NACHURS®

PREMIUM LIQUID FERTILIZERS

# maximize
## crop yield potential

r4 nutrient stewardship


NACHURS™

# NACHURS® Liquid Fertilizers

NACHURS liquid fertilizers offer a variety of products for flexible applications including in-furrow, banded, fertigation, strip-till/side-dress, and foliar. **NACHURS products are an important part of a complete fertilizer program, they are not meant to replace but compliment your base fertility program.**

NACHURS boasts six production plants and multiple terminals located across North America to help serve the nutrient needs of growers from coast to coast:

- Belle Plaine, Saskatchewan Canada
- Corydon, Indiana USA
- Marion, Ohio USA
- New Hamburg, Ontario Canada
- Red Oak, Iowa USA
- St. Gabriel, Louisiana USA

The NACHURS team includes sales managers, agronomists, and a full support staff. Contact your Authorized NACHURS Dealer or District Sales Manager (DSM) to find out to find out which NACHURS products will give your crop the nutrients it needs for maximum yield potential.

toll free: (800) 622-4877
info@nachurs.com
visit us online: www.nachurs.com


## Why Growers Choose NACHURS®

Since 1946 growers across the country have been reaping the benefits of NACHURS liquid fertilizers on a variety of crops: corn, soybeans, cotton, cereal crops, tobacco, peanuts, fruits and vegetables, just to name a few. Most crops have a critical need for phosphorus and potassium from germination through reproductive stages where maximum yield potential is determined. NACHURS liquid fertilizers ensure that the crop has adequate available nutrients when the plant needs it the most.

Give your crops a strong and uniform emergence with NACHURS in-furrow starter. When used as a foliar fertilizer the nutrients are absorbed quickly throughout the plant for a healthier crop. NACHURS products offer flexible application options to fit most crops and production practices. NACHURS liquid fertilizers can also be tank-mixed with most crop protection products to save growers time and money. Below is a summary of the features and benefits that NACHURS products offers their growers:

**▶ TOP QUALITY RAW MATERIALS**
NACHURS fertilizers are manufactured with the highest quality raw materials to provide ease of application, available nutrients, and crop safety.

**▶ LOW SALT INDEX & HIGH SOLUBILITY**
NACHURS fertilizers have a lower salt index and higher solubility.

**▶ CHLORIDE-FREE & LOW IMPURITIES**
NACHURS fertilizers are chloride-free and contain minimal heavy metals and impurities.

**▶ NON-CORROSIVE**
NACHURS fertilizers will not corrode your application equipment and storage tanks. Our products are environmentally friendly!

**▶ LOW APPLICATION RATES & STORAGE**
NACHURS fertilizer products store well and have lower application rates, requiring less storage capacity.

**▶ SALES, AGRONOMIC, & TECHNICAL SUPPORT**
NACHURS fertilizers have the most comprehensive sales, agronomic, and technical sales support in the industry.

**▶ EQUIPMENT REBATE**
To use NACHURS liquid fertilizers, your planter/drill may need modifications for in-furrow or precision placement. Ask your NACHURS authorized dealer about the Equipment Rebate Program, which offers rebates based on gallons purchased.

4 nutrient stewardship PARTNER

NACHURS liquid fertilizers are complementary to the 4Rs of Nutrient Stewardship as it encourages using the right fertilizer source, at the right rate, at the right time, and in the right place.


**RIGHT SOURCE**
Matches fertilizer type to crop needs.


**RIGHT RATE**
Matches amount of fertilizer to crop needs.

**RIGHT TIME**
Makes nutrients available when crops need them.

**RIGHT PLACE**
Keeps nutrients where crops can use them.

# Balanced Plant Nutrition Overview

Making the most efficient use of your dollars spent on crop nutrition is a constant goal of all growers today. As crop nutrition prices increase, each grower tries to maintain the balance between obtaining higher crop yields and staying within an overall crop inputs budget to obtain the highest possible profit level from each field.

We recognize this continual challenge that growers face each year as they prepare their crop plans for another growing season. Trying to bring about the economic balance with the natural and ever changing environmental conditions can be very frustrating. Our goal is to reduce the risk from variable weather conditions by managing the nutritional requirements for the crop in a balanced, timely manner to maximize net profits. This approach ensures the crop has the proper nutrition at each of its growth stages yet allows growers to be flexible in applying nutrients as the growing conditions vary during the season. The plant must have the proper balanced nutrition to be able to succeed under a variety of adverse conditions. While our products are part of a complete fertilizer package, they are not meant to replace your base fertility program.

## ▶ PLANTING

Once the seed has germinated, nutrition for the young seedling is provided by the starter nutrition program. One of the limiting factors affecting nutrient uptake of starter nutrition early in the season is soil temperature. Many growers today cannot seed all of their acres at the most opportune time so steps need to be taken to overcome this unavoidable problem. Healthy seedlings that are vigorous help to reduce the stresses brought on by harsh environmental conditions and seedling diseases. Phosphate and potassium are key nutrients for the establishment of a healthy crop. Once the root mass has been established, the plant is able to take advantage of the nutrients from the base fertility program.

Starter fertilizers require time to dissolve or to break down the polyphosphates into the plant available orthophosphate form. NACHURS starters are already in a liquid soluble form and 80-100% of the phosphate is in the orthophosphate form. The majority of potassium in the soil is not available to be taken up by the plant; it is commonly recognized that approximately 1% of the soil resident potassium is readily available in the soil solution making it available for exchange within the soil complex and plant uptake. NACHURS liquid fertilizers are very efficient in supplying nutrients for plant uptake even under cold, dry soil conditions. The low use rate of NACHURS fertilizers helps to reduce the overall time and handling of supplying crucial nutrients and helps increase planting efficiency. Growers can also easily apply any additional NACHURS micronutrients to balance the crop's nutritional requirements.

## ▶ VEGETATIVE & REPRODUCTIVE STAGES

Foliar applied plant nutrition supplies the crop with further nutrition determined by environmental conditions and by soil and plant tissue tests, maximizing yield potential and nutrient efficiency. Depending on the plant's requirements, NACHURS foliar nutrition products can be applied economically with many crop protection products at various stages. This dual application increases a grower's time efficiency and reduces application costs. NACHURS has developed several foliar nutrition products which can be mixed with additional NACHURS micronutrients to provide the proper nutrition solution.

NACHURS foliar nutrition programs give the grower the flexibility to reduce the base fertilizer program and then manage the remaining nutrient budget in a manner which ensures the efficient use of each nutrient by the plant. In doing so, the grower is proactively reducing their risk with environmental conditions and increasing profit potential.

▲ Highly available liquid fertilizer seed-placed and available in cold soils

▲ Herbicide timing

▲ Fungicide timing

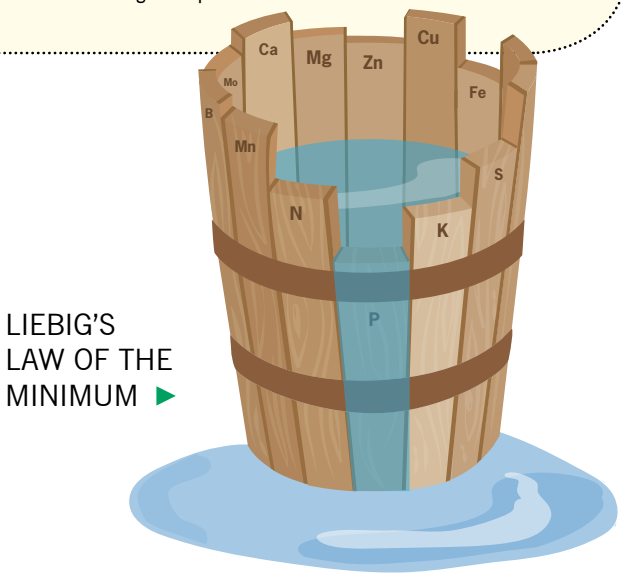
# Nutrient Functions and Interactions

All plants, whether it be corn, soybeans, wheat, cotton, cranberries, or canola, require nutrients for proper growth and development. About 90-95% of plant dry matter is composed of carbon, hydrogen, and/or oxygen. The remaining 5-10% is obtained from the soil and/or from fertilizer supplied by the grower. We may understand the importance of primary nutrients (nitrogen, phosphorus, potassium) in achieving production goals that are set each year, however, we often forget the importance of secondary nutrients (calcium, magnesium, sulfur) and micronutrients (boron, copper, iron, manganese, molybdenum, zinc) in the overall process of plant growth and development. Although these nutrients are required in much smaller quantities, they are essential for completion of many physiological cycles and processes within the plant. In many cases, plants cannot fully utilize primary nutrients without adequate supplies of secondary and/or micronutrients supplied at the appropriate time. Below is a listing of functions these nutrients provide within the plant.

