

Midwestern BioAg's SOILS GUIDE



WHY SOIL TEST?

The most valuable asset on any farm is the soil. And that soil is a unique asset — one farm's soil is different from what lies on neighboring farms. Nature, and a century of agricultural management, will do that.

The difference in soils between farms and fields means different inputs are needed for optimum performance. The fertilizer blend for a neighbor's farm — or an average farm, for that matter — may not be exactly right for yours. You can waste money, or your fields can underperform.

This is why we soil test. What we put on the soil should be determined by what's already in the soil. Thoughtful, informed input decisions for your farm start with these tests.

At Midwestern BioAg, we go beyond the standard P-K and pH soil tests. We conduct comprehensive secondary and trace mineral analyses to identify yield-limiting factors in your fields. These are the soil conditions that stop a plant from producing yields that match its genetic potential — a deficiency in just one trace mineral can have this effect.

With this booklet, we help you understand how to read your Midwestern BioAg soil sample. We explain the value of different types of organic matter, show the impact of cation exchange capacity (CEC), and offer a quick description of the minerals important to soil health. At the very back, we show results from a sample soil test, and offer nutrient and system targets for various soil types.

We encourage you to meet with your Midwestern BioAg consultant to discuss your soil reports and how we can help you build the kind of soil that helps you to grow healthier, more profitable crops and livestock in the short-term — while building soil health over the long-term.



Tear & Compare!

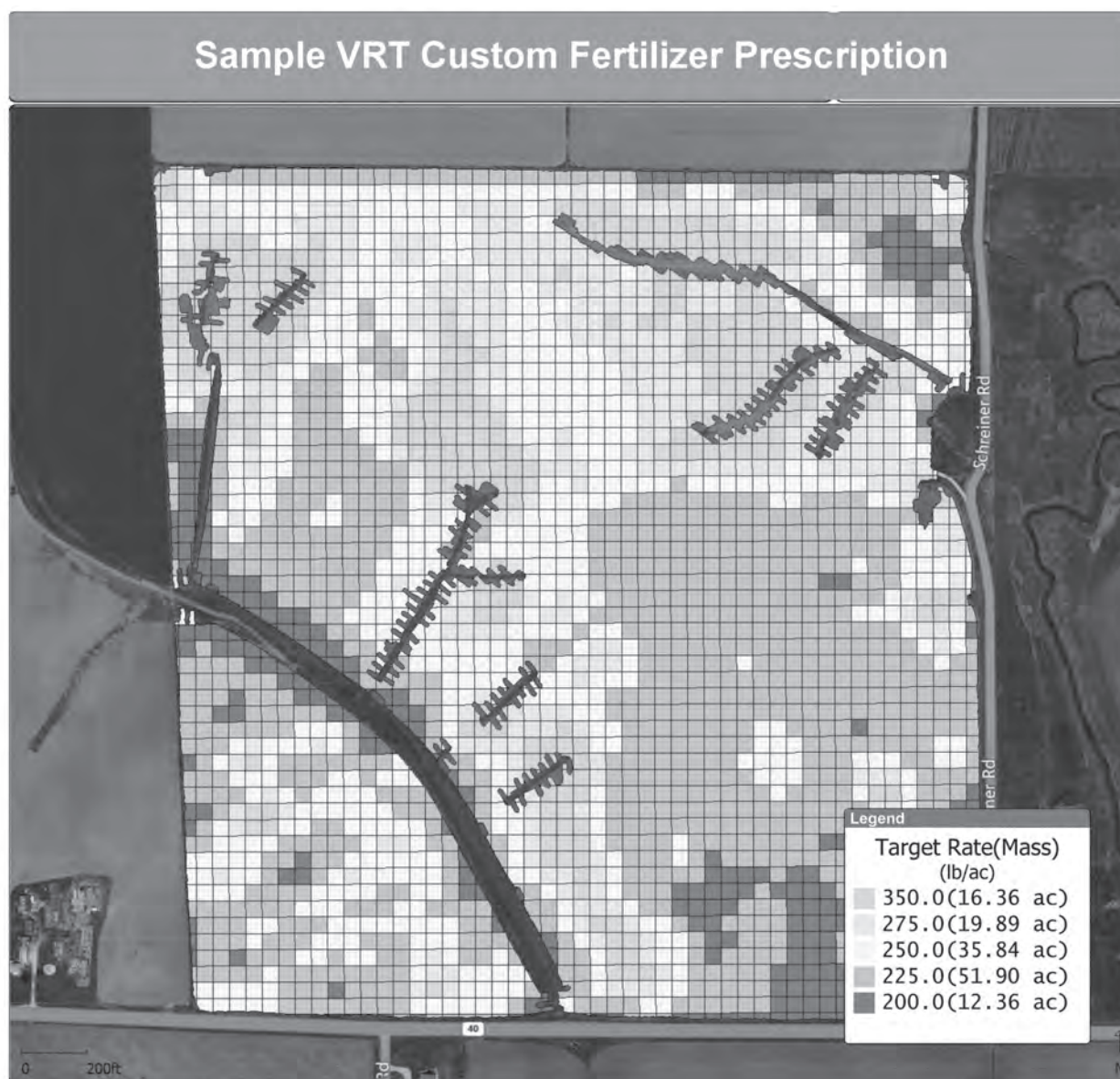
We've included a sample soil test report on page 17 to help you better understand the contents of this booklet. The sample report is on a perforated sheet, so you can remove it from this booklet and use it as a reference while paging through our *Soils Guide*. Or, tear it out and compare it to your own reports to better understand your soil's capacity.



