COLORADO SOIL HEALTH FUNDAMENTALS

PRIMER 4: BEYOND N-P-K

PRIMER 4 SUMMARY

The goal of the Colorado Soil Health Primer series is to demonstrate the core principles related to soil health management as practiced and researched within the boundaries of the State of Colorado. Colorado scientists studying the effects of management practices and the state's farmers and ranchers implementing and measuring the changes on the land participated in this project.

This series is not about instructing the exact tactics a farmer or rancher would need to improve soil health. The individual tactics and strategies must change from property to property — or even field to field — depending on the goals of the land manager, and the available natural and financial resources. This series of information will give readers the resources to understand and evaluate practical and proven ideas to explore and adapt into a new or existing operation.

The Colorado Saving Tomorrow's Agriculture Resources (STAR) program encourages farmers and ranchers to think differently about their soil fertility and health, and to think beyond nitrogen, potassium and phosphorus and the N-P-K input systems. STAR is designed to help farmers think about the entirety of the farm ecosystem's nutrient cycles by taking a step back and, as it were, asking the soil what it needs. Often, with this widened perspective, a producer will look differently at annual programs, will begin to observe changes in the land, and will make different choices based on what the landscape communicates.

From the sweeping dryland fields of eastern Colorado to the mountain meadow cattle operations of the high country, agricultural producers are hard at work, keeping their living systems thriving and healthy. The responsibility of providing both crop and livestock nutrient needs, via soil, is one of the most interesting and challenging areas of land stewardship. Colorado soils are diverse and this diversity determines how nutrients interface with other biotic and abiotic factors, including soil texture and structure, organic matter, biological activity, and soil hydrologic cycles.

Reaching regeneration potential will include fluctuations in fertility, viability, and health. This is unavoidable.

▲ *Source: Colorado Department of Agriculture and Michael Santistevan*

A soil health agriculture management system will account for these peaks and valleys while dialing in systems and finding balance. By doing so, the land manager will look at fertility management as a process of learning, a tactic of regenerative stewardship, and a means of generating profitable returns.

The following primer demonstrates how nutrient cycles, Colorado soils, and inputs (including fertilizers and amendments) function within systems of regenerative soil practices and help to conceptualize the mechanisms at work, in the soil, behind Colorado's STAR program.

COMMON TERMS

Cover Crops: The act of keeping the ground covered and maintaining living roots are two principles of soil management, and cover crops are a key tool to help farmers transition and measure the gains.

Pasture: Fields for grazing, wildlife passage or soil remediation are common across the state of Colorado.

Soil Biology: The life in the soil, from the smallest microbes to earthworms and dung beetles. The biology is responsible for helping break down organic matter and turning it into available nutrients for your crops.

Soil Chemistry: The ratios of elements in the soil are important and go beyond N-P-K.

Soil Health: The concept of maximizing an ecosystem's ability to feed soil microorganisms, leading to efficient nutrient cycling and turnover, which creates more nutrient availability for plants, increases soil water storage, and improves ecosystem sustainability and resiliency.

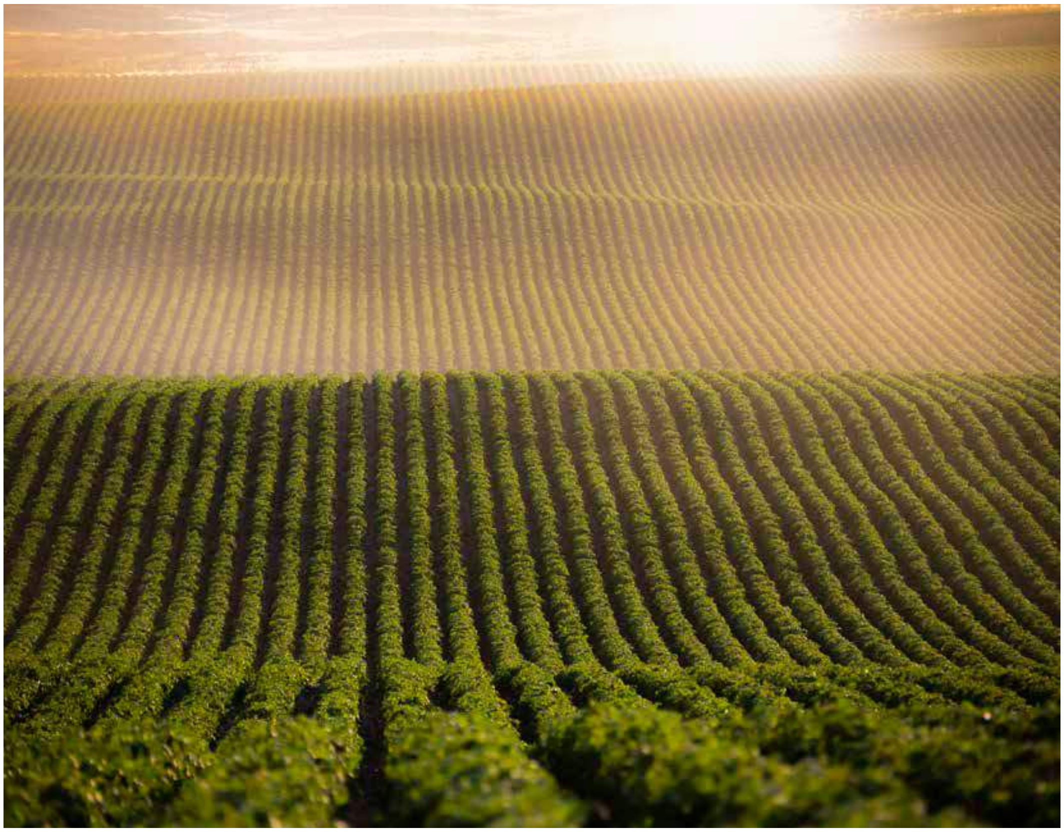
Soil Testing: The process of quantifying certain attributes of soil, including macro- and micro-nutrients, soil organic matter, cation exchange capacity, soil biology, water and/ or air.

