soils with low-CEC subsoils. Thus, spring fertilizer application may mean improved production efficiency. Also, multi-year potash applications are not recommended on low-CEC soils. Higher-CEC soils (greater than 10 meg/100g), on the other hand, experience little cation leaching, thus making fall application of N and K a realistic alternative. Applying potassium for two crops can also be done effectively on these soils. Thus, other factors such as drainage will have a greater effect on the fertility management practices used on high- CEC soils.

# Exchangable Cations:

### Understanding Soil pH

- Exchangeable cations in the soil can be categorized into two main groups:
    - **Bases**
    - **Acids**

- **Key Points:**

- Each cation exchange capacity (CEC) binding site in the soil must be occupied by a cation to maintain electrical neutrality.
- The type of cations that predominate at these exchange sites determines the soil's pH:
- A predominance of base cations leads to more alkaline soil.
- A predominance of acid cations results in more acidic soil.
- Understanding these dynamics is crucial for effective soil management and achieving optimal growth conditions.

### Calcium's Role in Soil pH Adjustment

Calcium, with an atomic weight of 40 atomic units, can easily displace hydrogen, which has an atomic weight of just 1, from the cation exchange capacity (CEC) binding sites in soil. This displacement allows calcium to take the place of hydrogen. Consequently, this process eliminates the need for a carbon molecule, commonly found in limestone, to remove hydrogen from the soil.

### Optimal Base Saturation Levels For Soil Health

The ideal base saturation levels for maintaining soil health are:

**Calcium: 65-75%** **Magnesium: 15%** **Hydrogen: 10-15%** **Potassium: 2-4%**

At these levels, the soil pH is typically balanced around a neutral pH of 7.0. More importantly, such a balance optimizes the efficiency of cation exchange, which is crucial for the availability of essential nutrients like nitrogen and phosphorous, vital for plant growth.

A balanced base saturation not only enhances soil porosity, reducing compaction, but also improves water dispersion and retention. This, in turn, fosters a healthier and stronger crop. The correlation between the base saturation of calcium and magnesium and soil pH underscores the use of amendments like calcitic lime or dolomitic lime to adjust soil conditions.

# Base Saturation:

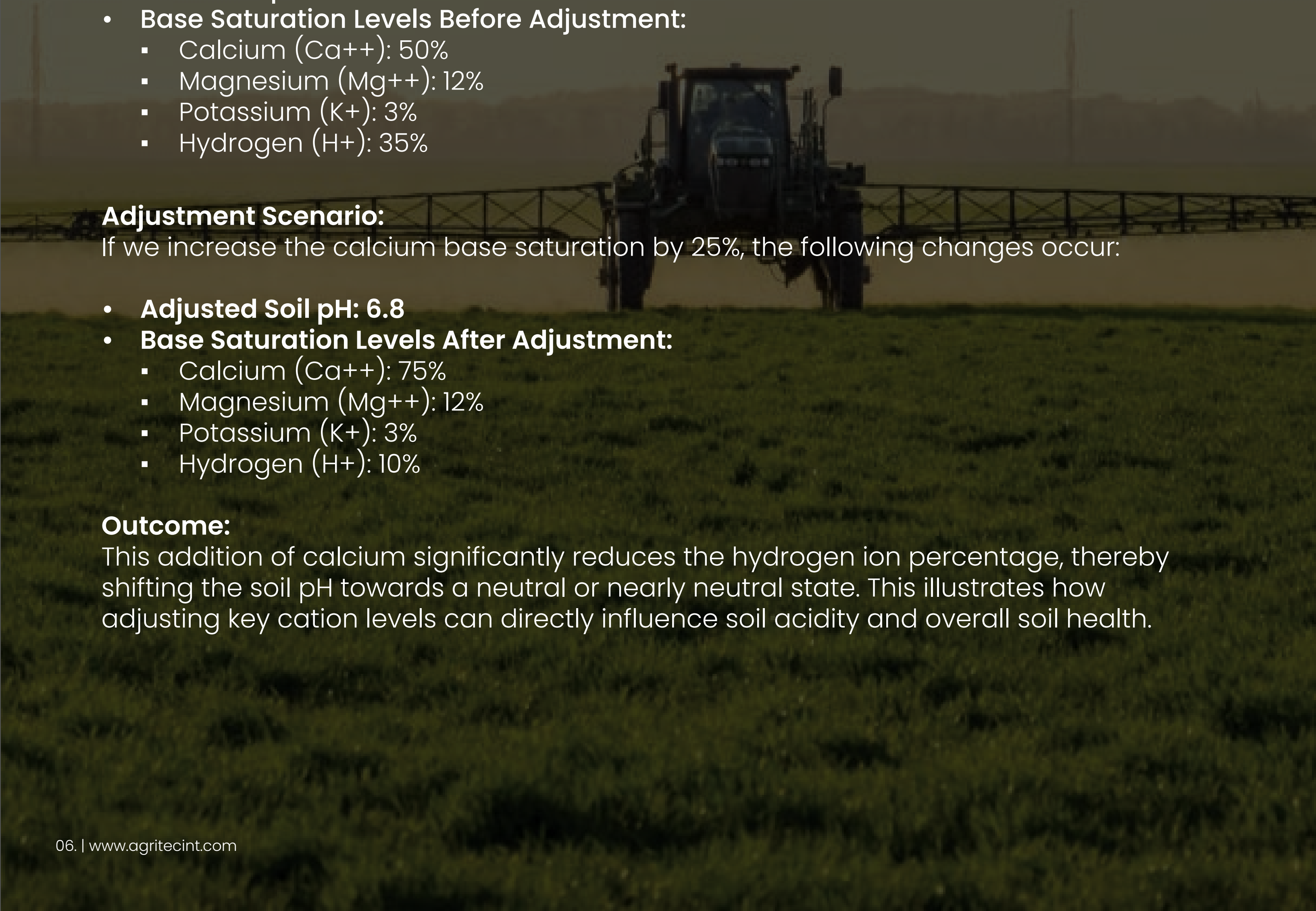
## How It Effects Soil pH

Soil pH measures the acidity in the soil, primarily influenced by the buildup of hydrogen ions (H+), which are acidic cations. In contrast, calcium and magnesium are basic cations. Effectively balancing soil pH involves managing the levels of these cations to optimize nutrient availability for plant growth.