DATA MANAGEMENT

Your soil test results give you great insight into crop performance on your farm. We recommend overlaying soil test data with other farm data, like yield maps and planter performance data, to illustrate how varying levels of soil nutrients can affect crop and soil productivity across fields.

Midwestern BioAg offers both grid and non-grid soil sampling services. On farms where grid sampling is used, data generated from this process allows growers to apply variable rate technology (VRT) to their fields. A sample VRT custom fertilizer prescription is pictured below. Using grid soil sample data, we set VRT rates that ensure nutrients are put down in the right amounts at the right locations. As you can see, application rates vary from 200 lbs. per acre to 350 lbs. per acre, allowing the grower to apply nutrients to this particular field in the most efficient and effective way possible. Suggested VRT application rates are available to our customers at no additional costs.



ABOUT SOILS

In this section, we look at properties that play major roles in soil fertility and productivity — soil organic matter, cation exchange capacity, percent base saturation and pH.

Organic Matter and Humus

Organic matter supplies many plant nutrients, including nitrogen, phosphorus, sulfur and trace minerals. It improves soil structure, aeration and drainage, and reduces erosion and increases CEC (see page 6). Organic matter also feeds beneficial soil life, i.e., microbes and earthworms.

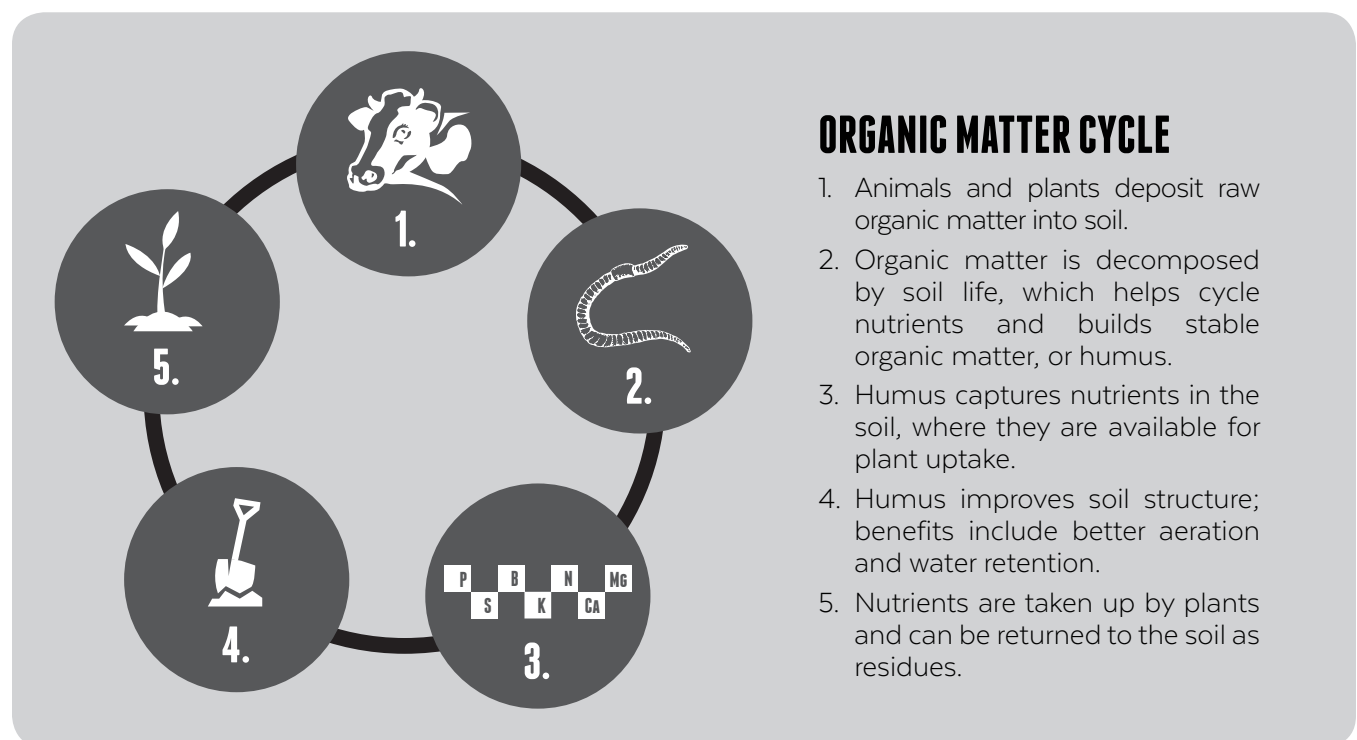
Humus is the dark organic material in soil and is formed as plant and animal matter decays. Because it is considered the stable component of organic matter, increasing humus content can help improve soil fertility and structure. It is a primary provider of key plant nutrients like nitrogen.