NRCS: The Natural Resources Conservation Service.

Source: Jim Ippolito & Megan Machmuller, Colorado State University

USDA-NRCS
Soil Management Principles

1. Limit disturbance
2. Keep soil covered
3. Strive for biodiversity
4. Maintain living roots
5. Integrate animals



▲ Crop growers in Colorado's STAR program are knowledgeable of soil chemistry and how it affects yields and crop health including rotations and biodiversity. For example, a soybean crop generally provides 20 to 40 pounds of nitrogen per acre to a following corn crop, which needs to be accounted for in making fertilizer recommendations. *Source: Colorado Department of Agriculture and Laura Harwood*

When a farmer or rancher applies a fertilizer, they are creating a chain reaction that changes the soil chemistry our plants depend on for nutrition. Managing farm fertility accurately — when to apply, and how much, and what types—can depend on the farm manager or soil consultant's understanding of nutrient cycles, soil types, ecosystem, farmer goals, and budget. This can be where regenerative land management shines by simplifying the effort.

Most farmers will tell you that nutrient cycling in the soil remains one of the more complex and difficult processes in farming to reverse engineer. Why? There are many variables to consider with soil texture and structure, organic matter, field capacity, and biological activity that all impact how nutrients and plants engage and grow.

Knowledge and understanding of the many layers of soil chemistry can be essential to anyone who works with plants or livestock, and there are a number of soil testing labs, agronomists and consultants available in the marketplace with decades of experience in reading soil tests and fixing deficiencies and excesses.

To explore the world of nutrients—their availability, mobility, and presence in Colorado soil—and the potential of soil health management principles to unlock naturally occurring elements for plant uptake, it is helpful to establish context that is grounded in fundamental soil chemistry.

An Elemental Balancing Act

A plant is compelled to take in nutrients for its survival, development, and reproduction. And, plants utilize nutrients to build the following four main molecules: carbohydrates, proteins, lipids, and nucleic acids.

The standard studied and accepted elements—16 or 17 depending on whom you ask—are recognized as essential to plant growth and are those sources of fertility that we all know as macro and micronutrients: Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, chlorine, iron, manganese, zinc, copper, molybdenum, and nickel. The non-mineral essential plant elements include hydrogen, oxygen, and carbon, which are taken up as a gas or water.

Each individual element/nutrient is composed of atoms. Atoms consist of positively charged protons (think of little round magnets) in their nucleus and the nucleus is orbited by negatively charged electrons (more little round magnets). These magnetic charges become important when you are managing cation exchange capacity in soils typical to Colorado. In order to build relationships with each other, elemental atoms share electrons with another element's atoms. Ths sharing of electrons is called bonding. The different types of bonds between elements (covalent, ionic, and hydrogen) also become relevant when ensuring the soil nutrients are available and digestible by the crop.

Nitrogen

Nitrogen is one of the most well-known macronutrients because it's important. How important? Nitrogen is a key part of the chlorophyll molecule—as well as a major component in photosynthesis. Nitrogen is also a building block for DNA and RNA. If that's not enough, nitrogen is an essential ingredient in the development of enzymes (proteins), which bring power and speed to chemical reactions. Any cellular activity within a plant requires the fuel of an enzyme. Nitrogen is also mobile in plants, which means that it moves where it is needed. The hallmark trait of yellow discoloration in older leaves of plants is often a sign of nitrogen deficiency.