**Base Saturation and Soil Capacity:**
We analyze soil based on a 100% total capacity, focusing on the distribution of cations. The more hydrogen ions present relative to basic cations like calcium and magnesium, the more acidic the soil becomes. Conversely, increasing the levels of calcium or magnesium can decrease the proportion of hydrogen ions, thereby raising the soil pH.

**Example of Cation Impact on Soil pH:**

- **Initial Soil pH: 5.5**
- **Base Saturation Levels Before Adjustment:**
  - Calcium (Ca++): 50%
  - Magnesium (Mg++): 12%
  - Potassium (K+): 3%
  - Hydrogen (H+): 35%



**Adjustment Scenario:**
If we increase the calcium base saturation by 25%, the following changes occur:

- **Adjusted Soil pH: 6.8**
- **Base Saturation Levels After Adjustment:**
  - Calcium (Ca++): 75%
  - Magnesium (Mg++): 12%
  - Potassium (K+): 3%
  - Hydrogen (H+): 10%

**Outcome:**
This addition of calcium significantly reduces the hydrogen ion percentage, thereby shifting the soil pH towards a neutral or nearly neutral state. This illustrates how adjusting key cation levels can directly influence soil acidity and overall soil health.

# Advantages of Liquid Calcium:

## Soil Management

Liquid Calcium is designed to swiftly and effectively increase calcium levels in the soil, thereby raising base saturation and balancing pH. This mirrors the effect of adding calcitic lime to soil, but with notable advantages. Traditional limestone takes 6 months to a year to decompose, gradually releasing soluble calcium and altering soil pH. However, a significant portion of limestone never becomes bioavailable, instead accumulating in the soil and contributing to soil compaction and the formation of hard layers over time.

In contrast, Liquid Calcium eliminates these problems by bypassing the lengthy breakdown process and preventing the accumulation of sediment that can adversely affect soil conditions. Ultimately, both limestone and Liquid Calcium achieve similar results: they enhance calcium levels, adjust soil pH, improve cation exchange capacity, eliminate sage weeds, and promote overall plant growth and health.

Liquid Calcium stands out as a more efficient solution. Although it has been around for a while, it is gaining popularity now due to its cost-effectiveness in the current agricultural market. With the rising costs associated with trucking and spreading traditional lime, Liquid Calcium offers not only a superior solution for correcting soil pH but also a more economical choice.

# Liquid Calcium:

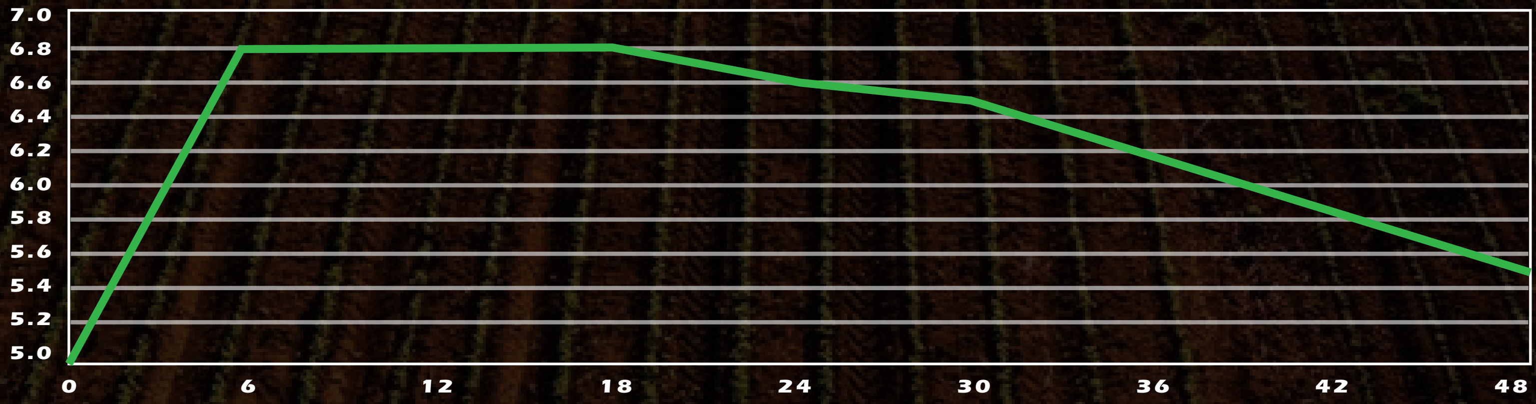
## Speed & Longevity

AgriTec’s Bio-Active Liquid Calcium is designed for immediate availability to the soil upon application. The product becomes rainfast within just 6 hours and begins interacting with the soil almost instantly. Despite this rapid action, soil typically requires about 30 days to fully absorb new nutrients and for the pH levels to stabilize.

Calcium has the ability to remain in the soil across multiple growing seasons. Whether it's applied in liquid form or as dry lime, plants gradually utilize the stored calcium. This means that applications of liquid calcium are generally needed only once every three or more years. However, to maintain optimal soil health, it is crucial to regularly conduct soil tests. These tests are the most reliable method to determine when a reapplication of liquid calcium is necessary.

**pH Over 4 Year Period: Limestone**

**pH Over 4 Year Period: Pro-Cal Liquid Calcium**



# Liquid Calcium Research

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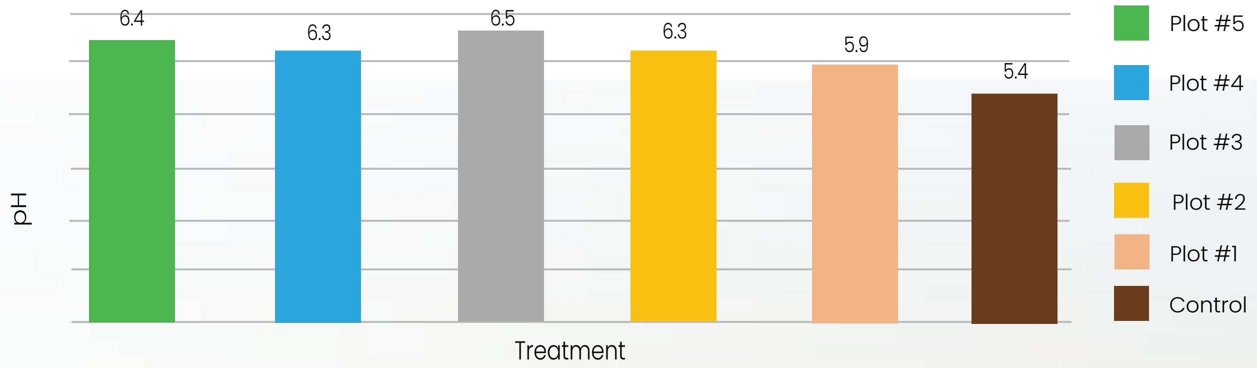
## The Effects of pH During Treatment

