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Biology Is Soil Fertility

Soil Microbes Are the Real Heroes

By Paul W. Syltie, Ph.D

Our tenure on the land — the very essence of civilization — is in the hands of our unseen microbial friends. That is a powerful statement, but one that I will not back away from, because it is true. Our very existence depends on the workings of the microscopic unicellular organisms that populate our soils, along with a few macroorganisms like earthworms as well.

How can I say this? Let's take a quick took at what these microbes in their almost infinite variety can do. First, let us define the plant microbiome. That is the array of microbes that populate the plant and associated soil.

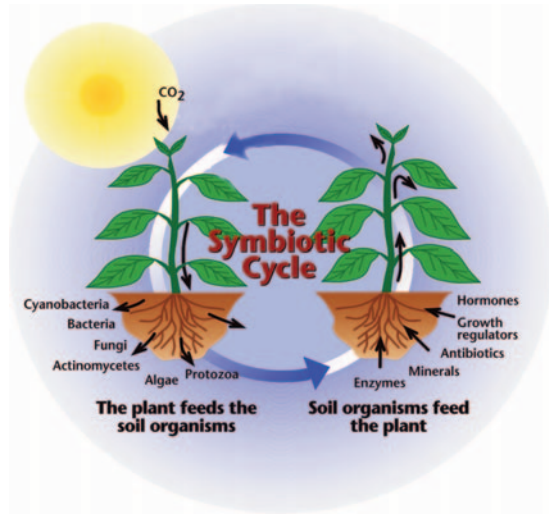
1. Phyllosphere microbes. These are bacteria, fungi, cyanobacteria, and other microbes that live on leaf surfaces.

2. Endophyte microbes. These fungi and bacteria grow in close association with internal root, stem, and leaf cells. They are passed on through seeds to the next generation.

2. Rhizosphere microbes. This third class of microbes populate the root zone of plants by feeding on root exudates carried down the stem through the phloem.

Effects of Microbes On Plants

There are direct and indirect effects of microbes in promoting plant growth, and these effects are closely interrelated. The entire system can be summarized by what I term the Symbiotic Cycle, which is shown in the figure here. Plants capture sunlight energy in chlorophyll, then transfer that energy to carbon compounds as carbon dioxide is fabricated with other elements into a host of compounds.



Up to 40% of this energy is then transferred down into the roots and excreted as a mucigel along root surfaces, where the carbohydrates, amino acids, organic acids, flavonols, lignins, sterols, fatty acids, enzymes, and other compounds feed a vast array of fungi, mycorrhizae, bacteria, cyanobacteria, actinomycetes,

See Soil Microbes Are the Work..., page 2

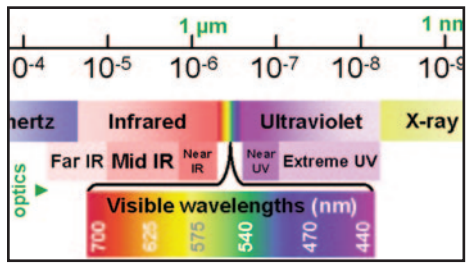
Ultraviolet Light for Seeds

A Newly Developed Technology That Really Works

By Paul W. Syltie, Ph.D.

The sun produces light energy that drives all life, either directly or indirectly. Only a tiny portion of this energy, which travels in waves or frequencies, is visible to us; the rest is invisible but has various uses in communications, such as for radio, television, and cell phones.

Many of us are familiar with the fact that photosynthesis is powered mainly by light in the reddish spectrum, leaving leaves to reflect green back to us. However, the invisible ultraviolet wavelengths have been known for some time to be beneficial to growth as well, besides giving us a suntan, or a burn if we get too much of it.



Ultraviolet light wavelengths are shorter than visible light but longer than X-rays.

Ultraviolet A light (UV-A) has a wavelength of 320-400 nanometers (nm), while ultraviolet B (UV-B) has a bit shorter wavelength, of 290-320 nm.[1] UV-A comprises about 3% of the photons in sunlight, while UV-B makes up only 1%; however, it is damaging to skin with excessive exposure Both of these wavelengths power photosynthesis, but most of the UV-B is absorbed by oxygen in the air before it reaches the earth's surface. UV-C light is filtered out by the ozone layer and never reaches the earth.