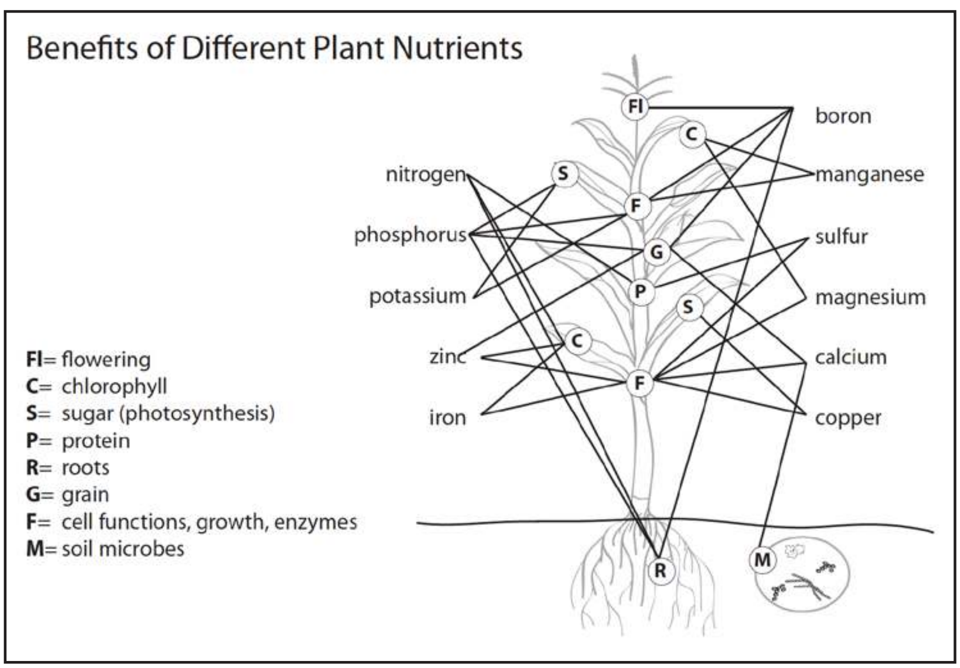
Steve Ela talks about his farm's nitrogen management system, "We have to manage fertility and soils for adequate but not excessive growth," he said. "If the tree doesn't grow well, then we don't have enough tree volume to produce fruit, and if the tree is over vigorous, it may not set fruit the best because it wants to just set vegetation. We are trying to balance so we have growth and renewal, but not so vigorous that we have to prune a lot to get sunshine on the fruit. We are learning as we grow. I have the goal of growing all of our nitrogen on the farm. We are close. We grow 60 to 70 percent of our nitrogen and offset that with off-farm nitrogen organic fertilizer."

Yet, most nitrogen is not available to the plants. Because nitrogen forms triple covalent bonds, it is very difficult to unlock. Nitrogen in our atmosphere takes the form of (N_2). One process of making nitrogen (N_2) available to plants is called nitrogen fixation. Rhizobia, members of a bacteria group known as diazotrophs, are the organisms responsible for forming a relationship with leguminous plants. Nodules develop on the legume plant roots as a result of this bond and assist the bacteria in converting N_2 to a plant-available form. The two plant-available forms of nitrogen include nitrate (NO_3) and ammonia (NH_4).

An additional route for nitrogen uptake in plants is through the microbial consumption of organic matter, which contains a small amount of nitrogen along with a high concentration of carbon. According to CSU soil and crop science research: "Nitrogen in soil organic matter becomes available to plants through a mineralization process. About 30 pounds of nitrogen per acre will be available to the crop during each growing season for each 1.0 percent organic matter in the surface soil layer." (Davis and Westfall, 2014).

When producers introduce high-protein, slow-release organic matter as a fertilizer, such as alfalfa, or feather, or blood meal, microbes convert even more nitrogen for plants to utilize, with the additional bonus of improving aggregate stability. Soil management principles that promote decomposition, organic matter, and microbial activity are paramount to regeneration because naturally occurring sources of plant-available nitrogen are very scarce and have been extracted extensively since the early 1800's.

▼ A look at how soil elements affect crop health. Nutrients will cycle throughout the season. *Source: Acres U.S.A./Biological Farmer*



Ela looks to build nitrogen in ways that work in concert with his farm's thin topsoil and tough as nails subsoil clay: "As soon as we plant trees, we will come in right away and plant a cover-crop that can outcompete the quack grass," Ela said. "We are going to primarily plant legumes, because I want that nitrogen fixation capability. At our farm location, we have fairly thin topsoil, about 8 inches to 20 inches topsoil and very deep subsoils, but those are heavy clays and the tree roots do not like that. We have these 3-year-old really big trees with roots the size of your leg that go down and when they hit that clay subsoil, they go sideways."