| NUTRIENT | FUNCTION IN THE PLANT |
|---|---|
| **Nitrogen (N)** | • Converts to amino acids, the building blocks for proteins<br>• Produces necessary enzymes and structural parts of the plant<br>• Becomes part of the stored proteins in the grain<br>• Works with chlorophyll to utilize the sunlight as an energy source<br>• Needed for rapid growth and full development |
| **Phosphorus (P)** | • Needs to be available during early development for max yield potential<br>• Needed for strong root development<br>• Encourages early plant growth for longer growing seasons<br>• Provides required energy for nutrient transport<br>• Plays a vital role in photosynthesis<br>• Essential in providing the genetics for all plant growth and development |
| **Potassium (K)** | • Plays a vital role in photosynthesis<br>• Regulates water use with stomatal activity<br>• Keeps transportation systems functioning normally<br>• Required for protein synthesis and starch synthesis<br>• Enhances quality by improving disease resistance and stress management |
| **Sulfur (S)** | • Mirrors phosphorus requirements in plants<br>• Primary constituent of many amino acids<br>• Aids in activation of enzymes and vitamins<br>• Needed for chlorophyll formation<br>• Used in nitrogen stabilization<br>• Nodulation in legume crops |

| NUTRIENT | FUNCTION IN THE PLANT |
|---|---|
| **Calcium (Ca)** | • Necessary for the proper functioning of growing points<br>• Forms compounds which strengthen cell walls<br>• Aids in cell division and elongation<br>• Neutralizes organic acids<br>• Regulates protein synthesis and slows the aging process |
| **Magnesium (Mg)** | • Only mineral component of the chlorophyll molecule<br>• Aids in formation of sugars and starches<br>• Plays important part in phosphorus translocation<br>• Aids in proper functioning of plant enzymes |
| **Boron (B)** | • Required for cell division<br>• Plays important part in calcium translocation<br>• Protein synthesis and hormone formation<br>• Carbohydrate metabolism<br>• Pollen viability<br>• Flower formation and fruit set |
| **Copper (Cu)** | • Required for chlorophyll production<br>• Aids in photosynthesis and enzyme formation<br>• Involved in oxidation-reduction reactions<br>• Regulates water movement in cells<br>• Needed for seed production |
| **Iron (Fe)** | • Necessary for the formation of chlorophyll<br>• Involved in oxidation process that releases energy from starches<br>• Protein formation<br>• Aids conversion of nitrate to ammonia in cells<br>• Plant respiration |
| **Manganese (Mn)** | • Essential for chlorophyll production and photosynthesis<br>• Aids in carbohydrate metabolism<br>• Oxidation-reduction reactions<br>• Enzyme activation<br>• Combines with iron, copper, and zinc in hormone balance |
| **Molybdenum (Mo)** | • Co-factor in nitrate reductase enzyme<br>• Essential for rhizobia in nitrogen fixation process<br>• Aids in nitrate utilization<br>• Involved in phosphate and iron metabolism |
| **Zinc (Zn)** | • Necessary in chlorophyll formation<br>• Involved in enzyme activation and production<br>• Required in hormone (auxin) and nucleic acid synthesis<br>• Aids in uptake and water use efficiency |

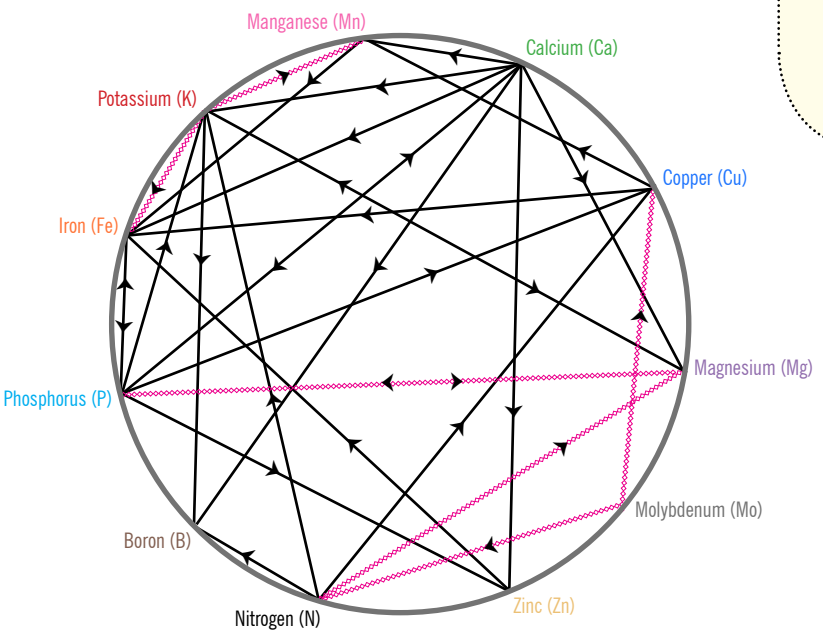
Most growers are well aware of Liebig's Law of the Minimum which states that any deficiency in a nutrient, no matter how small, will hold back the yield potential. As growers have evolved their crop nutrition programs to provide the maximum nutrients to achieve optimum yields, it is often a micronutrient deficiency that is restricting the plant from reaching its genetic potential.




LIEBIG'S LAW OF THE MINIMUM ▶

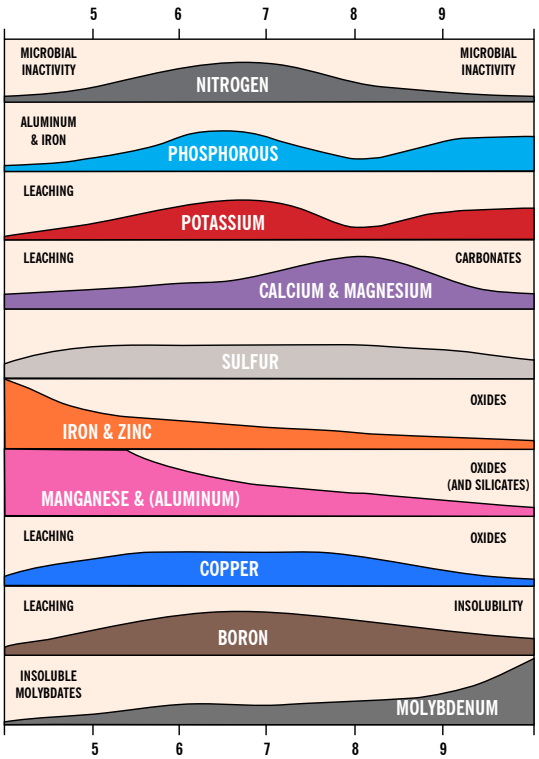
▲ A crop with a potassium deficiency greatly improves after a dose of **NACHURS K-fuel®**, powered by Bio-K®.