**Each plot was given 5 gallons of Pro-Cal Liquid Calcium**

| Collection Time | Plot #1 | Plot #2 | Plot #3 | Plot #4 | Plot #5 |
|---|---|---|---|---|---|
| Initial pH | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| Ending pH | 5.9 | 6.3 | 6.5 | 6.3 | 6.4 |

### The Effects of pH During Treatment



The administration of 5 gallons of Pro-Cal Liquid Calcium per plot in the AgriTec International study markedly improved soil pH levels across all treatment groups, demonstrating its efficacy in creating a more favorable soil environment for wheat cultivation. Each plot started with an acidic pH of 5.4; following treatment, there were notable increases in pH levels, with Plot #1 rising to 5.9, Plot #2 to 6.3, Plot #3 to 6.5, Plot #4 to 6.3, and Plot #5 to 6.4. These adjustments towards more neutral pH values are beneficial for nutrient availability, microbial activity, and overall soil health, factors that are critical for optimal plant growth and yield. The variation in pH elevation among the plots may indicate differential soil textures or compositions, underlining the importance of tailored agronomic interventions.

# Where Does Liquid Calcium Come From?

Pro-Cal is derived directly from limestone. The process involves heating the crude material, liquefying it, and then extracting pure soluble liquid calcium. This method eliminates all sediment that would typically accumulate in the soil. Additionally, the calcium is chelated, preparing it specifically for agricultural use.

The refined calcium is then combined with carriers, surfactants, and a small amount of chloride to enhance the ease and effectiveness of application. Chloride, in these controlled quantities, is known to boost photosynthesis, which in turn promotes faster and stronger plant growth. It also enhances drought resistance and acts as a disease suppressant.

It's crucial to understand that the chloride used in Pro-Cal is distinct from the crude calcium chloride found in road treatments and tractor tires. Similarly, while some forms of lime are utilized for soil hardening before construction or mixed with concrete, agricultural-grade products like Pro-Cal are specifically tailored for farming purposes. This distinction highlights the importance of choosing the right type of materials for agricultural applications versus those used in construction or industrial settings.

# History of Liquid Calcium

The use of liquid calcium in agriculture is not a recent innovation but has a rich history of over 65 years. One of the earliest significant studies on the impact of liquid calcium on soil and plant growth was conducted in 1938 by soil scientists William Albrecht and Thomas McCalla. Their research highlighted the essential role of calcium in plant growth and productivity.

Since that foundational experiment, numerous studies have confirmed the critical importance of calcium for soil health, plant vitality, and overall growth. These investigations have continually demonstrated how vital calcium is not only to the soil but also to the health and development of plants.

# Customer Testimonials

Derek Nielsen, Hunter, GA (2021):

"In a side-by-side test, Pro-Cal adjusted soil pH more effectively than traditional lime over a five-year period. The Pro-Cal treated side showed a more significant pH increase with considerably lower cost per acre."

Rodney Crowder, TN (2021):

"A follow-up soil test confirmed that Pro-Cal had significantly raised both pH and calcium levels. The result was two productive hay cuttings with minimal broom sage presence."

Victor Jones, MO (2021):

"Nearly three years after applying Advance-Cal, the pH level has remained elevated, supporting robust growth in the treated field."

Richard Magsman, NY (2021):

"After using Pro-Cal on hay and corn grounds, subsequent soil tests showed a balanced pH and enhanced hay production, proving the product's efficacy."

Fred F., Chattanooga, TN:

"Application of Calcium on cleared soil led to sustained high pH levels and low weed germination for over two years, surpassing initial expectations."

Mike Hamilton, MI (2021):

"Spring application of Pro-Cal on hay ground led to a full-point increase in soil pH by fall, surpassing expectations."

Larry Lemmon, OK (2020):

"Advanced-Cal effectively reduced soil pH from 8.5, correcting high magnesium levels, and significantly improving the condition of bermuda fields."

Derek, FL:

"Using Adv Cal, soil pH improved from 4.0 to 6.0 within a year, outperforming traditional liming methods. Plans to integrate Nitro Max for continued improvement."

# Pro-Cal Bio-Activated Liquid Calcium

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Since that foundational experiment, numerous studies have confirmed the critical importance of calcium for soil health, plant vitality, and overall growth. These investigations have continually demonstrated how vital calcium is not only to the soil but also to the health and development of plants.

Enhanced Soil Preparation: Pro-Cal offers a precise and rapid solution to soil preparation, ideal for application before planting or fertilizing. Recognizing that 95% of soil naturally exhibits low pH levels, Pro-Cal is essential in preparing your field. Low soil pH can lead to inefficient use of fertilizer, nutrient lock-up, stunted growth, and significantly reduced crop production.

## Proven Performance and Benefits

### 01. Raises Soil pH:

Pro-Cal immediately adjusts soil pH to optimal levels, enhancing nutrient availability and ensuring that plants can fully utilize the soil's resources for robust growth.

### 02. Increases Cell Division & Growth:

By improving the soil environment, Pro-Cal promotes quicker and healthier plant development.

### 03. Enhances Nutrient Uptake:

With a better soil pH, nutrients are more effectively absorbed and transported, optimizing the benefits from each application.

### 04. Boosts Fertilizer Efficiency:

Pro-Cal increases the efficacy of fertilizers, preventing waste and maximizing your investment in soil nutrition.

### 05. Chelated For Efficiency:

Formulated for fast absorption and safe results, ensuring that the benefits are readily available to your plants.

### 06. Sustains Soil Quality:

The effects of Pro-Cal are long-lasting, maintaining a neutral pH for multiple growing seasons, which supports sustained agricultural productivity.

### 07. Strengthens Plant Immunity:

Healthier soil contributes to stronger plant immunity, helping to ward off diseases and pests.