Ela goes on to describe a fascinating observation that has repeated itself over the years. The only two root systems he has observed growing through the tough layer of pan-like, clay subsoil include those roots belonging to the biennial field mallow *(Malva neglecta)*, and the hard-working root systems of alfalfa *(Medicago sativa)*.

Ela continues: "So, I'm going to choose alfalfa instead of a red clover for nitrogen fixation, because if that tap root is going to go down into that subsoil it means several benefits: it's not exploiting the same soil resources as my tree roots are, it's creating water channels down in the subsoil, it's building top soil because the organic matter of the alfalfa root is changing the structure of the subsoil, and it is bringing nutrients from the subsoil to the surface that the trees otherwise wouldn't have access to," he explained. "That being said, the tops of legumes are also very nitrogen rich. If you go and mow or green-chop a legume, that is a very fast fertilizer, because it breaks down quickly and becomes available quickly."

Ela adds that he also looks at building biomass when calibrating cover-crop mixes to build nutrients. He

CHEMICAL BALANCE

OUT OF BALANCE	IN BALANCE
Calcium less than 65%of CEC.	Calcium 75%-85% of CEC.
Magnesium over 20% of CEC.	Magnesium 12-18% of CEC.
Potassium less than 3% of CEC or more than 5%.	Potassium 3-5% of CEC.
Phosphorus less than 20 ppm (P1)	Phosphorus 25-50ppm (P1).
Sulfur less than 20ppm.	Sulfur over 25ppm.
N:S ratio over 15:1 in plants.	N:S ratio 10:1 in plants.
pH less than 6.0, over 7.0.	pH 6.5-6.8.
Low OM (organic matter).	Medium to high OM.
Low trace elements.	Adequate trace elements.

SYMPTOMS:	IN BALANCE
1. Hollow stems (alfalfa), difficult to establish, short-lived standards	1. Solid stems (alfalfa), easy-to-establish), long-lived stands
2. Poor dry-down of crops.	2. Good dry-down & keeping quality.
3. Low sugar content in plant.	3. High sugar content.
4. Mineral imbalance in feed.	4. Good mineral balance.
5. Crops show nutrient deficiency	5. Crops show no nutrient deficiencies
6. Herd health problems.	6. Healthy animals.
7. Crops stressed by weather.	7. High yield; low weather stress.
8. Weed problems.	8. Few weeds.

▲ These baselines can help farmers and ranchers connect the dots between deficiencies in crop health to imbalances in soil chemistry. *Source: Acres U.S.A./Biological Farmer*

uses dutch white clover, winter rye, and other diverse species along with alfalfa. The story of nitrogen and its relationship with living roots is a compelling way to look at nutrient cycling. Another macronutrient, phosphorus, is equally as fascinating in its soil dynamics.

Phosphorus

Phosphorus is a powerhouse nutrient because it supplies plant cells with the energy needed to do things like process sugars. Phosphorus is also an ingredient in DNA/RNA. Phosphorus builds strong roots, flowers, and fruits. When plants show signs of delayed and stunted growth, phosphorous deficiency can be counted as a possible culprit. And in ironic fashion, a deficiency of phosphorus in plants is in stark contrast to its abundance in Colorado soils.

Our soils need regenerative practices that build above ground biomass and underground living roots to unlock phosphorus. Phosphorus occurs in the soil from mineralized parent material (apatite). Colorado State University research shows: “In Colorado, the majority of our soils are alkaline and have a pH of 7.0 to 7.8 and greater. Soils with a pH of 7.5 and higher typically have a high calcium concentration that binds phosphorus as calcium-phosphate—creating an insoluble compound that is not available to plants. Therefore, it is necessary to amend agricultural soils with available forms of phosphorus at the correct agronomic rate” (Eliot et al., 2014).

Plant-available phosphorus occurs as a byproduct of organic matter decomposition, for which we have microbial organisms to thank, and also as a result of the symbiotic relationship between arbuscular mycorrhizal fungi (AMF) and the living roots of plants (and specifically, the trading of root exudates for nutrients, like phosphorous).

Lowell King, a farmer in Loma, Colorado, raises diverse cash crops, including corn, soy, alfalfa, and cattle. He describes how he keeps an eye on his nutrient levels, including phosphorus, and incorporates amendments: “We are reducing synthetics and my goal would be to eliminate them completely,” King said. “We try hard to include flax and buckwheat and some of those that are really notorious for being able to pull plant-unavailable phosphorus from the soil. We are working really hard to cycle as much as we can into the soil using plants and practices, and cycling plant residue back on instead of hauling it off (with the exception of our horse hay).”