Ways to Build Organic Matter:

- Incorporate more carbon into the soil, e.g., crop residues, cover crops, and compost.
- Balance both active and stable carbon.
- Add minerals such as calcium to stabilize organic matter.
- Till only where needed and apply nitrogen only when necessary.

Key Considerations:

- For every one-percent increase in organic matter, available nitrogen increases 10 to 20 lbs.
- For every one-percent increase in organic matter, soil water-holding capacity is increased by a minimum of 10,000 gallons of water per acre.
- Soil organic matter levels will vary depending on soil type and CEC.



Cation Exchange Capacity

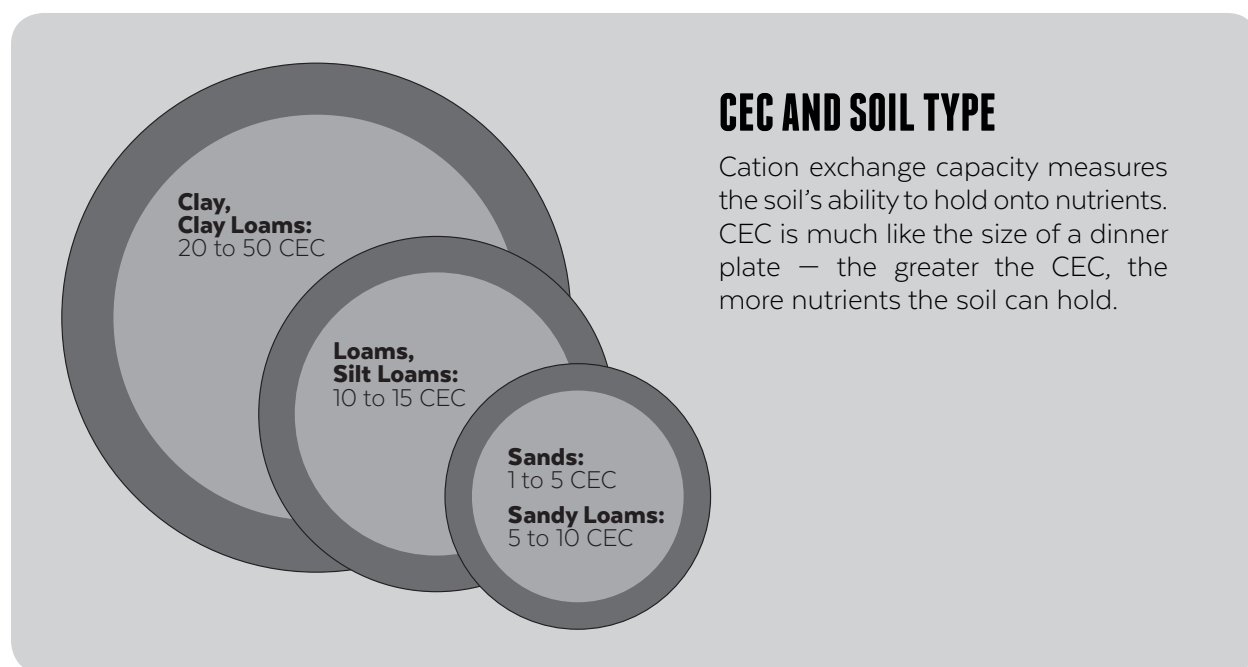
Cation exchange capacity (CEC) is a measure of soil's capacity to hold certain nutrients, e.g., potassium, magnesium and calcium. Soils with greater CECs can hold more nutrients, but this may not indicate plant availability. Without knowing CEC, it is difficult to make fertility recommendations because CEC indicates the soil's potential for crop production. Below are CEC ranges for common soil types:

- **Sandy soil CEC:** 3 to 5
- **Silt loam CEC:** 10 to 15
- **Clay loam CEC:** 20 to 25

CEC and Recommended Nutrient Levels

In the table below, recommended soil nutrient levels are outlined in relation to CEC; note how the potassium, magnesium and calcium levels change as CEC and base saturation are altered (see page 7). In order to ensure adequate nutrient levels at different CEC levels, it may be necessary to use different base saturation targets within the desired range. Soils with low CECs, because of their lack of capacity to hold nutrients, will require higher fertilizer application rates. Additional examples of CEC variation and its impact on nutrient availability can be found in the detachable soil test presented in Appendix A (page 17).

CEC & Recommended Nutrient Levels							
CEC	%K	%Mg	%Ca	%H	K (ppm)	Mg (ppm)	Ca (ppm)
5	5	18	70	<10	98	108	700
10	4	14	75	<10	156	168	1,500
15	3	14	75	<10	175	252	2,250
20	2.5	14	75	<10	195	336	3,000
25	2.5	12	80	<10	243	360	4,000



Percent Base Saturation

Percent base saturation is the percentage of exchangeable potassium, magnesium, calcium and hydrogen in the soil (total = 100%).