The effects of this UV radiation on plants are significant.

1. Photosynthesis and growth are stimulated. For instance, a study published in

See Hydrogen Power Is Coming, page 3

Soil Microbes Are the Workhorses!

Continued from page 1

protozoa, and other microbes.

The microbes then return the favor by producing an array of highly useful compounds that are taken up by the roots and transported upward to the leaves for further growth. These compounds include vitamins, antibiotics, growth regulators, enzymes, and a host of other materials.

The Fertility Connection

Above all, these bacteria, fungi, actinomycetes, protozoa, mites, and other organisms convert nutrients into available forms. It is this function that fuels the "biology is soil fertility" mantra.

The series of diagrams on the right illustrate how nitrogen, phosphorus, sulfur, potassium, calcium, magnesium, and the micronutrients all must go through a process of microbial interaction to become available for plant uptake and utilization. The white boxes are the available forms. These processes are centered within the rhizosphere primarily and make possible the utilization of nutrients both within the soil or added as manures, compost, and fertilizers.

Besides these actions of microbes to make essential elements available, and as already discussed in part, there are several indirect methods by which soil microbes serve as fertility mediators.[1]

1. Phytohormone and growth regulator production. These include cytokinins, auxins, gibberellins, ethylene, abscissic acid, brassinosteroids, and certain others. These affect seed germination, stem elongation, root hair development, flowering, fruit setting and other developmental processes

2. Siderophore synthesis. These low molecular weight compounds, synthesized by several bacterial strains like *Pseudomonas* and *Bacillus*, are essential for chelating insoluble iron (Fe^{+3}) and converting it to the soluble form (Fe^{+2}) that plants can use. Other insoluble elements are also complexed and converted to soluble forms by siderophores.

3. Enzyme production. The production of a number of enzymes by bacteria such as *Pseudomonas* and *Trichoderma* species are known to reduce abiotic stress conditions (drought, salt buildup, etc.). They also help protect against pathogens, including *Botrytis* and *Rhizoctonia*.

4. Antibiotic production. These compounds are low in molecular weight and include aldehydes, ketones, alcohols, lipopeptides, and heterocyclic nitrogenous compounds. They are very effective in helping the plant defend against pathogenic bacteria, fungi, and viruses.

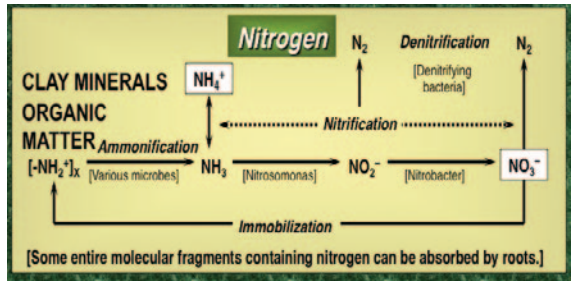
5. Induced systemic resistance. This response involves an activation of the jasmonate and ethylene pathways through *Streptomyces* and other bacteria, which signal the plant cells to deposit more callose, lignin, and phenolic compounds as protection against pathogens

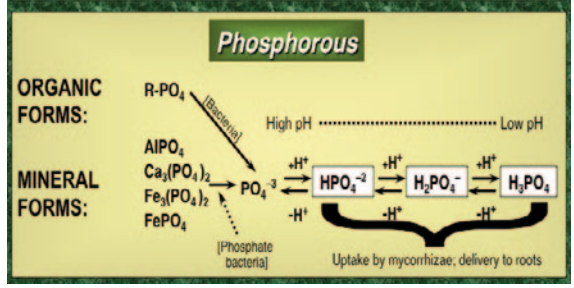
6. Production of HCN and ammonia. Both of these compounds have anti-pathogen and growth stimulating effects.