Potassium, another macronutrient, plays a prominent role in supporting plant stress response. This is due to potassium’s function as a regulator, both of water, and other cellular processes. Sufficient levels of potassium also contribute to a plant’s stress tolerance.

Secondary Macronutrients:

- **Calcium**, like **potassium**, assists in the movement of nutrients through and between the cellular matrix. Calcium is also a critical ingredient in cell-walls and tends to accumulate in young, dividing plant cells. Many Colorado tomato growers dread the tell-tale sign of calcium deficiency, blossom end rot, which appears as a rotten blotch on the bottom (the blossom-end) of tomatoes. This occurs when there is not enough calcium in the developing parts of plants.
- **Magnesium** locates itself in the very center of the chlorophyll molecule. As such, deficiency in magnesium results in a shortage of chlorophyll, which manifests as stunted growth in plants. Magnesium also catalyzes protein synthesis.
- **Sulfur** is a component of metabolic amino acids in plants and also is a building block for

cellular structures. In contrast to nitrogen deficiency occurring in older plant leaves, sulfur deficiencies often show as the yellowing of new plant leaves.

- **Silicon** is another nutrient that plays a crucial role in a plant's drought resilience. Silicon coats the lining of epidermal cells with a waterproof barrier.

Micronutrients: Small but Mighty

Micronutrients are anything but insignificant. Even in small amounts, these elements are critical for plant health and when any one nutrient is out of balance, farmers risk a crop that does not yield to its highest potential.

Here are some of the micronutrients responsible for whole-systems plant health.

- **Boron** is a constituent of cell walls and necessary for the development of plant parts.
- **Chlorine** works in tandem with potassium to regulate the opening and closing of stomata.
- **Copper** is a constituent of enzymes necessary to "run" photosynthesis and respiration.
- **Iron** moves electrons, makes chlorophyll, and builds enzymes.
- **Manganese** is necessary to split water bonds during photosynthesis for energy.
- **Molybdenum** is essential for the legume symbiont diazotrophs to fix nitrogen.
- **Nickel** plays a role in regulating nitrogen once mobile in plants.
- **Sodium** is essential in C4 plants.
- **Zinc** is instrumental in photosynthesis, plant growth, and plant resistance to stress.

Colorado's Unique Chemistry

Colorado State University regional extension specialist Annie Overlin knows soil. Annie works and lives in eastern Colorado and the San Luis valley region and is part of a sixth-generation ranching family.

Overlin's responsibilities include soil health management on rangelands, cover crop integration, and grazing operations. She describes how native and naturalized grasses and forbs absorb different nutrients based on differential root systems: "Plant tissue tests show us that forbs often accumulate a lot of calcium and other nutrients at higher rates than grasses," she said.

Overlin points out that some plants are also dynamic accumulators of nitrogen, but they don't fully process the nitrogen, so they are referred to as nitrate accumulators. One of those species is the "weedy" herbaceous perennial, kochia. But Colorado soils also demonstrate deficiencies as well.

"Many of our trace minerals are low when we run plant tissue tests," Overlin said. "Copper often comes up as low in the plains. We have an excess of sulfur which then contributes to the copper scarcity by binding up copper."

Cation Exchange Capacity

Cation Exchange Capacity (CEC) refers to the amount of negatively charged ions in a soil. Simply put, understanding CEC can help a land manager understand their field's growing potential by giving them the ability to measure the potential for the soil to hold nutrients the plant wants.

Cations are the positively charged ions of elements in the soil. According to David Mengel of Purdue University, most common soil cations are calcium, magnesium, potassium, ammonium, hydrogen and sodium. Common anions are chlorine, nitrate, sulfur and phosphate.

In general, clay soils with high organic matter content have a higher CEC value, which means that the soil has a greater capacity to hold more negative charged ions. Overlin adds, "At higher elevations, Colorado soils are not high in pH, but for the most part, the pH levels that I see, across the board, are higher than 7 and can go up to 8.4. Our lower river valleys will especially have those high pH levels."

Salinity and Soil Health

Annie Overlin has worked with soil samples from all over the state and has observed that high-elevation Colorado

▲ Soil types in Colorado can vary, but generally speaking, pH levels are high, ranging between 7 and 8.4. *Source: Colorado Department of Agriculture and Shelby Chesnut* soils can exhibit deficiencies in salts but areas in the San Luis valley, conversely, have high salts. CSU researchers reported: “Saline soils are found throughout Colorado. These salts originate from the natural weathering of minerals or from fossil salt deposits left from ancient sea beds. Salts accumulate in the soil of arid climates as irrigation water or groundwater seepage evaporates, leaving minerals behind.”