Nutrient	Ideal Levels	Common Levels
Potassium (K)	3% to 5%	1% to 8%
Magnesium (Mg)	12% to 16%	20% to 40%
Calcium (Ca)	70% to 75%	55% to 65%
Hydrogen (H)	0% to 5%	0% to 10%

pH Level

pH is a measure of soil acidity — the number of free hydrogen ions in a soil solution. The pH scale runs from 0 (most acidic) to 14 (most alkaline), with 7 being neutral. Soil pH greatly affects crop performance and soil microbial activity. A common misconception about pH is that soils with pH levels of 6.5 or above do not require additional calcium. However, while soil in this pH range may not need adjustment, it may still be low in available calcium. At Midwestern BioAg, we typically recommend maintaining a soil pH of 6.8 to 7.2 for optimum crop performance.

PH SCALE

Acidic

Alkaline

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
---	---	---	---	---	---	---	---	---	---	----	----	----	----	----

PH TARGET: 6.8 - 7.2

We recommend maintaining a pH of 6.8 to 7.2 to maximize both plant and soil health. Earthworms — a leading indicator of soil health — prefer a soil pH of 7. A meta-analysis of 58 studies spanning 100 years showed earthworm presence significantly increased crop yield by 25 percent and plant biomass by 21 percent.¹

As part of the larger soil ecosystem, earthworms are essential players in nutrient cycling, residue decomposition, and soil drainage and permeability. Because some agricultural practices (e.g., heavy tillage and excess application of salt through some types of fertilizers or irrigation water) can discourage earthworm establishment, it's important to limit harmful effects when possible.

¹van Groenigen, J.W. et al. Earthworms increase plant production: a meta-analysis. *Sci. Rep.* 4, 6365; DOI:10.1038/srep06365 (2014).

SOIL NUTRIENTS

Crops need a variety of soil nutrients to maximize plant health and performance. In the following pages, we outline the roles and benefits of several important soil nutrients. Crop performance can be limited by nutrient deficiencies. A greater understanding of key soil nutrients and their impacts on crop performance can help you develop a fertility plan to maximize plant productivity on your farm.

K

Potassium

Potassium (K) is an essential plant nutrient needed for nearly all plant growth and reproduction processes. This includes photosynthesis, sugar and protein production, enzyme activation, and disease resistance and recovery.

Benefits:

- Increases yield potential
- Increases plant quality, e.g., size, color, and taste
- Increases stalk strength and lodging resistance
- Improves winter hardiness
- Improves disease resistance
- Reduces water loss and wilting

Ideal Balance:

- 3% to 5% base saturation

Preferred Sources:

- Potassium sulfate (0-0-50-17S)
- K-Mag® or Trio® (0-0-22-22S-11Mg)
- Livestock manure

Key Considerations:

- For optimum yield, adequate potassium must be supplied at levels customized to crop needs
- Excess K can negatively affect plants
- High chloride levels found in 0-0-60 (potassium chloride) may have negative effects on soil life, soil structure and seed germination

Mg

Magnesium

Magnesium (Mg) is an essential part of chlorophyll and plays a vital role in photosynthesis and plant development. It is required for phosphate metabolism, plant respiration and the activation of several enzyme systems within the plant, all of which support healthy plant growth.

Benefits:

- Helps grow strong, healthy root systems
- Supports phosphorus uptake
- Facilitates plant protein production

Ideal Balance:

- 12% to 16% base saturation

Preferred Sources:

- K-Mag® or Trio® (0-0-22-22S-11Mg)
- Magnesium sulfate (9% Mg, 12% S)

Key Considerations:

- Excess Mg can tighten soils, interfere with potassium uptake and reduce nitrogen utilization
- Sulfur can improve magnesium availability
- Magnesium ppm levels should never fall below potassium ppm levels on soil tests

Ca Calcium

Calcium (Ca) plays a vital role in plant growth, specifically cell wall formation, cell division and pollination. It activates many plant enzyme systems and helps plants absorb other nutrients. Calcium also promotes healthy soil structure by loosening soils and stabilizing organic matter, which increases soil water- and nutrient-holding capacity.

Benefits:

- Stimulates soil life and improves soil structure
- Improves yields by supporting root development and increasing plant uptake of other nutrients
- Increases N utilization and sugar production
- Promotes overall plant health and quality, including stalk strength and disease resistance
- Improves heat and drought resiliency

Ideal Balance:

- 70% to 75% base saturation

Preferred Sources:

- Bio-Cal®
- OrganiCal™
- HumaCal®
- Calcium sulfate (gypsum: 23% Ca, 17% S)
- High-calcium lime (low Mg, Ca 30% to 35%)

Key Considerations:

- Calcium is the trucker of all nutrients; it helps move other nutrients into the plant
- Calcium improves both plant and soil health

P Phosphorus

Phosphorus (P) supports early plant growth, root development and protein production. A main component of adenosine triphosphate (ATP), phosphorus is a major driver of plant energy production, health and vigor.

Benefits:

- Promotes early root and seedling growth
- Improves flower formation and seed production
- Promotes earlier crop maturity
- Increases nitrogen-fixing capacity of legumes
- Increases crop quality, including higher plant sugar and mineral content

Ideal Balance:

- P1 (available): 25 to 50 ppm
- P2 (reserve): 50 to 100 ppm

Preferred Sources:

- Monoammonium phosphate (MAP) 11-52-0 or 10-50-0
- Phosphate rock
- Livestock manure

Key Considerations:

- We recommend MAP because it has a pH of 5, making the phosphorus more available
- DAP has a pH between 9 and 11, making P less available. DAP can also cause nitrogen volatilization



Na

Sodium

Sodium (Na) plays an important role in soil-plant relations, particularly in arid and semi-arid regions. It is required by all plants in small quantities. In most cases, high sodium levels can have a negative effect on soil structure and biology.