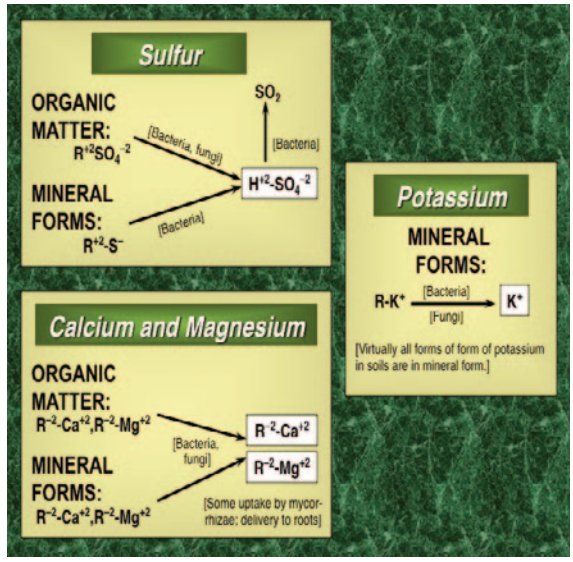
A Change in Paradigm

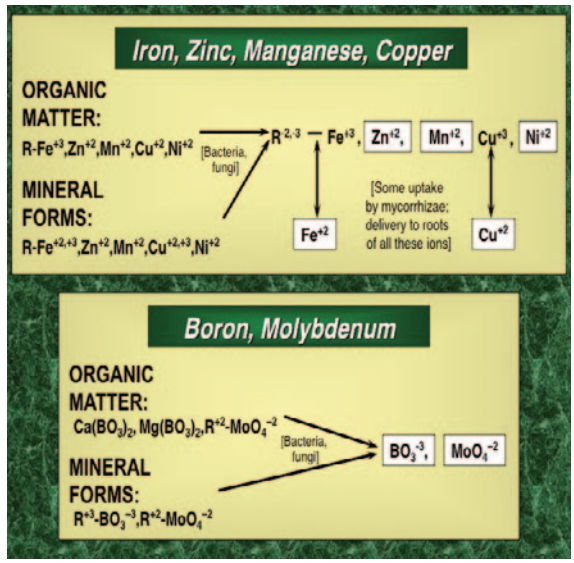
We need to focus on nurturing microorganisms in the soil and the plant as our friends in bringing us the highest yields of the highest quality. They not only are the workhorses for making nutrients available, but they also are highly active in keeping plants healthy.

We can encourage these friends of ours by making sure to return organic residues to the soil on an annual basis. Livestock manures should be applied whenever possible, and tillage should be limited so soil organic matter will not be oxidized and reduced. Organic matter forms the "heart of soil fertility," and should always receive our utmost attention. It is in this fraction that the bacteria, fungi, cyanobacteria, mites, protozoa, earthworms, and other soil organisms live and prosper. Let's give them the greatest chance possible to carry out their jobs! ❒









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Improved Seedling Vigor, Less Disease

Continued from page 1

Oecologia found that exposure to UV-A light increased photosynthesis by 12%. Another study published in *Scientia Horticulturae* found that UV-A light led to increased leaf size, dry weight, and growth potential.[2]

2. Resin production is increased, and stress is reduced. This resin increases flavonoids and terpenes in plants. Flavonoids give certain plants their rich, vibrant colors, while terpenes give plants their taste and smell. The resins provide a barrier against water loss on leaf surfaces and also deter pathogens and harmful insects. In fact, wavelengths shorter than 300 nm will kill some pathogens.

3. Root growth is improved. This is a consequence of point 1, but also due to the piping of this UV energy down the stems and into the roots.

What About Seed Effects?

While these plant effects from UV radiation have long been documented, effects on seeds themselves have more recently been researched, and the effects have been quite dramatic! The effect of UV light on seed germination is now being exploited on a commercial scale. UV technology was first developed for specialty crop seeds like lettuce, strawberries, and tomatoes, using targeted photomorphogenic signaling. This leads to growth induced by the plant's response to differences in the light spectrum.

The proprietary technology is based on 20 years of science and seven years of large-scale field validation by a company called BioLumic. The company has tested light-treated seeds on more than 3,000 United States field plots over three growing seasons. The average yield increased 15% with corn, and 12% with soybeans.[4]

According to Jason Wargent, Ph.D., founder and chief science officer at BioLumic, "Discovering that the same technology activated seeds as well as seedlings was a 'eureka' moment. It opened the door to broad-acre, commodity production of crops like soybean and corn benefiting from the same remarkable results of UV light treatment that we had developed for seedlings."[5]

The Way It Works

UV light is a signal wavelength that plants use to carry out certain processes to improve their productivity. This makes UV light a "programmable" input to crop seeds, allowing them to induce traits that can improve yield, quality, root growth, and resilience.[6]

Seeds germinate quicker and with greater vitality if treated with ultraviolet A and B.