## MULDERS CHART ▼




SOURCE: SCHUTTE AND MYERS' BOOK

## SOIL pH ▼




**SOIL pH**

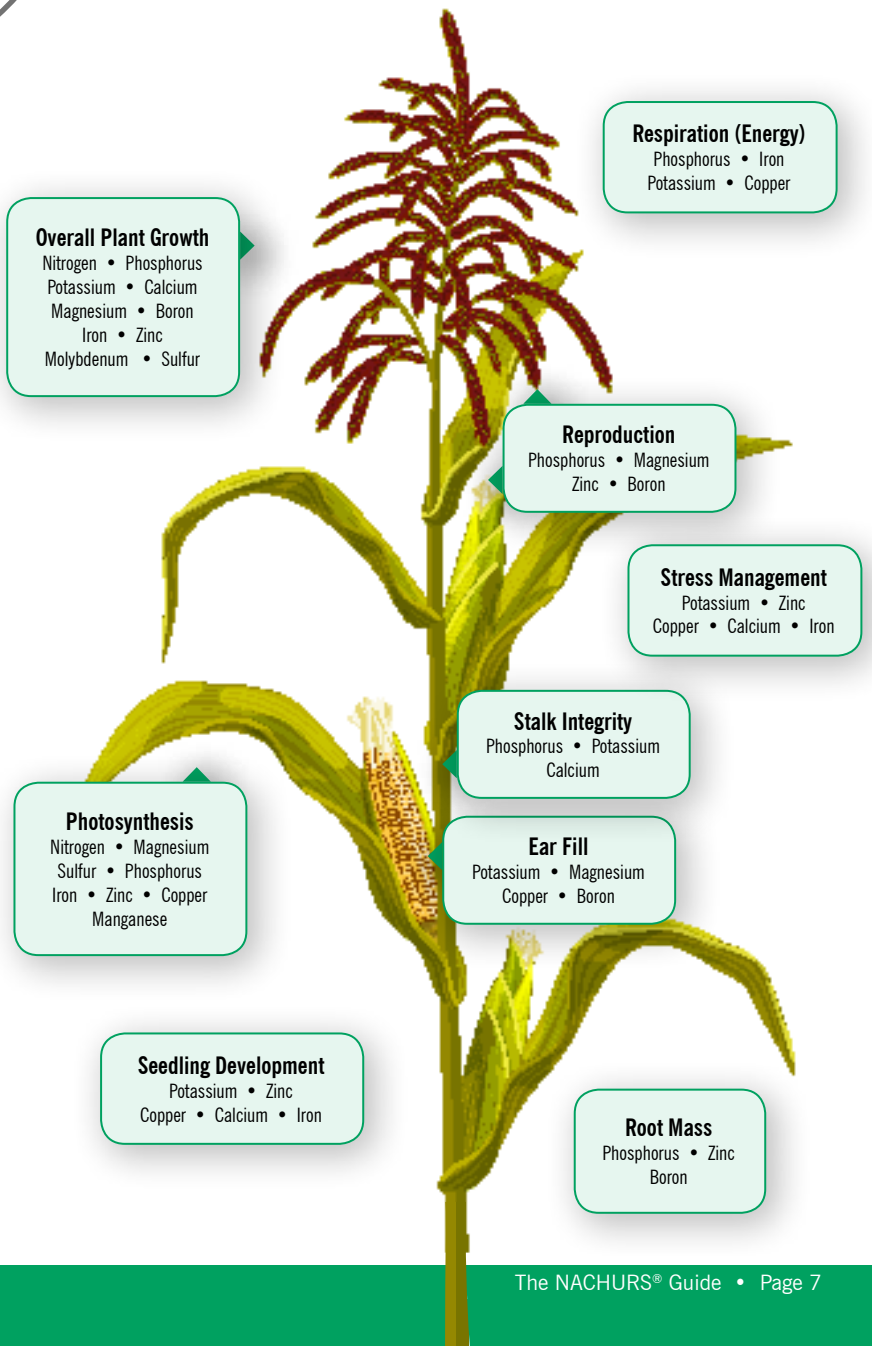
SOURCE: A&L LABS

Growers must take into account the interactions of nutrients with each other. Any over supply of one nutrient can cause another nutrient to become the limiting factor. Balance of nutrient supply is critical.

**ANTAGONISM** ——————>
A decrease in availability to the plant of a nutrient by the action of another nutrient.

**STIMULATION** ~~~~~~~~~~>
An increase in the need for a nutrient by the plant because of the increase in the level of another nutrient.

(see direction of arrows)



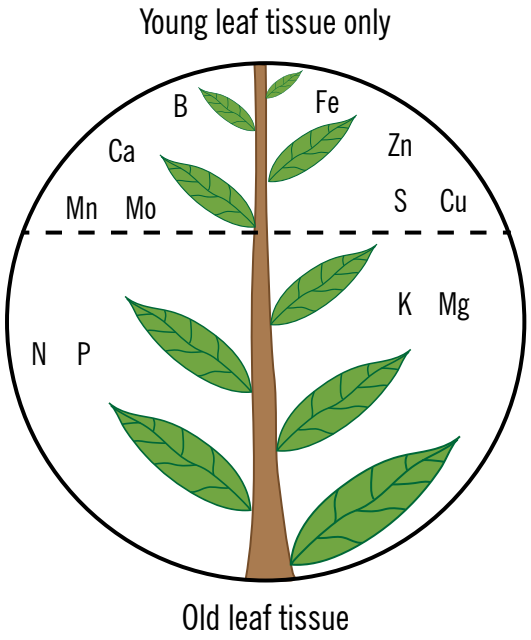
# Nutrient Deficiency Symptoms

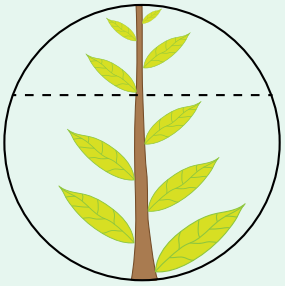
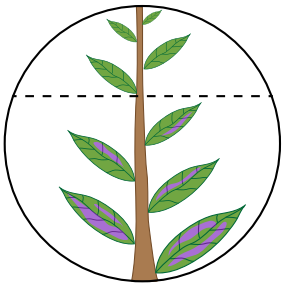
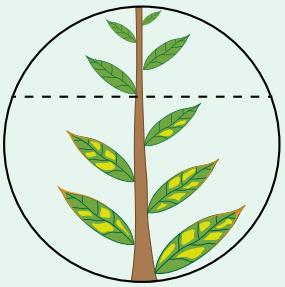
All twenty one nutrients required by the plant, including macronutrients, micronutrients, and secondary nutrients, must be in balance in order for the plant to maintain its utmost health to defend against unfavourable environmental conditions. A proper soil and tissue sampling program is key tool in managing plant nutrition.

| MACRONUTRIENTS | SECONDARY NUTRIENTS | MICRONUTRIENTS | |
|---|---|---|---|
| Nitrogen | Calcium | Boron | Manganese |
| Phosphorus | Magnesium | Zinc | Copper |
| Potassium | Sulfur | Molybdenum | Iron |

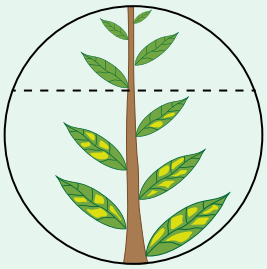
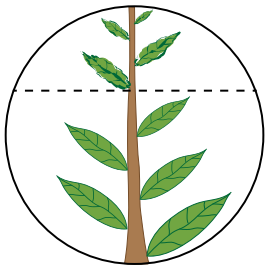
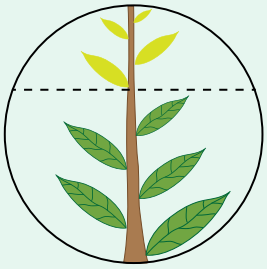
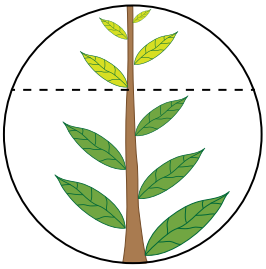
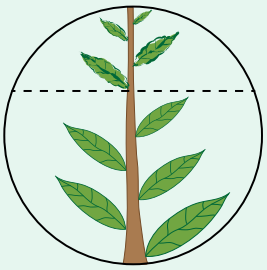
Micronutrient deficiencies are likely when one of the following conditions apply:

- Removal of large amounts by high yielding crops
- Leaching from sandy soils
- Naturally high pH soils
- Over-limed soils resulting in a high pH
- Land leveling
- Additions of high rates of phosphorus
- Soil compaction
- Cool, wet growing conditions
- Tie-up by the soil
- Use of sensitive crop varieties




| Nutrient | Position on plant | Chlorosis? | Leaf margin necrosis? | Color and leaf shape | Diagram | NACHURS® Product |
|---|---|---|---|---|---|---|
| Nitrogen (N) | All leaves | Yes | No | Yellowing of leaves and leaf veins |  Nitrogen (N) Deficiency | **NACHURS SRN®**<br>**NACHURS N-Rage Max®**<br>**NACHURS Finish Line®**<br>**NACHURS imPulse®** |
| Phosphorus (P) | Older leaves | No | No | Purplish patches |  Phosphorus (P) Deficiency | **NACHURS imPulse®**<br>**NACHURS TMR-F®**<br>**NACHURS Triple Option®**<br>**NACHURS Finish Line®**<br>**Aqua-Tech® 7-20-4***<br><br>* For overhead irrigation |
| Potassium (K) | Older leaves | Yes | Yes | Yellow patches |  Potassium (K) Deficiency | **NACHURS K-fuel®**<br>**NACHURS K-flex®**<br>**NACHURS Triple Option®**<br>**NACHURS Finish Line®**<br>**NACHURS TMR-F®**<br>**NACHURS playmaKer®**<br>**Rhyzo-Link® 3-10-13**<br>**Rhyzo-Link® 0-0-15**<br>**Aqua-Tech® 2-0-20** |

SOURCE: INTERNATIONAL PLANT NUTRITION INSTITUTE (IPNI)

| Nutrient | Position on plant | Chlorosis? | Leaf margin necrosis? | Color and leaf shape | Diagram | NACHURS® Product |
|---|---|---|---|---|---|---|
| Magnesium (Mg) | Older leaves | Yes | No | Yellow patches |  Magnesium (Mg) Deficiency | **NACHURS® 2.5% Mg EDTA** |
| Calcium (Ca) | Young leaves | Yes | No | Deformed leaves |  Calcium (Ca) Deficiency | **NACHURS® 3% Ca EDTA**<br>**NACHURS Liqui-Cal®** |
| Sulfur (S) | Young leaves | Yes | No | Yellow leaves |  Sulfur (S) Deficiency | **NACHURS K-flex®**<br>**Aqua-Tech® 2-0-20**<br>**Rhyzo-Link® 0-0-15** |
| Manganese (Mn)<br><br>Iron (Fe) | Young leaves | Yes | No | Interveinal chlorosis |  Manganese (Mn) and Iron (Fe) Deficiency | **NACHURS® 6% Mn EDTA**<br>**NACHURS® 4.5% Fe EDTA**<br>**NACHURS Finish Line®** |
| Boron (B)<br><br>Copper (Cu)<br><br>Molybdenum (Mo)<br><br>Zinc (Zn) | Young leaves | -- | -- | Deformed leaves |  Boron (B), Copper (Cu), Molybdenum (Mo), and Zinc (Zn) Deficiency | **NACHURS® 10% Boron**<br>**NACHURS® 7.5% Cu EDTA**<br>**NACHURS® 9% Zn EDTA**<br>**NACHURS Finish Line®** |

rhyzo-LINK®

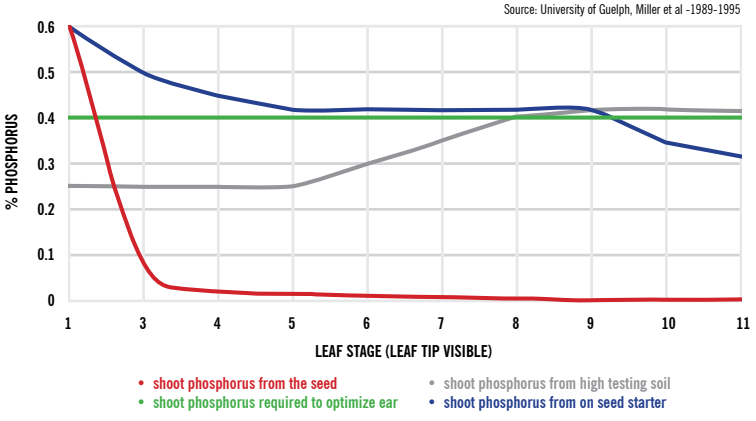
The microbiology in Rhyzo-Link® products react synergistically within the rhizosphere and with the plant to promote beneficial responses that improve soil productivity and plant health along with crop performance.

"Soil health has been defined as the capacity of soil to function as a living system. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, form beneficial symbiotic associations with plant roots, recycle essential plant nutrients, improve soil structure with positive effects for soil water and nutrient holding capacity, and ultimately improve crop production. A healthy soil also contributes to mitigating climate change by maintaining or increasing its carbon content."

- Food and Agriculture Organization of the United Nations

**Phosphorus Concentration in the Corn Shoot**

Source: University of Guelph, Miller et al -1989-1995



# Starter Nutrition

Starter nutrition is a key component of any balanced nutrition program. Starters provide the emerging seedlings with essential nutrients which are accessible near the young roots just as the sugars and starches are being depleted from the germinated seed. By encouraging vigorous seedling development through the use of a seed-placed starter, opportunity for greater yield and plant health can be positively impacted. Robust seedling development can better resist insect and disease pressure as well as thrive more effectively with any competing weeds.

In starter nutrition, phosphorous (liquid or dry) is a key nutrient since it is practically immobile in the soil and is known to promote vigorous root growth. A small amount of nitrogen in the starter provides the nutrition needed early on for rapid growth and full development without causing seedling injury. The addition of potassium in the starter enhances crop quality and improves disease resistance. If soil tests call for micronutrients, then it is most efficient to place them close to the seed with the starter nutrition for maximum benefit.

Starter nutrition can be described as the catalyst to achieve the full genetic yield potential of the plant. To increase the probability of the emerging seedlings roots and making contact with this catalyst, one can control its placement with properly equipped planters. By placing the starter nutrition as close to the seed as possible the efficiency in nutrient uptake by the plant is maximized.

Synergistic effect of nitrogen and potassium on the uptake of phosphorous:

| Treatment | % P Absorbed |
|---|---|
| P alone | 12.1 |
| N+P | 20.3 |
| P+K | 13.1 |
| N+P+K | 22.3 |

–Dr. John Strauss
Director of Agronomy Services, Tulsa, Oklahoma

## ▶ NITROGEN

Most plants absorb a majority of their nitrogen in the nitrate ($NO_3^-$) form and to a lesser extent the ammonium ($NH_4^+$) form. Plant growth seems to improve when a combination of ammonium and nitrate nitrogen is taken up by the plant. Once inside the plant, the nitrate transforms to $NH_4$-N through energy provided by photosynthesis.

**NITROGEN REQUIREMENTS**

| Corn | | Soybeans | | Wheat | | Alfalfa | |
|---|---|---|---|---|---|---|---|
| bu/A Yield | N lbs/A Required | bu/A Yield | N lbs/A Required | bu/A Yield | N lbs/A Required | tons/A Yield | N lbs/A Required |
| 150 | 199 | 40 | 220 | 50 | 105 | 5 | 300 |
| 175 | 233 | 55 | 303 | 75 | 158 | 7.5 | 450 |
| 200 | 266 | 70 | 385 | 100 | 210 | 10 | 600 |

Inside the plant, nitrogen converts to amino acids, the building blocks for proteins. These amino acids are then used in forming protoplasm, which is used in cell division. These amino acids are also utilized in producing necessary enzymes and structural parts of the plant and can become part of the stored proteins in the grain.