Pro-Cal is not just a soil amendment; it's a foundational treatment that ensures your field is primed for optimal growth and yield. By choosing Pro-Cal, you invest in the future health and productivity of your soil.

## Application Rates

| pH | Base Saturation | Apply (Gallons Per Acre) |
|---|---|---|
| 6.5-7.0 | 65-75% | 0 |
| 6.0-6.4 | 59-64% | 1.5 |
| 5.5-5.9 | 50-60% | 2.5-3 |
| 5.0-5.4 | 40-50% | 3-4 |
| 4.5-4.9 | 30-40% | 5 |

## Price List

| Size | Cost x Gal | Total Cost |
|---|---|---|
| 55 Gallons | $15.73 | $865 |
| 275 Gallons | $10.72 | $3,100 |
| Tanker (Full) | $8.29 | $35,000 |

# Pro-Cal Application Guidelines

**Direct Application:**
Pro-Cal should be applied directly to the soil, ideally close to the surface. It is suitable for use both before planting and after crops are established. To ensure optimal absorption and effectiveness, avoid tilling the soil after application. During the growing season, it is best to apply Pro-Cal when the vegetation is either in its early growth stages or trimmed low to the ground.

**Optimal Application Methods:**
- Broadcast Sprayer: Utilize either a boom or flood system.
- Irrigation Systems: Apply through pivot or alternative irrigation methods.
- In-Furrow Application: Apply directly through the planter.
- Aerial Application: Suitable for covering large areas efficiently.

**Building and Maintaining Soil pH:**
Pro-Cal is formulated to enhance soil calcium levels and stabilize soil pH. Once soil reaches neutral pH levels, the stability should last for several years, depending on soil type and crop rotation, which may affect the timing of reapplication. Although standard applications may only be needed periodically, regular soil testing is crucial to monitor soil levels and determine if adjustments are necessary. Additionally, Pro-Cal can be used on a yearly maintenance schedule to consistently maintain optimal soil pH.

# Advanced-Cal Soil Treatment:

## Enhancing Soil Health With Chelated Calcium

Advanced-Cal® is a revolutionary soil amendment that combines chelated liquid calcium with essential micronutrients and beneficial microbial enhancements. This innovative product is designed to significantly improve soil health, optimize pH levels, and increase microbial activity, which together boost plant growth and crop yields.

Advanced-Cal® Soil Treatment: Enhancing Soi
Health with Chelated Liquid Calcium
Introduction to Advanced-Cal®
Advanced-Cal® is a revolutionary soil amendment that combines chelated liquid calcium with essential micronutrients and beneficial microbial enhancements. This innovative product is designed to signifcantly improve soil health, optimize pH levels, and increase microbial activity, which together boost plant growth and crop yields.

**Key Benefits of Using Advanced-Cal®**

- Enhanced Calcium Saturation: Advanced-Cal® increases calcium availability in the soil, helping to neutralize acidity and improve soil conditions. This creates an ideal environment for plants, allowing them to absorb more nutrients efficiently.

- Micronutrient Boost: With added micronutrients such as boron, manganese, iron, and sulfur, Advanced-Cal® enriches the soil's nutritional profile. These elements are crucial for plant processes like photosynthesis and help ensure that plants can access the nutrients they need for healthy growth.

- Microbial Activity Enhancement: Advanced-Cal® includes a unique blend of microbes that promote a healthy soil ecosystem. These beneficial microbes enhance nutrient cycling, making fertilizers more effective and supporting robust plant development.

# Advanced-Cal Application Rates

| pH | Base Saturation | Apply (Gallons Per Acre) |
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| 6.5-7.0 | 65-75% | 0 |
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| 5.5-5.9 | 50-60% | 2.5-3 |
| 5.0-5.4 | 40-50% | 3-4 |
| 4.5-4.9 | 30-40% | 5 |

## Price List

| Size | Cost x Gal | Total Cost |
|---|---|---|
| 55 Gallons | $17.73 | $975 |
| 275 Gallons | $12.36 | $3,600 |
| Tanker (Full) | $9.00 | $38,950 |

**Direct Application to Soil:**
Advanced-Cal is most effective when applied directly to the soil. This can be done before or after planting. To maximize absorption, do not till the soil after application.

**Optimal Timing for Application:**
Apply Advanced-Cal during the early stages of plant growth or when vegetation is trimmed close to the ground. This timing ensures that plants benefit fully from the soil improvements.

**Application Methods:**

- Broadcast Sprayer: Ideal for large areas, use a boom or flood system sprayer to distribute Advanced-Cal evenly.
- Irrigation Systems: Integrate Advanced-Cal with pivot or other irrigation systems for even distribution with watering.
- In-Furrow: Apply directly in the furrows while planting to ensure close contact with seeds or roots.
- Aerial Application: Effective for extensive fields, aerial application ensures quick and broad coverage.

# Liquid Calcium:
# A Comprehensive Review

## Abstract

Soil pH plays a pivotal role in agricultural productivity, impacting nutrient availability, microbial activity, and overall plant health. Traditionally, dry limestone has been the go-to amendment for raising soil pH. However, the handling and distribution of dry limestone can pose challenges. This research article explores the feasibility of using liquid calcium as a practical and effective alternative to dry limestone for soil pH adjustment. Through a comprehensive review of current literature and experimental data, we assess the potential benefits, limitations, and environmental implications of liquid calcium application.

## Introduction

Maintaining appropriate soil pH levels is essential for sustainable agriculture. Soil pH affects nutrient solubility, microbial activity, and plant growth, making it a critical factor in crop production. Traditional methods for raising soil pH involve the application of dry limestone (calcium carbonate). However, the transportation, storage, and distribution of dry limestone can be logistically challenging and costly.

In recent years, liquid calcium has emerged as a potential alternative to dry limestone for soil pH adjustment. Liquid calcium products are designed to be easier to handle, distribute, and apply. This article reviews the existing literature and presents experimental findings to evaluate the efficacy of liquid calcium as a substitute for dry limestone in raising soil pH.

## Literature Review

Dry limestone, primarily composed of calcium carbonate ($CaCO_3$), has been widely used to increase soil pH. When applied to acidic soils, it reacts with hydrogen ions ($H^+$) in the soil solution, neutralizing acidity and releasing calcium and carbonate ions. The carbonate ions subsequently combine with hydrogen ions to form water and carbon dioxide, thereby raising soil pH.