According to BioLumic, seeds possess their own photomorphogenic signalling and response mechanisms. Within the thousands of genes contained in seed subregions are genes that have a function within UV signal transduction and regulation of downstream physiological outcomes. Using targeted applications of BioLumic technology, beneficial crop traits can be induced in a seed prior to sowing, so that the benefits can be extended over a greater range of crops.[7]

This has led to the development of various "recipes" designed for particular cultivars of different crops. Seeds are treated on a conveyor belt, where they receive the recipe and drop out the other side, which means seeds can be treated as they are being bagged for distribution. The storage life of these effects is at least six months.

Steve Sibulkin, CEO of BioLumic, says, "UV light signaling is the next frontier in plant science, changing the paradigm of crop production gains without solely relying on genetic modification, chemical inputs, or time-intensive breeding."[8]

The Path Forward

Based on their longstanding record of rapid adoption of scalable innovation, partnering with Gro Alliance and their network of corn and soybean farmers, this innovative UV seed treatment technology should move quickly into the farm marketplace and help increase farmer profitability, while contributing to a more sustainable global food production system.

Initial use of this new UV technology is slated to begin at Gro Alliance's corn and soybean seed production facilities in Mt. Pulaski, Illinois. Their intention is to expand across the Midwest in 2025. ❐

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Jefferson's Words On Agriculture and Life

Whenever there are in any country uncultivated lands and unemployed poor, it is clear that the laws of property have been so far extended as to violate natural right. The earth is given as a common stock for man to labor and live on. The small landowners are the most precious part of a state.

If people let government decide what foods they eat and what medicines they take, their bodies will soon be in as sorry a state as are the souls of those who live under tyranny.

Agriculture is our wisest pursuit, because it will in the end contribute most to real wealth, good morals, and happiness.

From *www.thisoldfarm.com*.

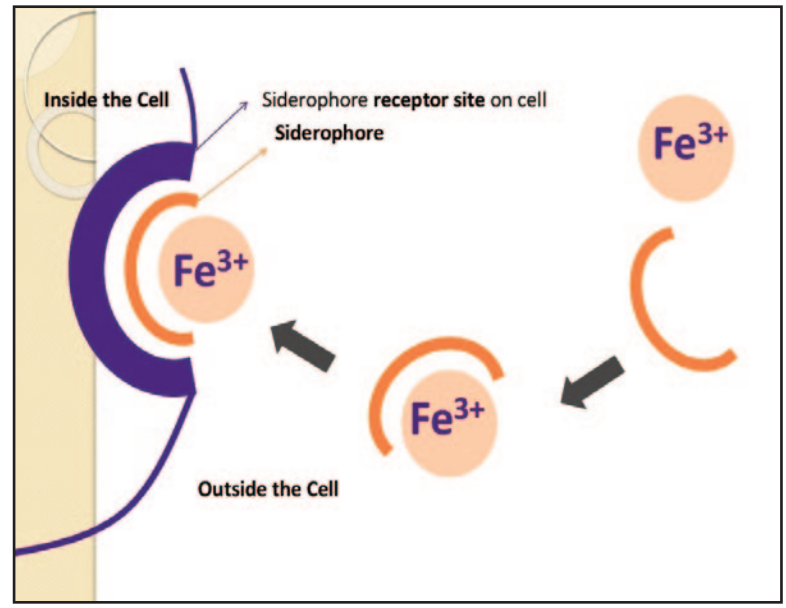
15-Minute Soils Course

Lesson 57: Siderophores and Iron Nutrition

There are at least 20 elements required for plants to grow, including C, H, O, P, K, N, S, Ca, Fe, Mg, B, Mn, Cu, Zn, Cl, Mo, Si, Co, Na, and Ni. Others are likely essential as well, but are not recognized officially.