Nitrogen serves as the source for the dark green color in the leaves of various crops. This is a result of a high concentration of chlorophyll. Nitrogen combined with high concentrations of chlorophyll utilizes the sunlight as an energy source to carry out essential plant functions including nutrient uptake.

Chlorophyll is associated with the production of simple sugars from carbon, hydrogen, and oxygen. These sugars along with their conversion products play a role in stimulating plant growth and development along with higher protein content in the grain.

## ▶ PHOSPHORUS

Plants take in phosphate in the orthophosphate form of $H_2PO_4$ and $HPO_4^{2}$. Traditional liquid phosphate fertilizers are 70% polyphosphate which must convert into the orthophosphate form in the soil solution. Although some polyphosphates will decompose without enzyme interaction, the primary conversion factor is enzymes produced by microorganisms and plant roots.

**CONVERSION OF POLYPHOSPHATE TO ORTHOPHOSPHATE**

| Soil pH | Days After Application | % Remaining In Polyphosphate Form |
|---|---|---|
| 4 | 100 | 50 |
| 7.2 | 30 | 50 |

Source: Sutton and Larson, Soil Science 97

### ORTHOPHOSPHATE

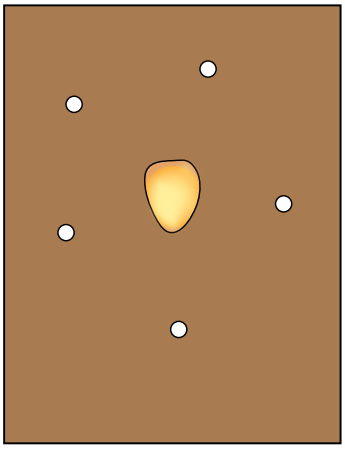
Each molecule contains a single atom of phosphorus. In simple terms, this looks like the individual links in a chain not being connected. In this form a plant can readily absorb the phosphorus.

### POLYPHOSPHATE

Poly means “many” and refers to multiple linkages of phosphorus in each molecule. In simple terms, this would look like a chain with the links connected. Here the polyphosphate form must go through a chemical reaction converting it into the orthophosphate form to be readily available for the plant to absorb the phosphorus. There are a variety of factors that can affect the conversion of the polyphosphate to the orthophosphate form. These include soil temperature (cooler temperatures can lengthen the conversion time), soil pH, clay content of the soil, application method, along with several other factors.

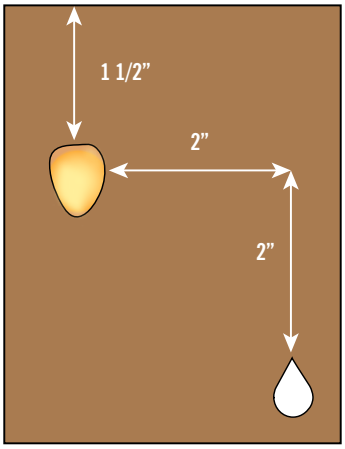
## Precision Placement

**BROADCAST- No Efficiency**



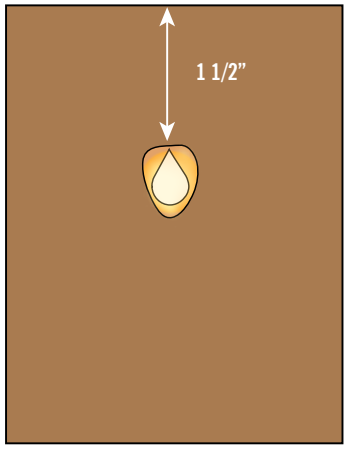
Leaves plant potentially short of P at a critical growth stage. Crop roots likely will not come in contact with the fertilizer during early growth as P only moves 1/10" in the soil.

**BANDED 2"x 2"- Inefficient**




Leaves plant potentially short of P at a critical growth stage. Roots may or may not come in contact with fertilizer during critical growth period. Crop roots will come into contact with approximately only 2% of the soil.

**IN-FURROW- Efficient**




Fulfills needs of the young plant in regard to P requirements. Phosphorus placed for maximum plant efficiency. Roots are in immediate contact with the fertilizer.

◀ NACHURS liquid starters can be placed directly on the seed safely, while other starters such as 10-34-0 should be banded because of their high salt index.

Since all plants must drink their food, dry forms of phosphate fertilizer which are already in the orthophosphate form must convert into a solution in the soil before the plant can uptake the nutrient. The conversion rates of both of these processes are dependent on soil moisture and temperature conditions.

Numerous studies have shown that a lack of phosphate early in plant growth will negatively affect the yield and maximum yield cannot be achieved even if phosphate availability or additional supply is available to the plant at later growth stages.

Work by the University of Guelph has show that the phosphate supply from seed placed starter fertilizers will provide the required amount of phosphate to the plant at this critical stage in plant development. The plant is unable to source enough phosphate from the soil at this stage even in soils which test high for available phosphate. NACHURS liquid fertilizers are 80-100% orthophosphate and are specifically manufactured to be placed directly on the seed.

> "The final grain yield is influenced by the tissue phosphorus concentration prior to the 6-leaf stage, regardless of the P supply at later stages."
>
> –Univesity of Guelph, Miller ET AL. 1988

**POTASSIUM REQUIREMENTS**

| Corn | | Soybeans | | Wheat | | Alfalfa | |
|---|---|---|---|---|---|---|---|
| bu/A Yield | $K_2O$ Required | bu/A Yield | $K_2O$ Required | bu/A Yield | $K_2O$ Required | tons/A Yield | $K_2O$ Required |
| 150 | 199 | 40 | 97 | 50 | 90 | 5 | 250 |
| 175 | 233 | 55 | 134 | 75 | 135 | 7.5 | 375 |
| 200 | 266 | 70 | 170 | 100 | 180 | 10 | 500 |

## ▶ POTASSIUM

The plants absorb the ionic form of potassium ($K^+$) from the soil. Plant roots will only come in contact with approximately 2% of the soil area. This is very critical in potassium management. Once the plant is growing, the potassium ion will only move a limited distance through the soil solution by diffusion during the growing season.

Potassium is one of the greatest investments in protecting a crop. It has the ability to strengthen stalks and stems, protecting the plant from lodging. It has the ability to make plant cells thicker to endure stressful conditions. In alfalfa and other forage crops, it is essential in providing optimum nutrition for winter hardiness. In soybeans potassium has proven to increase seed and grain quality by reducing the number of infected and shriveled seeds.

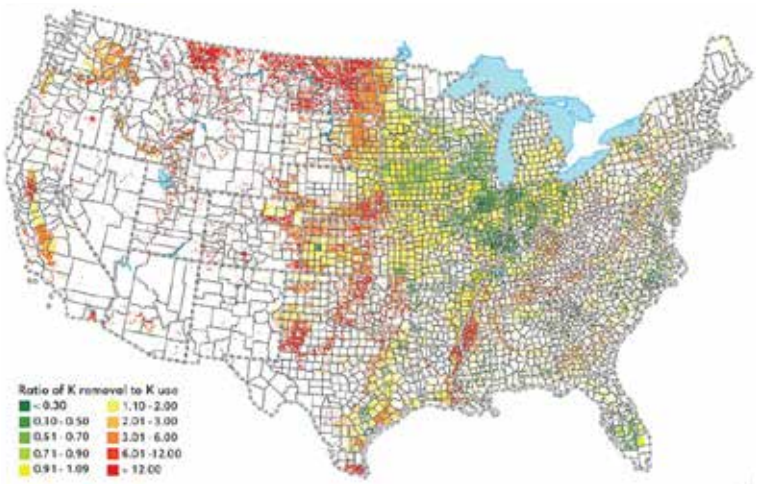
Potassium has this impact because it is involved in over sixty enzyme systems that regulate plant growth reactions. One of these major roles is in regulating water use efficiency in the plant. The opening and closing of the stomates in the leaves is directly related to the concentration of potassium in the cells that surround the stomates. If the plant has a shortage of potassium, the stomates will only open partially and be slower in closing.

