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A Place for Perennials

Researchers and Farmers Are Finding Ways to Put Perennial Plants to Work in Today's Agricultural Landscape

By Dean Houghton

Not much is left of Iowa's original prairie. Just 150 years ago, when European settlers were homesteading the land, most of the state was covered by deep-rooted perennials. Today, scientists estimate that only one tenth of 1% of that pristine prairie remains intact.

But there's a research project in central Iowa that may help put prairie back to work on the state's agricultural landscape. It's called STRIPs — Science-based Trials of Rowcrops Integrated with Prairies — and a team of more than 30 researchers and scientists are studying the ways that prairie plantings can affect everything from soil erosion to biodiversity.

"Our theory is that strategic placement of perennial vegetation into annual cropland can provide conservation benefits that are disproportionately greater than the land area occupied," says Matt Liebman, an agronomist at Iowa State University.

Perennial power. Perennials may become an important element of tomorrow's farming systems, says Rene Van Acker, a University of Guelph researcher with interests in cropping systems and multifunctional agriculture. "They are so different in terms of their ecology than annuals," he says. "they may take resources from greater ecological space by sending roots deeper in the soil, and they are growing when annuals are not."

Perennials plants in the farm landscape give many positive benefits besides just beauty and ecological integrity; they also improve profits and reduce soil erosion.

Long term crop rotation studies have shown that including perennials can fundamentally change the nature and capacity of the rotation, Van Acker insists. "This is one of the reasons that Washington State University and the University of Manitoba have perennial-grain breeding programs," he says. "If farmers had perennial grains, they would have a cash-flow-friendly option for increasing the diversity in their cropping system."

In the STRIPs project, researchers are integrating prairie into cropland devoted to a corn-soybean rotation. They're studying 12 small

See Prairie Strips Reduce, page 2

Foliar Applications Most Effective

By Paul W. Syltie, Ph.D.

The world of fertilizers is not as straightforward as it may sometimes seem, especially in the area of foliar versus soil-applied formulations. There appear to be two camps — one that states foliars are best, and another that states foliars have little worth. I have concluded that there is truth in both camps, and this article will attempt to sort through the benefits of foliar fertilizers as contrasted to soil applied types.

The Anti-Foliar Camp

Detractors of foliar fertilizers, such as Dr. John Sawyer of Iowa State University,[1] claim that field trials using nitrogen (N), phosphorus (P), or potassium (K) foliar fertilizers have not given benefits for either corn or soybeans in Iowa. Dr. Sawyer states that "Greater efficiency with a foliar nutrient application might be a theoretical advantage; however, research with various products has not shown this to occur." He claims that the main difficulty with applying N, P, and K via foliar sprays is the large amount of nutrient required, which cannot be achieved through sprays. For example, a 200 lb/acre N application for corn cannot be achieved through foliar sprays, primarily because of the number of trips over the field required to achieve that rate. High rate applications cannot be reached because of tissue damage issues as rates increase. Yield studies in

Nutrients are readily absorbed through the leaf surfaces of plants.

See Foliar Nutrients Are Readily, page 3

Prairie Strips Reduce Soil Erosion

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watersheds, comparing watersheds with 10% of the area planted to prairie at the lower end of converging slopes; 10% of the area in contour prairie strips; 20% of the area in contour prairie strips; and watersheds with 100% of the area devoted to the annual crops.

The prairie strips were established in 2007, and the effect on soil erosion has been obvious. "The prairie strips in these watersheds have dramatically reduced sediment loss," says Matt Helmers, an Iowa State University agricultural engineer. "We're seeing approximately 90% reduction in soil loss in the watersheds where 10% to 20% of the area is planted to prairie."

Gary Van Ryswyk cash-rents land from the U.S. Fish and Wildlife Service at the Neal Smith National Wildlife Refuge, where the STRIPs study is being conducted. He's seen the erosion control, and now plans to install some perennial strips on his own land. "I'll use an alfalfa-timothy-clover seeding and harvest strips to provide hay for my cattle operation."