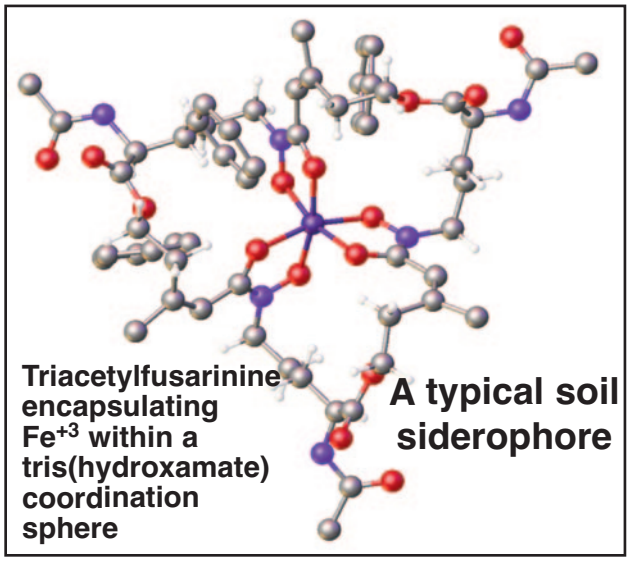
Amongst these elements, iron (Fe) is perhaps the most difficult for plants to acquire from the soil due to the very low solubility of the element in its Fe^{+3} oxidized forms, usually Fe_2O_3. The element comprises typically from 1 to 5% of soils, or about 20,000 to 100,000 lb/acre in the top six inches of soil. This iron is usually bound in silicate minerals and iron oxides and hydroxides, and is not readily available for plant uptake. Yet, plants require this element for numerous enzymatic processes, especially for the formation of chlorophyll. The amount of the element present in the Fe^{+2} or Fe^{+3} state depends on the soil pH, soil aeration, and organic matter content.

In order to be utilized, iron must be reduced to the soluble Fe^{+2} state, and the plant and soil bacteria, fungi, and other microbes have an excellent strategy to accomplish this. This strategy involves the use of **siderophores,** low molecular weight compounds that are secreted by microorganisms to chelate and scavenge ferric iron (Fe^{+3}) from the surrounding environment. Chelate means "claw." These chelate compounds grasp the iron ion and hold on to it with great tenacity. The compounds are primarily produced by bacteria, fungi, and the plants themselves that cultivate the growth of these microbes in their rhizospheres.



To date, approximately 500 siderophore structures have been identified. Siderophores are usually classified by the ligands (the chemical structure) used to chelate the ferric iron. The major groups of siderophores include the catecholates (phenolates), hydroxamates, and carboxylates (derivatives of citric acid). Citric acid can also act as a siderophore.

Siderophores are amongst the strongest soluble Fe^{+3} binding agents known. If you have a knowledge of chemistry, understand that siderophores often have formation constants (Kf) of 1025 or higher, making them some of the strongest Fe^{+3} binding agents known. Once a siderophore has bound Fe^{+3}, cells have elaborate mechanisms to detect the siderophore-Fe^{+3}



Triacetylfusarinine encapsulating Fe^{+3} within a tris(hydroxamate) coordination sphere

A typical soil siderophore

15-Minute Soils Course

complex and transport it into the cell.

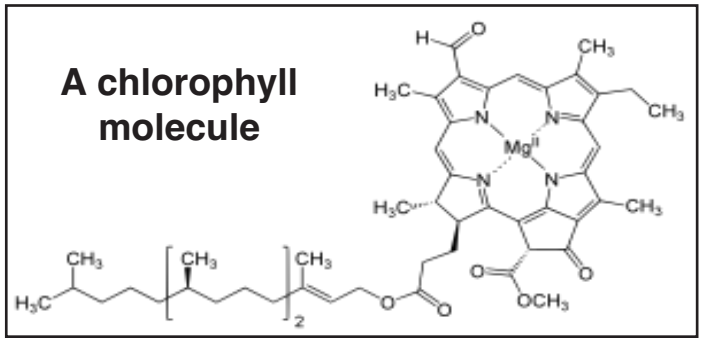
Siderophores usually form a stable, hexadentate, octahedral complex with Fe^{+3} preferentially compared to other naturally occurring abundant metal ions, although if there are less than six donor atoms water can also coordinate.