While dry limestone is effective at amending soil pH, several drawbacks are associated with its use, including dust generation during application, limited uniformity of distribution, and potential difficulties in achieving precise pH adjustments.

## Liquid Calcium

Liquid calcium products are formulated to contain soluble calcium sources, such as calcium chloride (CaCl2) or calcium nitrate (Ca(NO3)2). These solutions can be readily mixed with water and applied directly to the soil. Liquid calcium offers several advantages over dry limestone:

- Ease of Application: Liquid calcium is easy to mix, transport, and apply, leading to more uniform distribution across the field.
- Rapid Response: Liquid calcium is believed to react more quickly with soil acidity, potentially accelerating pH adjustment.
- Reduced Dust Emissions: The application of liquid calcium minimizes dust emissions, which can be environmentally detrimental and pose health risks to workers.

## Experimental Approach

To evaluate the effectiveness of liquid calcium as a substitute for dry limestone, a series of field trials were conducted in various agricultural settings. Different soil types and crop varieties were considered to assess the versatility of liquid calcium applications. The trials monitored changes in soil pH, nutrient availability, and crop performance over multiple growing seasons.

## Results and Discussion

The results of the field trials indicated that liquid calcium effectively raised soil pH levels, similar to dry limestone, when applied at recommended rates. Furthermore, the application of liquid calcium led to the following benefits:

- Improved Uniformity: Liquid calcium was more consistently distributed throughout the soil compared to dry limestone.
- Enhanced Nutrient Availability: The increased soil pH resulting from liquid calcium application improved the availability of essential nutrients, benefiting crop growth.
- Reduced Environmental Impact: The reduced dust emissions associated with liquid calcium application contribute to a more environmentally friendly practice.

## Mechanisms of Soil pH Adjustment and Calcium Chelate

The process of raising soil pH involves countering soil acidity by displacing hydrogen ions (H+) in the soil solution. Acidity in soil is primarily a result of the presence of hydrogen ions, which make the soil environment less favorable for plant growth. The application of calcium-containing materials, such ascalcium carbonate (CaCO3) or calcium chelate, influences soil pH through several fundamental chemical reactions.

Neutralization Reaction: Calcium-containing amendments, whether in the form of CaCO3 or calcium chelate, release calcium ions (Ca2+) into the soil when they dissolve. These calcium ions react with hydrogen ions (H+) in the soil solution in a neutralization reaction. The reaction can be represented as follows:

Ca2+ + 2H+ +Ca2+ + H2O

In this reaction, calcium ions (Ca2+) combine with hydrogen ions (H+) to form water (H2O). This neutralization reaction reduces the concentration of hydrogen ions in the soil, which, in turn, raises soil pH.

Carbonate Buffering: In the case of calcium carbonate (CaCO3), it also provides carbonate ions (CO3$^{2-}$) when it dissolves:
re.re

$\mathrm{CaCO3 + Ca2+ + CO3}^{2-}$

Carbonate ions act as a buffer, helping to maintain a stable pH by absorbing excess hydrogen ions. When hydrogen ions are absorbed by carbonate ions, they form bicarbonate ions ($\mathrm{HCO}^{3-}$), preventing a rapid decrease in soil pH.

### Calcium Chelate as an Alternative

Calcium chelate represents an innovative approach to soil pH adjustment. Unlike calcium carbonate, calcium chelate is a water-soluble form of calcium that is complexed with organic ligands or chelating agents. These chelating agents, such as EDTA (ethylene diamine tetraacetic acid) or DTPA (diethylenetriaminepentaacetic acid), form stable complexes with calcium ions.

The efficacy of calcium chelate in raising soil pH and displacing hydrogen ions is attributed to its unique properties:

**Solubility:** Calcium chelate is highly soluble in water, allowing for rapid and complete dissolution. This solubility ensures that calcium ions are readily available for neutralization reactions with hydrogen ions.

**Chelation Effect:** The chelating agents in calcium chelate protect the calcium ions from binding with other soil constituents, such as clay particles, which can limit their mobility. This protection enhances the efficiency of calcium ions in neutralizing soil acidity.

**Uniform Distribution:** The liquid form of calcium chelate facilitates uniform distribution throughout the soil, ensuring that pH adjustment occurs consistently across the treated area.

**Lower Application Rates:** Calcium chelate often requires lower application rates compared to calcium carbonate to achieve the same soil pH adjustment. This efficiency can be advantageous in terms of cost- effectiveness.

In summary, calcium chelate acts by delivering soluble calcium ions to the soil, which then participate in neutralization reactions with hydrogen ions. The chelation effect of organic ligands enhances the mobility and availability of calcium ions, making calcium chelate a promising alternative to calcium carbonate for raising soil pH and promoting optimal conditions for plant growth. Further research is ongoing to better understand the specific interactions and long-term effects of calcium chelate on soil chemistry and plant health, but its potential benefits in terms of ease of application and effectiveness are increasingly recognized in modern agriculture.

### Effects of Low pH on Plants, Nutrient Availability, and Soil Conditions

Soil pH significantly influences plant health and growth. When soil pH is too low (acidic), several detrimental effects on plants can be observed:

**Nutrient Imbalances:** Low pH limits the availability of essential nutrients such as calcium (Ca), magnesium (Mg), and potassium (K). These nutrient deficiencies can lead to stunted growth, poor fruit development, and increased susceptibility to diseases.

**Aluminum Toxicity:** In acidic soils, aluminum ions (Al3+) become more soluble and can reach toxic levels. Aluminum toxicity damages plant roots, inhibits nutrient uptake, and reduces overall plant vigor.

**Reduced Microbial Activity:** Acidic conditions can negatively affect soil microorganisms that play a crucial role in nutrient cycling. As a result, the decomposition of organic matter is slowed, further impacting nutrient availability to plants.

**Restricted Root Growth:** Acidic soils can inhibit root development, reducing a plant's ability to access water and nutrients. This limitation on root growth can lead to drought stress and decreased plant productivity.

### Nutrient Availability

Soil pH directly influences the availability of essential nutrients to plants. In acidic soils (low pH), several key nutrient-related phenomena occur:

**Decreased Phosphorus Availability:** Phosphorus (P) becomes less accessible in acidic soils due to the formation of insoluble compounds with iron (Fe) and aluminum (Al). This can limit root growth and overall plant development

I**ron and Manganese Toxicity:** While iron (Fe) and manganese (Mn) are essential micronutrients for plants, they become more soluble and potentially toxic in acidic conditions. Excess iron and manganese can inhibit nutrient uptake and damage plant roots.