Benefits:

- Minimizes water loss under stress
- Facilitates nutrient transport in plants

Key Consideration:

- Excess sodium can negatively affect crops and soil structure

S

Sulfur

Sulfur (S) is found in every living cell and plays an important role in plant photosynthesis and protein formation. Plants absorb sulfur as sulfate ions, which are readily leached from the soil through rainfall and irrigation. However, soil sulfur levels are often insufficient for high-yielding crops.

Benefits:

- Enhances nitrogen-use efficiency
- Helps loosen and aerate soil
- Improves winter hardiness
- Supports seed production
- Helps build humus in soil
- Reduces excess magnesium
- Improves protein content and helps plants form complete proteins

Ideal Balance:

- 50 ppm or 100# per acre

Preferred Sources:

- Ammonium sulfate (AMS, 21-0-0-24S)
- Potassium sulfate (0-0-50-17S)
- HumaCal®
- Calcium sulfate (gypsum, 23 % Ca, 17% S)
- Sulfate trace minerals

Key Considerations:

- Sulfur should be applied annually and must be present in a 10:1 nitrogen to sulfur ratio in plants to support protein development
- Sulfur should be supplied in sulfate form annually in the range of 25 to 100 lbs per acre

Zn

Zinc

Zinc (Zn) is needed for various plant growth functions including enzyme and hormone activity, flowering and corn ear size. Zinc was one of the first micronutrients identified as essential for plant growth. While zinc is required by plants in only small amounts, high yields are impossible without it.

Benefits:

- Increases test weight
- Promotes silking in corn and larger ears
- Hastens plant maturity
- Supports healthy plant growth

Ideal Balance:

- 5+ ppm or 10# per acre

Preferred Sources:

- MicroHume®
- MicroPack™ 5-5-5
- Zinc sulfate

Key Considerations:

- Zinc is important in phosphorus uptake and utilization within the plant. However, a phosphorus to zinc ratio over 10:1 can be detrimental
- As soil pH increases, zinc availability decreases

Mn Manganese

Manganese (Mn) directly supports photosynthesis and plays a vital role in plant enzyme systems. It activates many important metabolic reactions, all of which are necessary for normal plant growth.

Benefits:

- Increases phosphorus and calcium availability
- Accelerates germination
- Hastens plant maturity

Ideal Balance:

- 20 ppm or 40# per acre
- Manganese to iron: 1:1-2 ratio

Preferred Sources:

- MicroHume®
- MicroPack 5-5-5
- Manganese sulfate

Key Considerations:

- Some herbicides are known to tie up manganese. To help get manganese into the plant, chelated or carbon-based fertilizer sources are required
- Wheat and soybeans require more manganese than other crops

Fe Iron

Iron (Fe) is needed for plant metabolism and chlorophyll production. It is also used by nitrogen-fixing bacteria. As a component of many enzymes associated with energy transfer and nitrogen reduction and fixation, iron plays an essential role in crop growth.

Benefits:

- Supports crop growth
- Helps prevent leaf yellowing

Ideal Balance:

- 20 ppm or 40# per acre

Preferred Sources:

- MicroPack™ 5-5-5
- MicroHume®

Key Considerations:

- High iron levels can tie up phosphorus
- Watch for iron in feed; if you have high iron in the soil, expect phosphorus tie up
- Iron uptake decreases as soil pH increases

Cu Copper

Copper (Cu) is needed for enzyme function, protein synthesis, photosynthesis and flower formation. Plants also need copper for carbohydrate and nitrogen metabolism. While only small amounts are needed for survival, copper plays an important role in several plant-growth processes and the plant immune system.

Benefits:

- Reduces mold and other fungal diseases
- Supports healthy plant growth
- Increases stalk strength and plant quality
- Helps prevent leaf yellowing and withering

Ideal Balance:

- 5 ppm or 10# per acre

Preferred Sources:

- MicroHume®
- MicroPack™ 5-5-5
- Copper sulfate

Key Consideration:

- Excess copper can be toxic



B

Boron

Boron (B) is essential for cell wall formation, reproduction, sugar translocation and pollen tube formation. It also helps improve alfalfa growth and nitrogen fixation.

Benefits:

- Supports root development, leaf growth and pollen grain formation
- Improves seed set under stress
- Improves forage quality alongside of calcium
- Helps reduce barren corn stalks and increases yields

Ideal Balance:

- 2+ ppm or 4# per acre

Preferred Sources:

- MicroHume®
- MicroPack™ 5-5-5
- Calcium or sodium borate

Key Considerations:

- Boron and calcium work together to improve uptake of nutrients
- Boron levels must be addressed annually due to loss via leaching
- Crops vary widely in boron requirements and tolerances; care must be taken to avoid toxicity

N

Nitrogen

Nitrogen (N) is found in every living cell and is essential for growth in all crop types. It is a major element in chlorophyll production and a main component of amino acids, the building blocks of proteins. Plants require large amounts of nitrogen to support normal growth.