The Essentiality of Iron to Life

Iron is essential for almost all life, because of its vital role in processes like respiration and DNA synthesis. Virtually every cell requires iron, but in the Fe^{+2} oxidation state, which is the soluble form.

Chloroplasts containing chlorophyll within leaf cells

Iron is involved with the formation of chlorophyll, which is the overall most important group of molecules that exist on earth. It is these compounds that capture sunlight energy and transfer it to carbon compounds, which form the structure and function of every living cell for man, beast, plant, and microbe. The iron is replaced by magnesium during chlorohyll's synthesis, but iron plays a crucial role in its formation. ❒



Essentiality of Iron

Plants

1. **Activation of many vital enzymes, such as cytochromes in the electron transport chain**
2. **Synthesis of chlorophyll**
3. **Maintenance of chloroplast structure and function**
4. **DNA synthesis**
5. **Respiration**
6. **Activation of many metabolic cycles**
7. **Nitrogen fixation**

Humans and Animals

1. **Activation of vital enzymes supporting connective tissues, muscles, and nearly all tissue functions**
2. **Blood oxygen transport; a major component of blood hemoglobin and myoglobin**
3. **Synthesis of red blood cells**
4. **Expediting cell division**
5. **Maintaining immune function**
6. **Aiding hormone synthesis and function**
7. **Supporting neurological functions**

See How Much You Learned

1. The compounds that bind to iron and bring them into cells are _____.
2. Iron in the Fe^{+3} state is highly soluble. T or F.
3. Iron is essential for a. photosynthesis, b. red blood cell formation, c. respiration, d. humus.
4. Iron is replaced by_____during the process of chlorophyll formation.
5. Siderophores are produced by a. bacteria, b. algae, c. fungi, d. plant root cells.
6. Once a siderophore has bound Fe^{+3}, root cells can detect and absorb them. T or F.
7. In order for iron to be used by plants, it must be in the _____oxidation state.

Answers: 1. siderophores; 2. F; 3. a, b, c; 4. magnesium ; 5. a, c, d;6. T; 7. reduced, or +2.

Land Prices Continue to Creep Up

By Rhonda Brooks and Tyne Morgan
[Abridged from *Farm Journal, July/August 2023*]

The No. 1 question farmers are asking Paul Schadegg today is whether land values have finally hit a plateau.

"When we compare our data and data from the Federal Reserve surveys, we're definitely seeing some settling, a de-escalation," says Schadegg, senior vice president of real estate operations for Farmers National Company.

Along with that, he says there are fewer high-quality parcels of land coming to the marketplace.

The price of farmland in the United States and worldwide continues to rise.

Farmers National Company's midyear land values report released in mid-June says the pace slowed as a result of increases in interest rates, inflation and input prices.

The result is land values are now advancing by single digits across 18 states instead of double digits common in the past two years. But, farmers are still in hot pursuit of good ground.

"What we're seeing is when high-quality land is offered to the market, there's no shortage of demand," Schadegg says.

The latest Rural Mainstreet Index from Creighton University is less positive. The bankers surveyed forecast zero percent growth in farmland prices over the next 12 months.

"The lower quality land is getting hit the hardest," says Jim Rothermich of Iowa Appraisal. "At auction, we're seeing an uptick and no sales, and it's all lower quality farms."

Rothermich is even forecasting a 10% correction in land values in the next 12 months with current economics at play.

Schadegg says he sees lower quality land prices are a bit softer, and potential buyers are fewer and slower to bid.

"Land that has drainage issues, erosion issues, maybe fertility issues, things of that nature, those are the properties being discounted just a little bit," he says.

Looking Ahead

Schadegg says Farmers National Company currently has 107 listings, with 30-some scheduled to go to auction by early September.

June High Quality Values Per Acre

	2021	2022	2023
Illinois	$12,300	$15,000	$16,000
Indiana	$ 9,000	$12,000	$13,000
Iowa	$11,900	$15,000	$15,400
Minnesota	$7,800	$ 9,700	$10,000
Nebraska	$8,800	$11,500	$12,000
So. Dakota	$8,700	$11,000	$12,100
Wisconsin	$7,000	$7,900	$8,500

He anticipates high-quality land will continue to see strong interest through the end of the year.