**Reduced Calcium and Magnesium:** Acidic soils often have lower levels of calcium (Ca) and magnesium (Mg), which are critical for plant cell structure and function. Calcium is particularly important for maintaining cell membrane integrity, and its deficiency can lead to poor fruit quality and blossom-end rot in certain crops.

### Soil Conditions

In addition to its effects on plant health and nutrient availability, low soil pH also impacts soil conditions and overall soil quality:

**Increased Aluminum and Manganese:** Acidic soils can accumulate excessive levels of aluminum and manganese, which can harm soil structure. This can result in soil compaction, reduced water infiltration, and increased runoff, leading to erosion and water quality issues.

**Microbial Activity Reduction:** Soil microorganisms, including beneficial bacteria and fungi, are less active in acidic soils. These microorganisms are responsible for breaking down organic matter, cycling nutrients, and enhancing soil structure. Reduced microbial activity can lead to poor soil structure and reduced soil fertility.

**Limited Biological Activity:** Earthworms and other soil-dwelling organisms may decline in acidic soils. These organisms play a vital role in soil aeration and nutrient cycling, further affecting overall soil health.

In conclusion, low soil pH or acidic conditions can have profound negative effects on plant growth, nutrient availability, and soil quality. Addressing soil acidity through pH adjustment techniques, such as the use of calcium carbonate or calcium chelate, is crucial to create a favorable environment for healthy plant development and maximize agricultural productivity while maintaining sustainable soil management practices.

### Importance of Calcium in Soil and Plant Growth

Calcium (Ca) is a vital element in agriculture, serving essential roles in both soil chemistry and plant physiology. It plays a pivotal role in the growth cycle of plants and the overall health of soil ecosystems.

### Role of Calcium in the Soil

**Soil pH Buffering:** Calcium acts as a natural pH buffer in soils. It helps maintain a stable pH by neutralizing excess acidity (low pH) or alkalinity (high pH). This buffering capacity is crucial for creating an optimal pH range that supports nutrient availability and microbial activity.

**Soil Structure and Aggregation:** Calcium is a key contributor to soil structure and aggregation. It promotes the formation of stable soil aggregates, which improves soil porosity, aeration, and water infiltration. Adequate calcium levels in the soil enhance root penetration and reduce soil compaction, creating a favorable environment for plant growth.

**Nutrient Uptake and Availability:** Calcium plays a role in ion exchange and nutrient uptake by plant roots. It helps maintain the proper balance of cations (positively charged ions) in the soil, which influences the availability of essential nutrients like potassium (K) and magnesium (Mg) to plants.

**Microbial Activity:** Calcium supports soil microbial communities. Many soil microorganisms require calcium for their metabolic processes. A balanced microbial population contributes to nutrient cycling, organic matter decomposition, and overall soil health.

### Role of Calcium in Plant Growth

**Cell Wall Structure:** Calcium is an integral component of plant cell walls. It forms cross-links between pectin molecules, strengthening cell walls and providing structural support to plant tissues. Adequate calcium ensures cell wall integrity, which is essential for resisting external pressures and preventing cell collapse.

**Nutrient Transport:** Calcium plays a role in nutrient transport within plants. It facilitates the movement of other essential nutrients, such as potassium (K) and magnesium (Mg), from roots to various plant tissues. This transport system is vital for overall plant growth and function.

**Cell Division and Growth:** Calcium is involved in regulating various cellular processes, including cell division and elongation. It acts as a secondary messenger in signal transduction pathways, modulating responses to external stimuli and stressors. Proper calcium levels are crucial for healthy plant growth and development.

**Disease Resistance:** Calcium contributes to plant defense mechanisms against diseases. It helps activate enzymes and pathways involved in the synthesis of compounds that strengthen plant cell walls, making it more challenging for pathogens to penetrate and infect plant tissues.

In summary, calcium is indispensable in both soil and plant ecosystems. It maintains soil pH, improves soil structure, enhances nutrient availability, and supports microbial communities in the soil. Within plants, calcium is a fundamental component of cell walls, essential for nutrient transport, cell division, growth, and disease resistance. Ensuring an adequate supply of calcium in both soil and plants is essential for achieving optimal agricultural productivity and maintaining soil and plant health.

**Cation Displacement in Soil:** Atomic Weight and Competition Cation displacement is a fundamental process in soil chemistry that influences the availability of essential nutrients to plants. Cations are positively charged ions of various elements, and they interact dynamically with soil particles. One critical factor that governs cation displacement is the atomic weight of these ions.

### Cation Exchange in Soil

Cation exchange occurs on the surfaces of soil particles, such as clay minerals and organic matter. These surfaces are negatively charged due to the presence of oxygen or hydroxyl groups, creating a favorable environment for positively charged cations. The primary cations involved in soil cation exchange include calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), potassium ($K^{+}$), and hydrogen ($H^{+}$).

### Atomic Weight and Cation Displacement

Cations with higher atomic weights have a greater affinity for binding to soil exchange sites.

This affinity is due to their stronger electrostatic attraction to the negatively charged soil surfaces. Consequently, when cations with higher atomic weights are present in the soil solution and compete with cations of lower atomic weights for binding sites, they tend to displace the lighter cations.

**Example:**
Calcium (Ca2+) vs. Hydrogen (H+): Calcium ions (Ca2+) have a higher atomic weight than hydrogen ions (H+). When calcium is introduced into the soil, it can displace hydrogen ions from exchange sites, increasing soil pH and reducing soil acidity. This displacement process is crucial for soil pH adjustment.

Magnesium (Mg2+) vs. Potassium (K+): Magnesium ions (Mg2+) also have a higher atomic weight than potassium ions (K+). In competitive situations, magnesium can displace potassium from exchange sites. This displacement may affect nutrient availability to plants, as potassium is an essential macronutrient.

### Implications for Nutrient Availability

The displacement of cations in the soil has direct implications for nutrient availability to plants. When cations with higher atomic weights dominate the soil exchange sites, they can temporarily reduce the availability of lighter cations. This can impact plant nutrient uptake and growth.