Potassium is also vital in photosynthesis. If a plant is deficient in potassium, photosynthesis will decline, in turn, the plants respiration rate increases causing the plant's carbohydrate supply to decrease. Carbohydrates provide energy for plant growth when they are broken down, which potassium plays a key role in.

## POTASSIUM TECHNOLOGY: NACHURS® Bio-K®

NACHURS offers a potassium-based fertilizer technology: NACHURS® Bio-K®. This technology is a combination of an inorganic salt reacted with an organic acid to form a potassium acetate fertilizer. What makes Bio-K® unique is in the origination of its organic-based carrier (anion), the acetate molecule. Acetate is a natural plant metabolite that has many important functions within the plant as well as in the symbiotic relationship between plant roots and soil microbes/mycorrhizal fungi. Acetate is also a very important part of signaling compounds (flavonoids, lipochitooligosaccharides, etc.) which promote plant-soil microbe relationships and increased plant productivity. Since the carrier portion of Bio-K® is a natural plant metabolite, it is more rapidly and readily taken up by plants, which in turn leads to increased potassium use efficiency and higher productivity.

### Map of potassium removal to potassium use ratios for the US in 2012




IPNI NuGIS (http://nugis.ipni.net)

bio-K®

Not all potassium is created equal. Bio-K® is the preferred source of potassium for plant uptake due to the acetate carrier molecule: more efficient and readily absorbed by the plant. Just because a soil test may say there is plenty of potassium for optimum production, that does not mean it is all available during the growing season.

"A higher starter rate won't compensate for fertilizer being farther from seed. The closer the starter is to the seed, the better the response is."

–Ken Ferrie, Farm Journal Agronomist

nutrient stewardship

Stewardship, sustainability, and efficiency are essential to help feed the world. We must change how we grow a bushel of corn, a bale of cotton, a bag of potatoes, a ton of forage...

"One of the touted benefits of foliar fertilization is the increased uptake of nutrients from the soil."

–George Kuepper, NCAT Agriculture Specialist, Foliar Fertilization, 2003

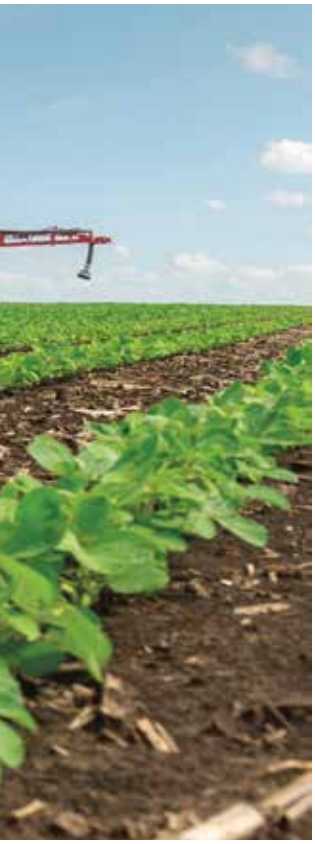
| RATE OF FOLIAR ABSORPTION | |
|---|---|
| **NUTRIENT** | **TIME FOR 50% ABSORPTION** |
| Nitrogen (As Urea) | 1/2 - 2 hours |
| Phosphorus | 5 - 10 days |
| Potassium | 10 - 24 hours |
| Calcium | 10 - 94 hours |
| Magnesium | 10 - 24 hours |
| Sulfur | 5 - 10 days |

Source: Michigan State University

| POUNDS OF SOIL APPLIED NUTRIENTS REPLACED BY ONE POUND OF FOLIAR APPLIED NUTRIENT | | |
|---|---|---|
| **NUTRIENT** | **FOLIAR** | **SOIL** |
| **N** | 1 | 4 |
| **P** | 1 | 20 |
| **K** | 1 | 6 |
| **S** | 1 | 5 - 7 |
| **B** | 1 | 30 |
| **Cu** | 1 | 12 |
| **Mn** | 1 | 30 |
| **Mg** | 1 | 75 |
| **Zn** | 1 | 12 |

# Foliar Nutrition

The application of foliar nutrition has been in use for many years in high value specialized crops. As growers are looking to maximize net returns and nutrient efficiencies, the application of foliar nutrition is making its way into many of the progressive growers' crop nutrition programs. Growers are experiencing the positive effect this strategy has on increasing crop yields, nutrient efficiencies and reducing the impact that environmental factors impose on their nutrient programs.



The effectiveness of foliar applied nutrition was first reported by the Michigan State University in the early 1950s. The U.S. Atomic Energy Department provided the University with a grant and radioisotopes of all nutrients for them to study the rates of absorption and movement within the plant. These early studies concluded that foliar applied nutrients were 8-10 times more effective in supplying the required nutrients than soil applied nutrients.

Other work has established the equivalency of foliar applied nutrients to soil applied nutrition. This type of work confirms what growers are seeing in their fields when foliar nutrition is used with a base fertility program.

The advantages of using foliar applied nutrition with a base fertility program are:

- Correct nutrient deficiencies as determined from soil or tissue tests
- Strengthen damaged crops
- Speeds up growth
- Stimulate root uptake
- Provide nutrient efficiency

Foliar nutrition results are highest when the plant is showing high growth activity, going from the vegetative to reproductive stage and when deficiencies are present or when the crop has been damaged. To achieve the best results, the foliar product should contain nitrogen to act as an electrolyte to carry the other nutrients and phosphorous to move the nutrients within the plant.

The foliar nutrients enter the plant through the leaf stomata and hydrophilic pores in the leaf cuticle. The nutrients are only absorbed while in solution on the leaf surface. For this reason, applications are best made in mornings and evenings when heavy dew is on the leaf surface, when there is high humidity, and temperatures are below 68°F.

The initial benefit of a foliar application is an increase in chlorophyll synthesis which can often result in leaves turning a darker green. The increase in photosynthetic activity will stimulate extra root growth; in turn the root hairs excrete excess sugar which stimulates microbial colonies. These bacterial colonies provide auxins and other root stimulating compounds. With the increase in cellular activity gas exchange increases the uptake of water. As the roots take up more water they also bring in more of the nutrients from the soil solution. The foliar application stimulates the entire "pumping system" in the plant to increase the uptake of the base applied nutrition.

Crops benefit in two manners by the foliar application of nutrients:

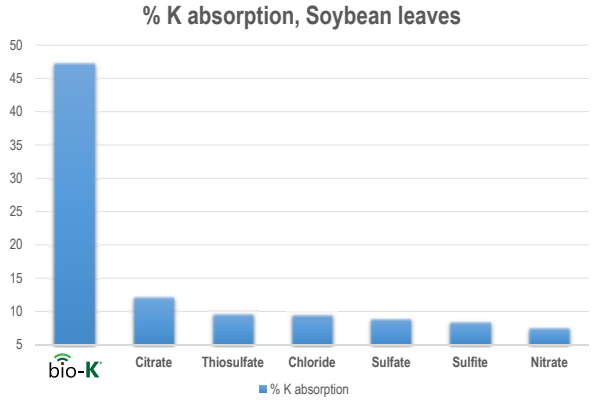
1) by the rapid influx into the plant of the foliar applied nutrients
2) by the increased uptake of the base applied nutrients

This planned approach, utilizing staged foliar applications, delivers the highest efficiency of nutrients and the greatest ability to minimize negative influences of stress factors which in turn creates the highest return on the investment of the grower's crop nutrition program.

## ▶ N-P-K

Foliar feeding maintains a nutrient balance within the plant, which may not occur strictly with soil uptake. Absorption of essential nutrients through the plant's roots may at times be limited by root distribution, soil temperature, soil moisture, or soil nutrient imbalances or other factors. Primary nutrients that are foliar fed are mobile and will be transported throughout the plant. Potassium is readily absorbed and highly mobile. Phosphorus is absorbed at a slower rate, but is also mobile and transported at a rapid rate.