"With fewer properties being offered to the market, it creates a unique supply-demand scenario that definitely favors the landowner," he says. "That'll help maintain both the current and long-term value of farmland." ❒

Critical First 48 Hours After Planting

By Roger Elmore, Jim Specht, and others, University of Nebraska—Lincoln, NE
[Abridged from Cold Soil Temperature and Soil Planting Window, April 12, 2018]

Plant corn hybrids that are more cold tolerant first. Be aware though that "imbibitional chilling" is a physical phenomenon that can override genetics. Imbibitional water uptake occurs within the first 48 hours after a seed is planted. Once planted, corn seeds need a two-day (48-hour) window when the soil temperature at planting depth does not drop much below 50°F.

When soil temperatures drop much lower than 50°F within that two-day time frame, chilling injury may affect seed germination and subsequent seedling growth. During the osmotic phase of water uptake, which starts about 48 hours after the initial imbibitional phase of water uptake ends, the risk of chilling injury approaches zero. Thereafter, temperatures below 50°F can slow germination and delay seedling emergence. This can result in a longer exposure to soil-borne pathogens, particularly in soggy wet soils. If you expect the latter, use fungicide seed treatment for at least your earliest planted corn fields.

When corn seeds imbibe water, cell membranes stretch and cells expand. When a damaged cell membrane rehydrates, it may not return to its normal shape and size. This can create a "leaky" cell. Water is at its densest at about 39°F, so when cold water is imbibed, it may result in additional membrane damage. These ruptured membranes may occur in the cell walls and in the mitochondria. In the plant this action may disrupt the embryo/endosperm enzymatic conversion to energy, but mostly results in leakage of cell solutes and sugars. This, in turn, is likely to reduce growth rate and interfere with growth of the emerging seedling.

Planting when soil temperatures are above 50°F alleviates concerns of imbibitional chilling affecting corn emergence.

Concerning cool soils and corn planting dates, for best results begin planting a more cold-tolerant corn hybrid when soil temperatures are in the high 40s and the short-term forecast calls for warm days that will continue pushing soil temperatures higher.

Sometimes, a given year's optimum planting date may actually be in May! Planting early is not always the best! ❒

Cornmeal and Creativity on the Great Plains

By Joe Johnston

[*Abridged from HistoryNet, 2/27/2017*]

In 1857 Nebraska Territory schoolteacher Mollie Dorsey Sanford recorded that her breakfast was cornbread and salt pork; lunch was cold cornbread, wild greens and boiled pork; and supper was hoecakes (cornbread), cold greens, and pork. Mealtimes were like that for many settlers on the Great Plains. In her beloved *Little House* series of

Johnnycakes were common on the Great Plains in the early days of America, and they still are popular for many Americans.

semiautobiographical novels, Laura Ingalls Wilder describes how her pioneer family enjoyed homegrown vegetables and what meat they could raise or hunt, but just about every meal included cornbread. Children typically started the day with corn fritters for breakfast. A bucket lunch at school consisted of perhaps a boiled egg and a corn fritter. Dinner at the home table might be boiled pork, dried apples soaked in water and baked, and, of course, cornbread.

Sometimes there was no game, the potatoes froze and bugs ate the squash, but corn rarely failed. Each stalk held the promise of one or two good-sized ears. A farmer could grow corn in a big field or crowded corner and often planted all the way up to the front door. Corn could be boiled, fried, or roasted. But fresh corn on the cob lost its flavor quickly and soon spoiled, so settlers preserved most of it by drying it on racks in the sun or in a corn crib, a shed with slatted sides spaced to allow plenty of air circulation. Dried corn could then be boiled and added to stews and soups or ground into cornmeal, the most dependable and versatile food on the Plains.

Hoecakes, or johnnycakes—the cornmeal version of pancakes—could be baked or fried, leavened or not, and might contain combinations of nuts and dried fruit. Cornmeal was used to make everything from mush to squash bread and piecrusts. Knowing cooks added kernel corn to a cornmeal mix for corny cornbread. Coffee was a luxury, so some folks developed a taste for a hot drink made from charred corn.