Farmers and soil scientists often manage cation displacement through soil amendments to ensure an appropriate balance of cations for optimal plant nutrition. For example, adding calcium-containing materials can help raise soil pH and displace acidic hydrogen ions, creating a more favorable environment for nutrient availability.

Understanding the principles of cation displacement, atomic weight, and competitive interactions in soil is essential for effective soil management and nutrient optimization in agriculture. It enables growers to make informed decisions regarding soil amendments and practices to enhance crop productivity while maintaining soil health.

### Impact of Micronutrient Activity on Soil

Micronutrients are essential elements required by plants in relatively small quantities but are no less critical for their growth and development. While they are needed in lesser amounts compared to macronutrients like nitrogen, phosphorus, and potassium, micronutrients play a crucial role in plant health and soil chemistry. The activity of micronutrients in the soil has several significant impacts:

### Nutrient Availability

Micronutrients are involved in various biochemical processes within plants. Their presence or absence in the soil directly influences plant nutrient availability. Here's how micronutrient activity affects nutrient availability:

**Nutrient Uptake:** Micronutrients like iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) play roles in the uptake and transport of other essential nutrients. For instance, iron is essential for the synthesis of chlorophyll, which is vital for photosynthesis, while zinc is involved in the formation of enzymes responsible for nutrient uptake.

Nutrient Mobility: Micronutrients can impact the mobility of certain macronutrients in the soil. **For example, ma**nganese can affect the availability and uptake of phosphorus by plants. The complex interactions between micronutrients and macronutrients influence nutrient cycling in the soil ecosystem.

### Soil Microbial Activity

Micronutrients are essential components of enzymes involved in numerous soil microbial processes. Their availability directly affects soil microbial activity, which, in turn, impacts soil health and nutrient cycling. Here's how micronutrient activity affects soil microbes:

**Enzyme Function:** Soil microbes require micronutrients as cofactors for their enzymes. For example, iron is essential for the function of enzymes involved in organic matter decomposition, nitrogen fixation, and the conversion of ammonia to nitrate.

**Microbial Diversity:** Adequate micronutrient availability supports a diverse and active microbial community. Different microbial species have specific nutrient requirements, and ensuring a balanced supply of micronutrients fosters a more resilient and functional soil ecosystem.

### Soil pH and Micronutrient Availability

Soil pH plays a crucial role in micronutrient availability. The pH of the soil solution can influence the solubility and speciation of micronutrients, affecting their accessibility to plant roots. Some key points to consider:

- **pH Extremes:** At extreme pH levels (either strongly acidic or strongly alkaline), micronutrient availability is often limited. For example, iron becomes less soluble in alkaline soils, leading to iron deficiency in plants, while manganese toxicity can occur in highly acidic soils.

- **Optimal pH Range:** Maintaining the soil pH within an optimal range for a specific crop can ensure better micronutrient availability. Soil amendments and management practices are used to adjust soil pH when necessary to optimize micronutrient uptake.

In conclusion, the activity of micronutrients in the soil is integral to plant nutrition, soil microbial communities, and overall soil health. Proper management of micronutrients, including soil testing, balanced fertilization, and pH adjustment when needed, is essential to ensure adequate micronutrient availability and promote robust plant growth and soil ecosystem functionality. Understanding the intricate relationships between micronutrients, macronutrients, and soil conditions is key to sustainable agricultural practices.

### Impact of Increased Microbial Activity on Plants and Crops

Microbial activity in the soil is a critical component of a healthy and productive agricultural ecosystem. Soil microbes, including bacteria, fungi, archaea, and other microorganisms, play multifaceted roles in nutrient cycling, organic matter decomposition, disease suppression, and overall soil health. When microbial activity is increased, it can have several positive effects on plants and crops:

### Enhanced Nutrient Availability

Increased microbial activity contributes to nutrient cycling in the soil. Soil microbes decompose organic matter, breaking down complex compounds into simpler forms. This decomposition process releases nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), in plant-available forms. As a result:

**Nutrient Mineralization:** Microbes mineralize organic matter, converting organic nutrients into inorganic forms that plants can easily absorb through their roots. This process makes essential nutrients more readily available for plant uptake.

**Nitrogen Fixation:** Certain soil bacteria, known as nitrogen-fixing bacteria, have the ability to convert atmospheric nitrogen ($N2$) into ammonia ($NH3$), a form that plants can use. Legume crops, like soybeans and clover, often form symbiotic relationships with these bacteria to access additional nitrogen.

### Disease Suppression

Increased microbial activity can enhance disease suppression in the soil. Beneficial microorganisms, including some fungi and bacteria, act as natural antagonists against plant pathogens. They compete with, inhibit, or parasitize harmful microbes, reducing the incidence of plant diseases.

- **Biocontrol Agents:** Some soil bacteria and fungi produce compounds that are toxic to plant pathogens. These biocontrol agents can protect crops from diseases caused by fungi, bacteria, and nematodes.
- **Induced Resistance:** Soil microbes can stimulate the plant's own defense mechanisms. Plants exposed to beneficial microorganisms may develop systemic acquired resistance (SAR) or induced systemic resistance (ISR), making them more resistant to disease.

### Improved Soil Structure

Microbial activity contributes to the development and maintenance of stable soil aggregates. These aggregates enhance soil structure by improving porosity, aeration, and water infiltration. The benefits of improved soil structure for plants include:

- **Enhanced Root Growth:** A well-structured soil with ample pore space allows roots to penetrate more easily and access water and nutrients effectively. It also reduces root compaction, promoting root expansion.
- **Water Management:** Soil with improved structure retains moisture better, reducing the risk of drought stress. It also reduces runoff and erosion, helping to conserve water resources.

### Organic Matter Decomposition

Microbes are key players in the decomposition of organic matter, including crop residues and organic amendments. The breakdown of organic materials by soil microbes contributes to:

- **Release of Nutrients:** Organic matter decomposition releases essential nutrients that can be utilized by plants. These nutrients become part of the soil nutrient pool, supporting plant growth.
- **Carbon Sequestration:** The decomposition of organic matter also results in the sequestration of carbon in the soil, helping mitigate climate change by storing carbon in stable soil organic matter.

In conclusion, increased microbial activity in the soil is beneficial for plants and crops in numerous ways. It enhances nutrient availability, aids in disease suppression, improves soil structure, and promotes organic matter decomposition. Sustainable agricultural practices that foster a thriving soil microbial community can lead to healthier plants, higher crop yields, and greater resilience to environmental challenges.