Salinity impacts crop health and nutrient availability. Salt excesses in Colorado soils can interfere with ion exchanges, impede root development and inhibit seed germination.

Yet, Coloradoan farmers possess a mighty tool to treat high salinity, and it is a tool that aligns with one of STAR’s five soil management principles: soil armor. According to research by CSU’s Troy Bauder and other extension specialists, “Crop residue at the soil surface reduces evaporative water losses, thereby limiting the upward movement of salt (from shallow, saline groundwater) into the root zone. Evaporation and thus, salt accumulation, tends to be greater in bare soils. Fields need to have 30 percent to 50 percent residue cover to significantly reduce evaporation.”

Crop Needs and Inputs

CSU extension has conducted and published extensive studies on fertilizer recommendations for some of the state’s major crops, in tandem with insights for understanding how these nutrients will interact with variable Colorado soils.

The harmful down-stream environmental impacts of over fertilization can cause ecosystem devastation, and even lawsuits between growers. Growers can use general recommendations with the help of certified crop advisors, extension agents, or agronomists to make sure fertilizer amounts are appropriate and precise. Colorado houses a statewide extension program with regional expertise for fertilizing crops.

Here is nutrient information specific to corn, potatoes, and wheat grown in Colorado:

Corn is a multi-million dollar industry in Colorado agriculture, so the soil chemistry needed is more commonly known. According to 2014 research by Davis and Westfall, “Adequate soil fertility is one of the requirements for profitable corn production. Nitrogen is the most yield-limiting nutrient, unless previous manure applications or excessive nitrogen fertilizer rates leave high residual nitrate levels in the soil. Phosphorus is the next most limiting nutrient, while zinc, iron, and potassium also may be limiting in some Colorado soils.”

Colorado’s potato industry is one of legacy, history, and market loyalty. Potatoes in the state are mostly grown on sandy soils, and so nitrogen and phosphorus are the most limiting nutrients, while zinc might also fall short in some areas.

The total production value of Colorado wheat, in 2021, totaled $466,052,000. Wheat producers invested in soil health and crop yields know that ensuring balanced levels of nitrogen is critical to production value.

Fertilizers and Soil Health

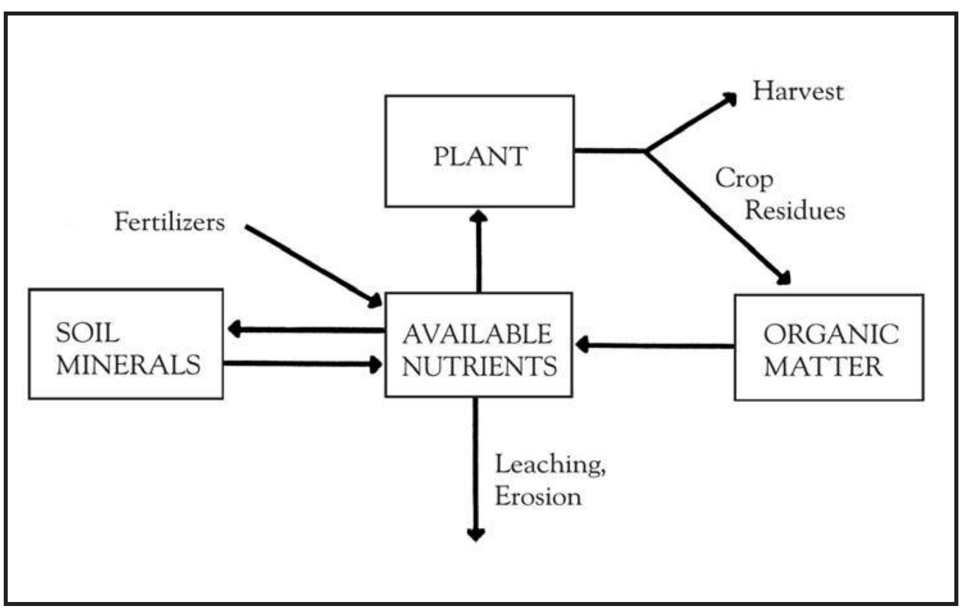
The spectrum of fertilizers available to boost crop yields and health is wide and diverse. Specialty crop growers may utilize organic amendments that work in tandem with microbial soil biology to unlock the land’s greatest potential in supporting plant health.

Brandon Kail, owner of Rocky Mountain BioAg, which specializes in biological fertilizers, explains that many soils that haven’t been managed for soil health are deficient in first trophic level photosynthetic bacteria and that these organisms are keystone species for the whole of the soil-food-web.