Waking on May 13, 1855, her first morning in Kansas Territory, homesteader Miriam Davis Colt wrote in her journal, "Can anyone imagine our disappointment this morning on learning…that no mills have been built." Many a prosperous settlement grew up around the first settler to build either a gristmill or sawmill on a creek bank. At a gristmill, water running across a paddlewheel rotated an axle, which turned the machinery to crank a heavy millstone set atop a fixed bed stone. The miller poured dried corn kernels between these stones to make meal and took a share of it in lieu of payment. While awaiting the arrival of such an entrepreneur, the Colts and their neighbors ground their corn by hand, as American Indians had done for millennia.

"I live entirely on food made of corn," Miriam lamented. ❒

Why do farmers farm, given their economic adversities on top of the many frustrations and difficulties normal to farming? And always the answer is: "Love. They must do it for love." Farmers farm for the love of farming. They love to watch and nurture the growth of plants. They love to live in the presence of animals. They love to work outdoors. They love the weather, maybe even when it is making them miserable. They love to live where they work and to work where they live. They like to work in the company of their children and with the help of their children. They love the measure of independence that farm life can still provide."

Wendell Berry

Statement of Purpose

Vital Earth Resources is a for-profit private corporation dedicated to the development, production, and sale of top-quality, ecologically sound horticultural and agricultural products. *The Vital Earth News* is a periodic publication of Vital Earth Resources to inform customers and other interested parties about our products and programs, and to educate our readership on critical issues facing growers today and in the future.

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Thank you! The Team at Vital Earth Resources, Inc.

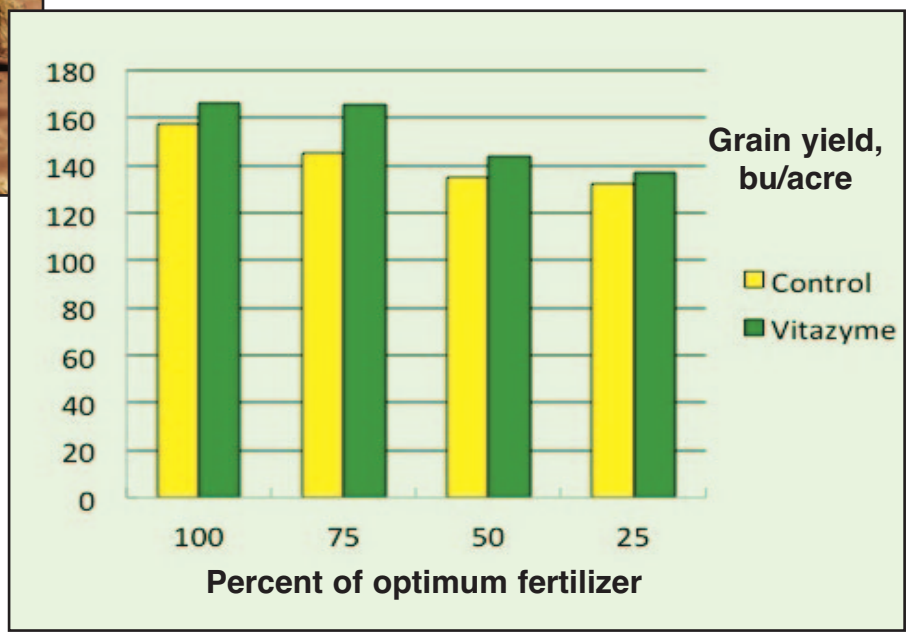
Fertilizer Efficiency Improves With Vitazyme Application

For many years, research has shown that Vitazyme will improve the utilization of fertilizer elements, especially nitrogen but also all applied nutrients. With the current rise in fertilizer prices, several research trials were initiated in 2023 to show how Vitazyme improves fertilizer efficiency. Below: a western Tennessee study.

THE PROGRAM

***Vitazyme*: 13 oz/acre in-furrow at planting, and again at 13 oz/acre on the leaves and soil at 6-8 leaves**
***Fertilizer*: 100% was 80 N, 60 P, 80 K lb/acre**

Above: At 50% of optimum fertilizer, the plant height, leave area, and root structure were increased with Vitazyme.



Below: Root structure and volume were dramatically improved at all fertilizer levels with Vitazyme (right).

Right: Ear size and fill were improved with Vitazyme at all fertilizer levels. Here we see the improvement at the 50% fertilizer level.