The prairie strips in the study contain a variety of plant species, which offer nectar sources and habitat niches for pollinators and beneficial insects, as well as grassland songbirds. Preliminary results show a boost in bird numbers on the prairie strips. And in terms of economics, it appears that prairie strips offer more bang for the buck than other technologies such as constructed wetlands or cover crops when it comes to stopping erosion and holding nutrients in place.

Pasture-cropping. Australian farmer Colin Seis has more than a decade's worth of experience with a system he calls "pasture-cropping." He direct-seeds cereal crops into his warm-season grasses during their dormant season. He harvests a grain crop of wheat, oats, or cereal rye just as the grass is beginning its summer growth. "This combines grazing and cropping into a single land-use method where each one benefits the other economically," says the pioneer of this unique system that does not destroy the perennial pasture base. It's catching on. Today more than 2,000 growers are following this pasture-cropping approach Down Under.

Prairie plants not only beautify the land, but attract beneficial animals and insects that help stabilize the ecosphere and recycle nutrients .

Big bluestem and yellow coneflowers are beautiful sentinels of the more humid eastern Great Plains. Bluestem can stand taller than a man!

Growing woody plants also is a way that farmers are putting more perennials to work. A number of livestock operations plant trees as a natural filter to prevent dust from leaving the farm; and trees can be part of border and buffer plantings.

Ed Ulch farms in eastern Iowa near Lake Macbride. "We've always felt that we needed, and wanted, to take extra precautions to protect water quality in the lake," he says.

One of those extra steps was a stream-bank restoration project. He planted Carolina poplar trees in a dense stand in combination with a grass seeding. "This approach clearly has been effective in controlling stream-bank erosion," he observes.

In Nebraska, the Arbor Day Foundation is leading a consortium along with Oregon State University, Rutgers University, and the University of Nebraska to breed a better hazelnut.

Hazelnuts are a multimillion dollar crop in Oregon, used primarily in confections, but this group of researchers is looking to develop a hybrid that will grow well in climates all across North America. Hazelnuts are classified as a riparian buffer zone species, acting as a natural biofilter to prevent sediment and nutrients from reaching surface water. Plants thrive with minimal maintenance.

The nut crop also is a promising source of energy in the form of biodiesel. Preliminary research shows that hazelnuts potentially could produce twice as much oil per acre as soybeans. This perennial could power the nation's biofuel needs while also protecting the environment. [John Deere, *The Furrow Magazine* by Dean Houghton, 2012] □

The Value of Prairies. With our current understanding of natural ecosystems, it's difficult to believe that tallgrass prairie was ever considered worthless. Yet the history of the past two centuries is one of disregard for the prairie landscape. When Major Stephen Long published his map of the Great Plains in 1822, he labeled the entire prairie region "The Great American Desert".... When the first Euro-Americans settled on the plains, they converted prairie to cropland with little thought about what they were destroying. One of the most extensive and important ecosystems in North America almost vanished. Fortunately, people have come to recognize the ecological, economic, and cultural values of prairie.
From *Native Prairie Hay Meadows: A Landowner's Management Guide*, Kansas Natural Heritage Inventory of the Kansas Biological Survey, Lawrence, KS, 2008.

Foliar Nutrients Are Readily Absorbed

Continued from page 1

Iowa have indicated that for both corn and soybeans there has been no yield benefit from foliar treatments.[2]

While foliar iron applications might help overcome iron chlorosis of soybeans on high-pH soils, Dr. Sawyer recommends utilizing varieties that are tolerant of iron chlorosis rather than foliar feeding iron. He also claims that foliar manganese will not help overcome manganese deficiency of soybeans induced by glyphosate (Roundup) applications.

The Pro-Foliar Camp

Many agronomists are aware of the great value of foliar feeding nutrients to crops. They say it is the most efficient way to increase yield and plant health, with field tests showing yield increases of 12 to 25% above conventional fertilization.[3] More than 90% of the foliar applied nutrients are utilized by the plant, whereas a similar amount applied to the soil results in only 10% utilization. Soil applied nutrients like N can be lost to the air, leached out by rainwater (N, K, S, etc.), or fixed into unavailable compounds (P, K, Zn Mn, Cu, Fe, etc.). In sandy loam soils, foliar applied fertilizers are up to 20 times more effective than comparable soil applied fertilizers.