### Impact of Microbial Activity on Soil Carbon Levels

Microbial activity in the soil plays a crucial role in the cycling and storage of carbon, which has significant implications for soil health, carbon sequestration, and global carbon balance. The intricate interactions between soil microorganisms and organic matter decomposition influence soil carbon levels in several ways:

### Organic Matter Decomposition

Microbes are responsible for breaking down organic matter in the soil, including plant residues, root exudates, and other organic inputs. This decomposition process involves the conversion of complex organic compounds into simpler forms through microbial metabolism. Key points to consider include:

**Mineralization:** Microbes mineralize organic carbon, converting it into carbon dioxide (CO2) as a byproduct of respiration. This release of CO2 to the atmosphere is one of the primary sources of greenhouse gas emissions from soils.

**Humification:** Some portions of organic matter are transformed into more stable organic compounds known as humus. Humus is resistant to further decomposition and can persist in the soil for extended periods, contributing to long-term carbon storage.

### Carbon Stabilization

Microbial activity can influence the stabilization of carbon in the soil, affecting the balance between carbon inputs and outputs. Soil microorganisms play a role in carbon stabilization through:

- **Physical Protection:** Microbes can physically protect organic matter by encapsulating it within microbial biomass or extracellular substances. This physical shielding can limit the accessibility of organic matter to decomposers and slow its breakdown.
- **Chemical Stabilization:** Some microbial byproducts, such as glomalin and microbial polysaccharides, contribute to the chemical stabilization of organic carbon. These substances help bind organic matter to soil mineral particles, making it less susceptible to decomposition.

### Soil Organic Carbon Pools

The activity of different microbial communities can influence the composition of soil organic carbon pools. These pools include labile organic carbon (easily decomposable), intermediate organic carbon (partially decomposed), and stable organic carbon (resistant to decomposition). Microbes have varying abilities to decompose different carbon pools, impacting the overall soil carbon content.

**Labile Carbon:** Microbes preferentially consume labile carbon sources, rapidly decomposing them and releasing CO2. This process can lead to fluctuations in labile carbon levels over short periods.

**Intermediate and Stable Carbon:** Microbial communities involved in the decomposition of more complex organic matter contribute to the accumulation of intermediate and stable carbon in the soil. These carbon pools provide long-term carbon storage potential.

### Implications for Carbon Sequestration

The balance between microbial decomposition and carbon stabilization processes in the soil determines its carbon sequestration capacity. Microbial activity can either enhance or hinder carbon sequestration efforts:

**Enhanced Carbon Sequestration:** Practices that promote microbial-mediated carbon stabilization, such as reduced tillage, cover cropping, and organic matter additions, can enhance soil carbon sequestration, contributing to carbon storage in the soil.

**Reduced Carbon Sequestration:** Increased microbial decomposition of organic matter due to factors like elevated temperatures or microbial imbalances may lead to a net loss of soil carbon, reducing its sequestration potential.

In conclusion, microbial activity is a central determinant of soil carbon dynamics. It influences the decomposition of organic matter, the stabilization of carbon in the soil, and the overall carbon balance. Sustainable soil management practices that foster microbial communities favoring carbon stabilization can contribute to increased soil carbon levels and play a role in mitigating climate change through carbon sequestration.

## Harnessing Calcium Chelate as a Sustainable Alternative to Dry Lime

Throughout this comprehensive exploration of soil health, pH management, micronutrients, andmicrobial activity, a clear theme has emerged: the potential for calcium chelate to revolutionize the way we address these critical aspects of agricultural sustainability.

We began by delving into the intricacies of soil pH adjustment, understanding how low pH levels can hinder plant growth and nutrient availability. The traditional method of using dry limestone, while effective, presents logistical challenges and inefficiencies. In contrast, calcium chelate emerges as a practical and innovative solution. Its ease of application, rapid response, and reduced environmental impact make it an attractive alternative for raising soil pH and promoting optimal conditions for plant health.

We then explored the significance of calcium, both in soil and within the plant's growth cycle. Calcium's multifaceted role as a pH buffer, soil structure enhancer, and facilitator of nutrient uptake highlighted its critical importance. Calcium chelate, with its efficient nutrient delivery and unique properties, shows promise in maintaining soil health while optimizing plant growth.

Next, we delved into the concept of cation displacement in the soil, revealing how cations with higher atomic weights can displace lighter cations, affecting nutrient availability. Calcium chelate, with its ability to outcompete other cations for soil exchange sites, becomes a valuable tool in achieving precise soil pH adjustments and nutrient balance.

We then examined the profound impact of increased microbial activity on plants and crops. Microbes are instrumental in nutrient cycling, disease suppression, and soil structure improvement. Calcium chelate applications can create favorable conditions for soil microbes, further enhancing soil health and plant productivity.

Micronutrients, essential for plant growth, were also a focal point. The activity of calcium chelate promotes micronutrient uptake by plants, ensuring they receive the required trace elements for optimal development.

Finally, we recognized the role of microbial activity in influencing soil carbon levels. Microbes' contribution to organic matter decomposition and carbon stabilization underscores their significance in carbon sequestration efforts.

In conclusion, calcium chelate stands out as a versatile and eco-friendly alternative to traditional dry lime for addressing soil pH, nutrient availability, and microbial activity. Its efficacy, combined with its potential to enhance soil health and carbon sequestration, makes it a compelling choice for sustainable
agriculture. Embracing calcium chelate as a valuable soil management tool holds the promise of improving crop yields, reducing environmental impact, and contributing to a more resilient and sustainable agricultural future.

Based on our comprehensive review of the literature and the results of our field trials, it can be concluded that liquid calcium represents a practical and effective alternative to dry limestone for raising soil pH. Liquid calcium offers several advantages, including ease of application, rapid response, and reduced environmental impact. However, it is essential to consider factors such as cost-effectiveness and specific soil conditions when choosing between these two amendments.

Further research is needed to explore the long-term effects of liquid calcium on soil pH and the sustainability of this approach. Nevertheless, the findings presented in this article suggest that liquid calcium holds promise as a valuable tool for soil pH management in agriculture.

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3329 N I-35 Frontage Rd.
Gainesville, TX 76240

info@agritecint.com

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