Benefits:

- Improves yields
- Increases plant protein content
- Supports uptake of other essential nutrients

Preferred Sources:

- Ammonium sulfate
- ESN® (polymer-coated urea 44-0-0)
- Liquid 28% or 32% with L-CBF
- Healthy soils and earthworm activity
- Plowdown of legumes (green manure)
- Livestock manure

Key Considerations:

- Since available nitrogen in the soil varies widely over time, it is generally not reported on soil tests. However, two methods for determining the N content of soil are widely practiced. These are the pre-plant nitrate test and the pre-sidedress nitrate test. These tests give producers an idea of the amount of nitrogen available in the soil in the form of nitrate either prior to planting or prior to sidedressing.
- Over-application of nitrogen can lead to nitrate leaching and soil acidification



What's in Your Fertilizer?

Midwestern BioAg Blend: 5-14-16-11S	
Ingredient:	Description:
Ammonium sulfate	21-0-0-24S
MAP	11-52-0
Potassium sulfate	0-0-50-17S
K-Mag	0-0-22-22S-11Mg
Calcium sulfate	Plant available Ca & S
Rock phosphate	Natural source of P & Ca
MicroPack 5-5-5™	Homogenized trace minerals
HumaCal®	Calcium, sulfur & humates
Compost crumbles	Highly available NPK and soluble Ca

At 200 lbs/ac, this blend provides 10-28-32, plus 22 pounds sulfur, 3 pounds magnesium, 7 pounds calcium, as well as zinc, manganese, copper and boron. It contains less than 1 percent chloride.

Typical Industry Blend: 9-23-30	
Ingredient:	Description:
DAP	18-46-0
Potassium chloride	0-0-60

At 200 lbs/ac, this blend provides 18-46-60. While it does supply NPK, it contains no secondary nutrients or trace minerals. It also contains 23 percent chloride. Fertilizers with high chloride content can harm soil structure and provide less nutrients (by density) than Midwestern BioAg blends.

Higher-Quality Ingredients; Balanced Plant Nutrition

Midwestern BioAg fertilizers go beyond NPK to deliver calcium, sulfur and trace minerals to build soil organic matter and nutrient availability while improving yields. Our fertilizers are:

- **Balanced.** We balance and blend the right nutrients for your soil and crops, optimizing yields and quality. We address yield-limiting factors by complementing NPK with calcium, sulfur, trace minerals and carbon to feed soil life and increase nutrient availability.
- **Healthier for the Soil.** Some fertilizers can negatively impact soil life and plant health. Our fertilizers contain materials that stimulate and support both soil microbes and plant roots.
- **Available Season-Long.** Most fertilizers give plants a quick charge for a short period of time; ours deliver nutrients throughout the growing season. We mix soluble nutrients with others that are available season-long, enhancing nutrient uptake and performance throughout the year.

Midwestern BioAg's Conventional Fertilizer Blend Ingredients

Based on your soil test results, we'll work with you to create a complete fertility plan to meet your soil and crop needs. Our recommendations may be two-part: First, we'll correct any soil nutrient deficiencies and improve your soil structure with an application of the appropriate soil amendment. Next, we'll address immediate crop growth needs with a balanced fertilizer blend. Recommendations will be made using the following high-quality, highly available plant and soil nutrients.

Dry Fertilizer Ingredients

- **MicroPack 5-5-5™:** MicroPack 5-5-5 is a balanced, homogenized micronutrient pack that contains trace minerals (zinc, manganese, iron, boron and copper) and NPK with calcium, magnesium and sulfur in both soluble and slow-release forms. Its homogenized pellets are an effective and efficient way to deliver trace nutrients to your crops.
- **HumaCal®:** HumaCal is a pelletized nutrient package containing humates, calcium sulfate and calcium carbonate. An excellent source of available calcium and sulfur, HumaCal is easy to apply and blend with other fertilizers.
- **Chicken Manure Crumbles:** A natural source of plant nutrients and organic matter, crumbles help support both crop performance and soil life. They provide unique forms of plant-available NPK, soluble calcium and trace minerals.
- **Phosphate Rock:** Phosphate rock provides crops with slow-release phosphorus, calcium, sulfur and trace minerals.
- **ESN® (44-0-0):** ESN is a polymer-coated nitrogen source that delivers time-released nitrogen to crops based on soil temperature and moisture levels.
- **Ammonium Sulfate (21-0-0-24S):** Ammonium sulfate is an excellent source of plant-available nitrogen and sulfate sulfur. It resists nitrogen loss naturally, without any need for inhibitors or stabilizers.
- **Monoammonium Phosphate (11-52-0):** Monoammonium Phosphate (MAP) is our main source of soluble phosphorus. MAP is a low-pH, plant-available phosphorus source that contains limited amounts of ammonia.
- **Potassium Sulfate (0-0-50-17S):** Potassium sulfate is a stable, low-chloride and slow-release potassium and sulfate sulfur source with low chloride levels (<1%).
- **K-Mag® Granular (0-0-22-22S-11Mg):** K-Mag, or potassium magnesium sulfate, is water soluble and will work immediately upon application. It is a highly plant-available source of potassium, magnesium and sulfur.
- **SuperCal SO4®:** SuperCal, or pelletized gypsum, provides 21% calcium and 17% sulfate sulfur. These pellets hold together for accurate application but break down quickly in the soil for improved nutrient uptake.