The use of microbial inoculants can jumpstart microbial food webs in degraded soils with other important factors, such as living roots, in place. Other organically sourced inputs help Colorado farmers to work with soil biology in order to promote balanced nutrient levels in their soils and for their crops.

How is this related to soil chemistry? Mixed-vegetable and fruit grower Tim Ferrell, of the 40-acre Berry Patch Farms, in Brighton Colorado, relies on a tested mixture of kelp and fish emulsion, applied through his drip irrigation system, to provide his crops a slow-release and natural source of nitrogen and micronutrients.

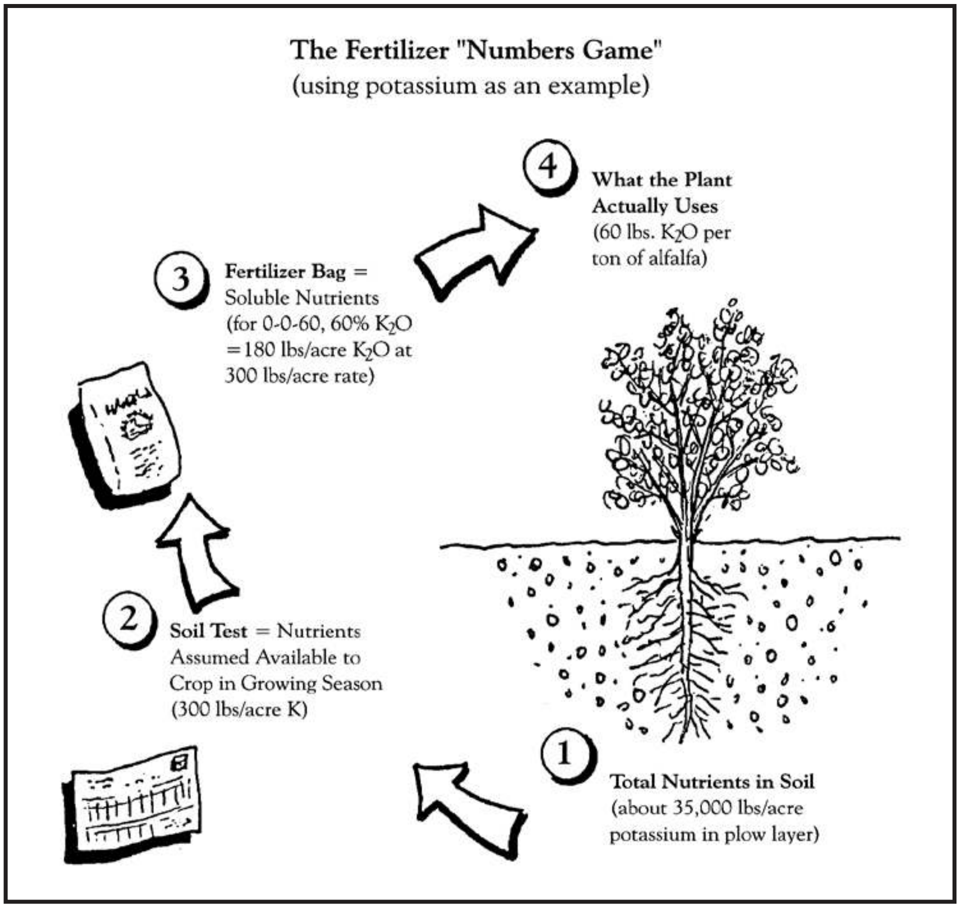
Steve Ela utilizes a combination of organic nitrogen sources and chelated micronutrient applications to support his tree-fruit. Lowell King relies



◀ This chart shows you how fertilizers flow in and out of a crop. *Source: Acres U.S.A./ Biological Farmer* on biological foliar sprays, as well, with 30 percent mix of sugars and micronutrients for his crops.

Listed below are some common organic and mined mineral sources of soil boosting nutrients essential to plant growth listed with the primary nutrient provided (minor nutrients from each source are not listed) and note, this is not an exhaustive list:

- **Alfalfa meal**: nitrogen source
- **Azomite**: source of trace minerals
- **Blood meal**: nitrogen source
- **Bone meal**: phosphorus source
- **Feather meal**: nitrogen
- **Fish emulsion**: slow-release source of nitrogen and other macronutrients
- **Kelp**: concentrated source of trace minerals and micronutrients
- **Langbeinite**: potassium source
- **Manure**: nitrogen source
- **Seabird guano**: phosphorous



▲ This chart shows you how fertilizers flow in and out of a crop. *Source: Acres U.S.A./ Biological Farmer*

Compost

Organic matter is a tremendously beneficial food source for the microbial communities that create soil aggregate stability and unlock nutrients for plants to utilize. Compost, simplified, is the decayed and decaying remains of carbon and nitrogen rich material, such as food scraps, manure, leaves, grass, and woody remnants, like those from commercial mushroom growing operations. Commercial and institutional composting facilities around the state of Colorado utilize nature's own intelligent design to recycle and reuse large-scale food refuse, animal manure, and landscaping debris as they promote composting processes that turn these base ingredients into rich soil amendments.