**Foliar absorption of potassium after 48 hours from organic and inorganic K carriers**




Journal of Plant Nutrition, 9(2), 143-157 (1986)

## ▶ SLOW RELEASE N (SRN)

Slow release nitrogen products allow plants to absorb nitrogen on the leaf surface several weeks after foliar spraying. Nitrogen is a critical component throughout the growth and development of plants, and when used in conjunction with N-P-K fertilizers, can help maximize yields. Slow release nitrogen products can also be incorporated with most crop protection chemical programs for timely applications.

## ▶ MICRONUTRIENTS

NACHURS micronutrients are versatile and can be easily mixed with most crop protection chemicals for timely applications.

"A nutritionally-balanced crop is much better able to withstand stresses put upon it by adverse growing conditions (cold or hot, dark or bright, wet or dry, etc., weather)."

– Noel Garcia, CCA, Technical Director, Texas Plant & Soil Lab

**MICRONUTRIENT RESPONSES**

| Crop | Mn | B | Cu | Zn | Mo | Fe |
|---|---|---|---|---|---|---|
| Corn | M | L | M | H | L | M |
| Soybeans | H | L | M | M | M | M |
| Wheat | H | L | H | L | L | L |
| Canola | M | H | H | M | L | |
| Alfalfa | M | H | H | L | M | M |
| Oats | H | L | H | L | L | M |
| Grass | M | L | L | L | L | H |
| Barley | M | L | M | M | L | H |
| Dry Beans | H | L | L | H | M | H |
| Potatoes | H | L | L | M | L | |
| Rye | L | L | L | L | L | |
| Peas | H | L | L | L | M | |

Legend: H... High M... Medium L... Low

# Secondary Nutrients and Micronutrients

Even though micronutrients are required in very small quantities, they are essential for healthy plant growth and profitable crop production. Most of the secondary nutrients and micronutrients can be provided to plants in a chelated form with the exception of sulfur, boron, and molybdenum. EDTA chelated micronutrients provide an economical source for correcting nutrient deficiencies and improving plant health. Preventing micronutrient deficiencies in a crop is far better than correcting them after symptoms appear.

Always refer to a soil or tissue report to determine the nutrients needed to correct micronutrient deficiencies.

## ▶ WHAT IS A CHELATE?

A chelate is a complex organic molecule that surrounds the nutrient ion. Chelates are used as carriers for micronutrients, to keep them in solution and protect them from reactions that cause the micronutrient to become insoluble and unavailable to the plant. Chelation allows nutrients to remain available to the plant even if environmental conditions are less than optimal. There are many forms of chelates that can be used, ranging from EDTA, citric acid, amino acids, and organic acids.

## ▶ THE EDTA DIFFERENCE

Unlike other micronutrient sources such as -complexes, partial chelates, and natural organic complexes, EDTA chelated micronutrients are 100% available to the crop. Other micro sources contain too little complexing agent and undergo major chemical changes, delivering significantly less micronutrient in a form available for plant uptake. While these sources of micros may offer cost savings at first, they can actually create deficiencies for lack of nutrient availability.

| Type of Micronutrient | Chemical | Stability | The Facts |
|---|---|---|---|
| Chelated | EDTA<br>DTPA<br>EDDHA | Strong | Stable at high pH<br>Stable with phosphates<br>Crop safe |
| Sequestered | Phenolics<br>Lignosulphonates | Moderate | Only for foliar application |
| Complexed | Amino Acids<br>Citrates<br>Glucoheptonates | Weak | Cheap but poor storability |
| Inorganic | Sulfates<br>Nitrates<br>Carbonates | None | Only for foliar application<br>High rates required<br>Risk of phytotoxicity |

EDTA fully chelated micronutrients are specifically formulated to prevent nutrient tie up. With the EDTA chelating process, a ring-like structure is placed around the micronutrient, protecting it from being tied up with the soil or other nutrients, thus ultimate nutrient availability to the plant is assured, and deficiencies can be corrected.

### NACHURS® 100% EDTA CHELATES

Other manufacturers do not offer EDTA chelates or use a percentage of EDTA and some other chelating agent. NACHURS micronutrients are fully chelated and can be applied to soil at planting time or foliar spray applied directly to the plant. The stability of NACHURS chelated micronutrients makes them compatible with most pesticides and won't settle out or react with other components in NACHURS liquid fertilizers. NACHURS 100% EDTA chelated micronutrients include: calcium, copper, iron, magnesium, manganese, and zinc.

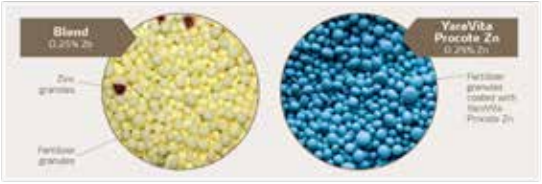
## ▶ MICRONUTRIENT COATING ON DRY NPK

Spreading fertilizer with a micronutrient coating guarantees accurate application of the micronutrient and reduces uneven distribution across the field. Coating ensures that every plant receives adequate micronutrients, which ensures optimum plant efficiency. The more even the supply of micronutrients, the easier it is for plant roots to reach these nutrients. Micronutrient uptake is therefore more efficient with even supply; plant roots need to reach available micronutrients.

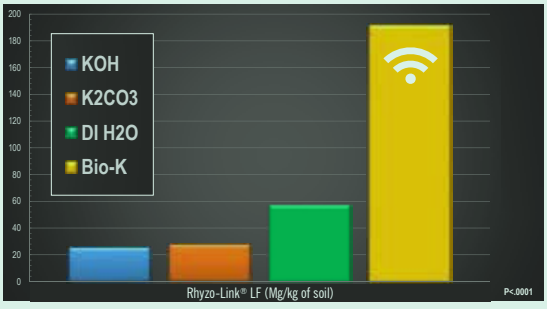
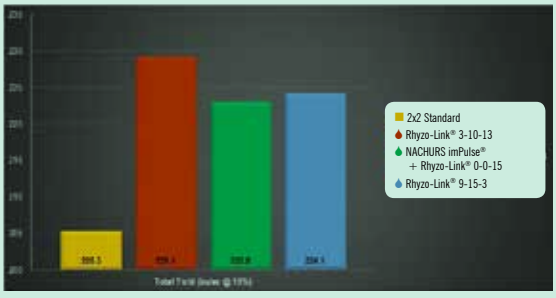
### YaraVita® PROCOTE® TECHNOLOGY

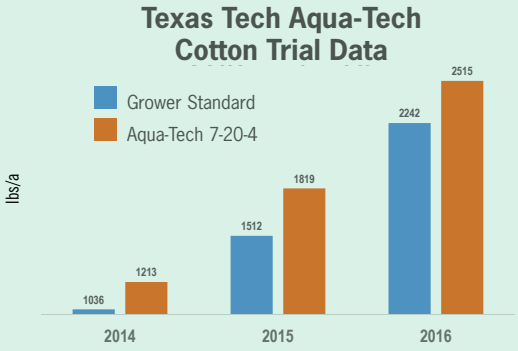
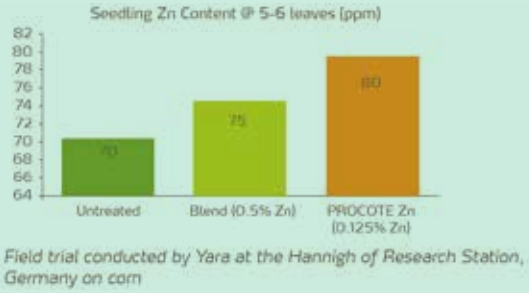
YaraVita PROCOTE is Yara's innovative range of liquid suspension fertilizer coatings. The micronutrients zinc, boron, copper, manganese and their combinations are available, offering three main benefits:

- Ensures even micronutrient supply with each fertilizer granule
- Enhanced micronutrient efficiency, crop performance, and improves yield
- Easily applied, saving time and resources