Calcium & Liming Products

- **Bio-Cal®:** Bio-Cal is a liming material with 32% calcium. It provides multiple sources of soluble and slow-release calcium that are both readily available to plants upon application and season-long.
- **Gypsum:** Gypsum provides calcium and sulfur, two essential nutrients for plant performance and yield.
- **High-Calcium Lime:** High-calcium lime can increase soil pH and improve yields. The added calcium in high-calcium lime can also improve nutrient availability and overall plant health.

Midwestern BioAg's Organic-Allowed Fertilizer Blend Ingredients

Fertilizer and soil amendment recommendations for organic farms work much the same way. We'll start with a soil to test to identify nutrient deficiencies, and then build a recommendation to correct yield-limiting factors in your fields using soil amendments and crop fertilizers. Recommendations will be made using the following high-quality, organic-allowed plant and soil nutrients.

Organic-Allowed Dry Fertilizer Ingredients

- **MicroHume®:** MicroHume is a homogenized micronutrient blend that provides calcium, sulfate sulfur, boron, copper, manganese and zinc. Blended with humates for enhanced nutrient availability, this low-pH micronutrient package helps keep nutrients available throughout the season. MicroHume is OMRI-listed for use on organic farms.
- **HumaCal®:** HumaCal is a carbon-based, pelletized nutrient package containing humates, calcium sulfate, and calcium carbonate. An excellent source of available calcium and sulfur, HumaCal is easy to apply and is OMRI-listed.
- **Chicken Manure Crumbles:** A natural source of plant nutrients and organic matter, crumbles help support both crop performance and soil life. They provide unique forms of plant-available NPK, soluble calcium and trace minerals.
- **Phosphate Rock:** Phosphate rock provides crops with slow-release phosphorus, calcium, sulfur and trace minerals.
- **Potassium Sulfate (0-0-50-17S):** Potassium sulfate is a stable, slow-release potassium and sulfate sulfur source with low chloride levels (<1%).
- **Intrepid Granular Trio® (0-0-22-22S-11Mg):** Intrepid Granular Trio, or sulfate of potash magnesia, is a low-chloride, OMRI-listed potassium fertilizer. It is an excellent plant-available magnesium source. Its combination of soluble and slow-release nutrients support crop production season-long.
- **SuperCal SO4®:** SuperCal, or pelletized gypsum, provides 21% calcium and 17% sulfate sulfur. These pellets hold together for accurate application but break down quickly in the soil for improved nutrient uptake.
- **Feather Meal (13-0-0):** Feather meal is an OMRI-listed nitrogen source derived from premium-quality feather, blood and meat meal, which also supplies chelated calcium to crops. Feather meal helps stimulate soil life and promotes plant nutrient uptake.

Organic-Allowed Calcium & Liming Products

- **OrganiCal™:** OrganiCal contains 24% calcium, 4% sulfur and humates to help improve crop quality, yield, and soil structure. OrganiCal is OMRI-listed and includes two calcium sources – finely ground gypsum and 300-mesh high calcium lime.
- **Gypsum:** Gypsum provides calcium and sulfur, two essential nutrients for plant performance and yield.
- **High-Calcium Lime:** High-calcium lime can increase soil pH and crop yields. The added calcium in high-calcium lime can also improve nutrient availability and overall plant health.

Midwestern BioAg's Conventional & Organic Liquid Fertilizer Products

- **L-CBF BOOST™ 4-0-3-2S:** BOOST is a molasses-based carbon additive designed to improve the efficiency and performance of your liquid fertilizer program. Derived from sugar cane molasses, BOOST helps stimulate soil biology in early spring and cycle nutrients in the soil. BOOST can be applied in-furrow or foliar to all major crops. We recommend applying BOOST to corn, beans, wheat and alfalfa to help improve yield potential.
- **L-CBF 10-14-1:** 10-14-1 is a liquid carbon-based fertilizer derived from sugar cane molasses and quality plant nutrients. 10-14-1 helps stimulate soil biology in early spring and cycle nutrients in the soil, making it an excellent starter for corn, soybeans and small grains. 10-14-1 can be applied in-furrow, 2x2 or foliar to promote early-season growth.
- **L-CBF TerraFed™ 1-0-3:** TerraFed is a liquid carbon-based fertilizer derived from sugar cane molasses. It delivers quality plant nutrients in a cane-molasses base to stimulate soil biology in early spring and cycle nutrients in the soil. Now OMRI-listed, TerraFed can be applied in-furrow, sidedressed or broadcasted to all major crops.
- **Kelpak:** Kelpak is a liquid seaweed concentrate derived from Ecklonia maxima kelp. It is a natural and unique source of Auxins and Cytokinins, a group of plant growth bioregulators that are proven to have a number of beneficial physiological effects on plants. Kelpak helps promote root development and increases root tip growth for better plant nutrient and water uptake, and is organic-approved by WSDA NOP. We recommend applying Kelpak in-furrow or foliar with L-CBF liquid fertilizers.
- **RootSurge®:** RootSurge delivers chelated micronutrients and plant-growth promoting microbes to help stimulate root development early in the season. Chelation binds minerals in a plant-available form, preventing loss from leaching. When added to our L-CBF liquid fertilizers, RootSurge can enhance early season vigor by increasing microbial activity and nutrient acquisition. RootSurge also contains humic acids to help chelate nutrients in the root zone and improve availability.
- **Calcine:** When added to irrigation water, Calcine® mobilizes salts out of the root zone and improves soil productivity. Reducing soil salinity improves soil health by increasing water-holding capacity and infiltration, reducing compaction and boosting rates of earthworm establishment. Together, these effects reduce dependency on irrigation and lower production costs.
- **Grower's Secret Nitrogen 12-0-0:** Grower's Secret Nitrogen is an OMRI-listed, water-soluble nitrogen product derived from soy protein hydrolysate. It can be used as a nitrogen source in organic and conventional production to help plants grow quickly, increase seed and fruit production and improve plant quality and appearance. Grower's Secret Nitrogen can be applied as a stand-alone product or in combination with most products.