Each composting business has a unique approach to creating soil-beneficial organic matter—some offer solely composted dairy manure, while others focus strictly on institutional food waste. Compost provides great soil structure building and nutritional enrichment to soil, but growers should be aware of some concerns with the overloading of compost, specifically, excessive phosphorus. Depending on the base ingredients in compost, some products can have a ratio of nitrogen to phosphorus that is too low. This means that soils can end up with excess phosphorus once the nitrogen has been cycled through. Excess levels of phosphorus can impede microbial activity and restrict the uptake of other nutrients in plants. The STAR program promotes soil health practices that help Colorado producers avoid issues of nutrient excesses and deficiencies, and foster balanced nutrient cycles.

Living Soil and Nutrients

Ultimately, Colorado producers who utilize any of the five soil health principles are taking strides to foster living soil systems that are more efficient at cycling nutrients and have greater capacity to utilize appropriate applications of fertilizers and amendments for plant health and crop production.

Lowell King aptly observes, "We are tracking nutrients with soil tests and tissue tests and what is showing is that without adding phosphorus, our numbers are increasing, and we 100% credit that to soil biology."

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The STAR program was originally developed by Champaign County Soil and Water Conservation District (CCSWCD) in Illinois and is now also administered in four other states: Colorado, Indiana, Iowa, and Missouri. The Colorado STAR Plus program grew out of a stakeholder process launched by the Colorado Department of Agriculture and other partners in 2019 that was facilitated by the Colorado Collaborative for Healthy Soils, involved more than 250 stakeholders and resulted in passage of HB21-1181 and SB21-235, which authorized and funded the launch of a state soil health program based around STAR. This state stimulus funding and additional grant funding received from the Gates Family Foundation, Colorado Department of Public Health and the Environment, Colorado Water Conservation Board, NFWF, and NRCS have enabled the launch of the first round of the STAR Plus program.

Getting Involved with Colorado STAR

In the summer of 2021, legislation was passed in the Colorado House of Representatives funding the Agricultural Soil Health Program for 2022. The Colorado Soil Health Program is built around the framework of an Illinois program called STAR, which stands for Saving Tomorrow's Agriculture Resources. STAR was developed to be a free resource for farmers and ranchers, helping them evaluate their current land practices, and particularly focusing on nutrient and soil loss. The STAR program encourages best soil health practices, and rewards producers with recognition, a high rating, and a field sign. While the STAR rating system is a useful metric for farmers to measure their own conservation efforts, it is also a tool for consumers interested in a farmer's soil health practices.

The program was originally created in the Champaign County Soil & Water Conservation District in 2017, with the assistance of the Illinois Department of Agriculture, as a means to facilitate specific environmental and agricultural goals that were outlined in the state's Nutrient Loss Reduction Strategy. Colorado, as well as Iowa and Missouri, have adopted this program framework.

Best management practices for agricultural land use have been developed since the 1930s by the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS). The STAR program utilizes these best practices, and also relies on a panel of experts, including university researchers and scientists, to establish appropriate ranking systems based on different resource factors. STAR Plus is an additional level of producer support that "facilitates capacity building by providing matching state funds towards the cost of these projects and activities within each district". This means that the state provides technical and financial assistance to producers over the course of three years, through grants and services like soil testing that are facilitated through the state's conservation districts.

Any farmer or rancher can visit the STAR website and fill out these forms in order to receive this rating. The first 100 participants in a year also receive a free soil test.

To participate, the only requirement is that the farmer or rancher fill out a form to the best of their knowledge, describing their farm practices in detail for a specific field chosen by the producer. The forms include questions about cropping practices, tillage regimes, fertilizer and nutrient applications, and other management practice information. The producer then receives a STAR rating from 1-5 that demonstrates their incorporation of the five principles of STAR: Soil Armor, Minimize Soil Disturbance, Plant Diversity, Continual Live Plant/Root, and Livestock Integration in their cropping system. Earning five stars in a field means that a farmer or rancher is implementing all five soil health principles on that field, while earning one star means that they are following only one.

COLORADO Department of Agriculture Conservation Services Division

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SAVING TOMORROW'S S.T.A.R. AGRICULTURE RESOURCES