# NACHURS Technologies

| | bio-K® ELEVATE YOUR K® | rhyzo-LINK® RISE TO YOUR POTENTIAL® |
|---|---|---|
| Overview | NACHURS® Bio-K® is a premium source of potassium fertilizer combined with a natural plant metabolite; the most effective and efficient source of potassium. Using Bio-K® technology results in quicker germination, improved root development, and an elevated abiotic stress tolerance; leading to better plant establishment, more vigorous growth, and higher yields. | NACHURS® Rhyzo-Link® is a Proprietary Plant Growth Promoting Rhizobacteria (PGPR) technology paired with premium NPK fertilizer, delivering the highest concentration of multi-strain, pure culture rhizobacteria. Rhyzo-Link® is also powered by NACHURS® Bio-K®: a unique potassium technology. This technology ultimately leads to increased soil and plant health benefits resulting in maximum and sustainable yield potential. |
| The Technology | What makes Bio-K® unique is in the origination of its organic-based carrier (anion), the acetate molecule. Acetate is a natural plant metabolite that has many important functions within the plant as well as in the symbiotic relationship between plant roots and soil microbes/mycorrhizal fungi.<br><br>Since the carrier portion of Bio-K® is a natural plant metabolite, it is more rapidly and readily taken up by plants, which in turn leads to increased potassium use efficiency and higher productivity. | Rhyzo-Link® solutions are the next generation in plant fertility, combining a high quality NPK fertilizer with a pure culture, poly-microbial component (PGPR) for use in a wide range of environmental conditions and cropping systems. This "Bio-Charged" fertility solution is designed to provide greater nutrient utilization and efficiency via increased plant biomass, as well as better adaptability to biotic and abiotic factors which occur through numerous physical, chemical, and environmental interactions. Rhyzo-Link® solutions provide a buffering or moderating "link" between soil health/ chemistry and plant productivity through efficient balance, placement, and recovery of soil/plant nutrients. |
| The Science | The majority of potassium in the soil is not available to be taken up by the plant. Only 1% is readily available in soil solution and is available for cation exchange with soil colloids, therefore available to the growing crop.<br><br>Acetate fuels microbial growth, which leads to greater biomass carbon production and improved soil health. Soil health and microbial populations promote increased root growth. More roots leads to greater nutrient and water retention, increased plant growth, less soil erosion, and improved soil porosity. | Rhyzo-Link® is designed to build a healthy soil rhizosphere which can support increased plant growth and productivity. The rhizosphere is the narrow region of soil that is directly influenced by root secretions and associated soil microorganisms.<br><br>The rhizosphere contains many bacteria that feed on sloughed-off plant cells, and the proteins and sugars released by roots (root exudates). Protozoa and nematodes that graze on bacteria are also more abundant in the rhizosphere. Much of the nutrient cycling needed by plants occurs immediately adjacent to roots. |
| The Research | **2015 Texas A&M AgriLife Extension – Lubbock, TX**<br>**Soil microbial biomass carbon (SMBC) study***<br>  <br><br>*Application rate: 4 gal a.i./acre (93.5% K-salt + 6.5% PGPR) = 1.5 ul a.i./90 g soil | **2015-17 IRF Corn In-furrow**<br>**Standardized Trial Summary Yuma, Colorado**<br>  <br> |
| The Products | NACHURS imPulse®<br>NACHURS playmaKer®<br>NACHURS Triple Option®<br>NACHURS K-flex®<br>NACHURS K-fuel®<br>NACHURS K-fuse<br>NACHURS TMR-DP® | NACHURS Finish Line®<br>NACHURS N-Rage® Max<br>NACHURS® Rhyzo-Link® 0-0-15<br>NACHURS® Rhyzo-Link® 3-10-13<br>NACHURS® Rhyzo-Link® 9-15-3<br>NACHURS® Aqua-Tech® 2-0-20<br>NACHURS® Aqua-Tech® 7-20-4 | NACHURS® Rhyzo-Link® 0-0-15<br>NACHURS® Rhyzo-Link® 3-10-13<br>NACHURS® Rhyzo-Link® 9-15-3<br>NACHURS® Rhyzo-Link® LF<br>NACHURS® Rhyzo-Link® SI |

| | FERTIGATE WITH CONFIDENCE® | THE COLORS OF YIELD |
|---|---|---|
| Overview | NACHURS® Aqua-Tech® is a unique polyamine technology that allows for greater plant productivity through fertigation systems, delivering highly available low-salt nutrients safely and precisely. Offering much flexibility, Aqua-Tech® products can be used in-furrow and foliar on a variety of crops. Aqua-Tech® contains NACHURS® Bio-K® technology which ultimately leads to better plant establishment, more vigorous growth, and higher yields. | YaraVita® PROCOTE® is Yara's innovative range of liquid suspension fertilizer coatings. YaraVita® PROCOTE® ensures growers can reliably and accurately spread an even distribution of essential micronutrients on their growing crops; enhancing micronutrient efficiency, crop yield and quality. Fertilizer blenders will find YaraVita® PROCOTE® easy to use due to its benefits of significantly reduced dust and losses. |
| The Technology | Aqua-Tech® phosphorus chemistry refers to a polyamine molecule with proprietary additives and compatibility agents which helps protect phosphorus against adverse interaction with metals (calcium, iron, aluminum, etc.) and bicarbonates which may be contained in irrigation water sources. Products selected for this line have unsurpassed nutrient solubility and plant availability. Polyamine technology occupies the cations to prevent them from binding to plant available phosphate.<br><br>Aqua-Tech® also contains NACHURS® Bio-K® which has a lower molecular weight, lower salt content, and greater solubility. | YaraVita® PROCOTE® is a complete product range for production of high-quality, custom blended fertilizers. It can be applied to a broad variety of fertilizer types. Liquid-based micronutrient suspension is sprayed in small quantities into the blending vessel. It completely coats every fertilizer granule, resulting in a dry, dust-free end product, free-flowing and ready to use.<br><br>Other coating technologies rely on micronutrient powders which can result in significant micronutrient loss due to dust off and segregation. YaraVita® PROCOTE® offers a superior solution using Yara's proprietary, innovative liquid suspensions. Yara is able to eliminate micronutrient loss which ensures the farmer receives what they pay for. |
| The Science | Properly-managed applications of plant nutrients through all sources of fertigation significantly enhance fertilizer efficiency. Fertigation through drip irrigation is gaining recognition as a best management practice and is one of the primary reasons many growers install drip irrigation.<br><br>Understanding the function and timing of key nutrients is an important aspect of utilizing SDI to maximize nutrient delivery. Nutrient concentration in row crops is often greater when the plant is small but nutrient uptake increases as the plant grows, with maximum uptake of many nutrients occurring during the reproductive phase. | Micronutrient deficiencies are widespread but remain mostly undetected. Steadily increasing crop yields further deplete soil micronutrient levels and can limit the growth and development of crops. This is often referred to as "hidden hunger". Adequate micronutrient supply limits the effect of hidden hunger.<br><br>Micronutrients are essential for plant growth and health. Though these are required only in small quantities, they can make a big difference. Most farmers apply micronutrients only when symptoms appear. However, yields decrease long before symptoms appear. |
| The Research |  |  <br>*Field trial conducted by Yara at the Hannigh of Research Station, Germany on corn* |
| The Products | NACHURS® Aqua-Tech® 2-0-20<br>NACHURS® Aqua-Tech® 7-20-4 | YaraVita® PROCOTE® BCMZ<br>YaraVita® PROCOTE® BMZ<br>YaraVita® PROCOTE® B<br>YaraVita® PROCOTE® Cu<br>YaraVita® PROCOTE® Mn<br>YaraVita® PROCOTE® Zn |

# What if your crops could communicate?

bio-K® rhyzo-LINK® aqua-TECH® YaraVita® PROCOTE®

## They would ask for the latest NACHURS® Technologies.

Contact us today to learn about how to maximize yield and increase profitability with the best liquid fertilizer technologies on the market.

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