APPENDIX A: SOIL TESTS AND DESIRED NUTRIENT LEVELS

The soil test below is a sample test designed to illustrate how targeted nutrient levels may vary by soil type and cation exchange capacity (CEC). Each field in the soil test below, A, B or C, has a different soil type and CEC. Tear out this sample test and use it as a reference as you page through this booklet. Compare this test and the recommended nutrient levels on page 6 to your own soil test to help you gain a better understanding of your own soil's production capacity.

Soil Test with Multiple Field Samples															
Sample ID	Organic Matter %	Cation Exchange Capacity CEC meq/100g	Percent Base Saturation (Computed)					Soil pH	Potassium	Magnesium	Calcium	Sodium	Phosphorus		Sulfur
			% K (+)	% Mg (+)	% Ca (+)	% H (+)	% Na (+)						P ₁ (WEAK BRAY) (-) ppm	P ₂ (STRONG BRAY) (-) ppm	
FIELD A	2.1	10.4	6.1	19.9	73.4		0.6	248	248	248	1525	15	186	187	25
Desired Level			3-5	12-16	70-75			6.8	122-203	150-200	1456-1560		25-50	50-100	50
FIELD B	2.7	17.2	1.7	36.5	61.5		0.3	7.4	113	754	2109	12	22	56	10
Desired Level			3-5	12-16	70-75			6.8	201-335	248-330	2408-2580		25-50	50-100	50
FIELD C	1.7	4.6	4.7	31.3	52.4	11.2	0.4	6.3	84	173	482	4	31	41	12
Desired Level			3-5	12-16	70-75			6.8	54-90	66-88	644-690		25-50	50-100	50

Micronutrients	Sample ID	Zinc Zn (+) ppm	Manganese Mn (+) ppm	Iron Fe (+) ppm	Copper Cu (+) ppm	Boron B (-) ppm
		FIELD A	FIELD A	FIELD A	FIELD A	FIELD A
	Desired Level	5.0	20.0	20.0	5.0	2.0
	FIELD B	3.8	4.0	23.0	1.7	1.5
	Desired Level	5.0	20.0	20.0	5.0	2.0
	FIELD C	1.0	11.0	74.0	0.3	0.4
	Desired Level	5.0	20.0	20.0	5.0	2.0

Multiply the results in ppm by 2 to convert to pounds per acre of elemental form.

APPENDIX B: SUMMARY OF SOIL NUTRIENT TARGET LEVELS

Below is a summary of all soil nutrient target levels outlined in this booklet. Recommended potassium, magnesium and calcium levels will vary depending on soil type; please see pages 6 and 7 for additional information. Because available nitrogen in the soil varies widely over time, it is generally not reported on most soil tests.

Summary of Soil Nutrient Target Levels	
Nutrient	Ideal Balance
Potassium	3% to 5% base saturation, see page 7 for more information.
Magnesium	12% to 16% base saturation, see page 7 for more information.
Calcium	70% to 75% base saturation, see page 7 for more information.
Available Phosphorus (P1)	25 to 50 ppm
Reserve Phosphorus (P2)	50 to 100 ppm
Sulfur	50 ppm
Zinc	5+ ppm
Manganese	20 ppm
Iron	20 ppm
Copper	5 ppm
Boron	2+ ppm
Nitrogen	Varies; see page 12 for more information.

ABOUT MIDWESTERN BIOAG

For over 30 years, Midwestern BioAg has helped producers improve farm yields sustainably through comprehensive whole-farm management. Our full line of proven, proprietary products feeds the soil an optimum, balanced diet that supports soil life. In turn, farmers improve farm margins by growing healthier, more nutrient-dense crops. With our animal nutrition products, livestock producers can then fill any remaining nutritional needs, again benefiting from an improved bottom line. By supporting the farm as a system, farmers, livestock and consumers all benefit through improved food nutritional quality and lowered environmental impacts.

We have core facilities in Wisconsin, Minnesota, Michigan, Illinois, Ohio, and Iowa, and a sales force and network of dealers covering 29 states and three Canadian provinces.



800.327.6012
MidwesternBioAg.com