Furthermore, foliar feeding is an effective method for correcting soil deficiencies and overcoming the soil's inability to transfer nutrients to the plant under low moisture conditions. The effectiveness of foliar nutrients is determined by (1) the condition of the leaf surface (especially the waxy cuticle), (2) the time the solution remains on the leaf surface, (3) the rate of diffusion of the nutrients into the leaf, and (4) the type of formulation (water-soluble forms are best).[4] It is important that a fine mist is applied, and that the mist strikes leaf surfaces at a 90° angle.

Foliar nutrient applications can be sprayed on plants in single or multiple applications to, in most cases, enhance the efficiency of uptake greatly.

Many researchers have praised the value of foliar sprays, as seen below.[5]

- T.S. Osborne, Ph.D., University of Tennessee. "... research indicated that only 10 to 12 per cent of phosphorus fertilizers as taken up by plants in the first year; the rest was 'locked in' the soil or washed away. Fertilizer applied to soil is largely wasted because it is either bound by soil particles or is washed out of the root zone. If chemical elements could go directly into leaves and bypass the wastefulness of soils, a tremendous saving would result."
- Ail. Bertrand, Ph.D., and L.L. Rusoff, Ph.D., Louisiana State University. "Tracer elements were used to ascertain conclusively that plants absorb nutrients though their foliage, fruit, flowers, and twigs as well as their roots."
- *Agricultural Chemicals Magazine*. "Phosphorus availability studies have given a ratio of 20 to 1 in favor of foliar feeding over soil feeding. There seems little doubt that where soil fixation exists, foliar applications of nutrients constitute the most efficient method of fertilizer 'placement', and with plants of sufficient leaf area foliar feeding with all the elements can make a significant contribution toward the total nutrient requirement."
- S.H. Wittwer, Ph.D., Michigan State University. "Farmers should fertilize according to soil test recommendations, follow with 'starter solutions' or 'pop-up' fertilizers, and finish the job with foliar applications."
- L.J. Lund. Ph.D., University of California-Riverside. "In every case, for a given amount of applied nitrogen, foliar applications resulted in higher leaf nitrogen content as compare to soil applied nitrogen."[6]

Foliar fertilizers come in many types, including urea, potassium phosphate, calcium nitrate, potassium nitrate, and a host of chelated elements such as EDTA and amino acid chelates of iron, zinc, copper, manganese, and magnesium. Comparable efficiency ratios of foliar and soil applied nutrients are shown in the table below.[7]

The Value of Foliar Fertilizers

Based on the available field trial data, there is no question that foliar fertilizers can be effective, and usually are. However, there are exceptions as Dr. Sawyer in Iowa has pointed out, where ideal soils and growing conditions may limit their application for major crops, such as corn and soybeans. Yet, in most cases foliar applied nutrients are beneficial, oftentimes greatly so. In general, the following points may be made.

Fertilizer	Crop	Foliar value	Soil value
P (H_3PO_4)	Beans, tomatoes	1	12
Fe ($FeSO_4$)	Sorghum (grain)	1	25
Mg ($MgSO_4$)	Sorghum (grain)	1	100
	Celery	1	50-100

(1) Foliar N is about 4 to 8 times more effective than soil N.

(2) Foliar P, K, and micronutrient fertilizers are about 15 to 20 times more effective than soil applied forms.

(3) When it is known that soil uptake of a nutrient may be limited by the pH, a soil deficiency, or the crop, then apply the foliar nutrient as needed, especially if indicated by soil or leaf analysis. One example is calcium for apples.

Foliar nutrient applications are usually an effective means of nourishing crops and enhancing yields, and their use can be even further enhanced by using Vitazyme along with them. Vitazyme, a complex mixture of growth regulators, aids in the uptake and utilization of both soil and foliar applied nutrients for all crops. □

Bibliography

1. J. Sawyer, Foliar fertilization of corn and soybean, Iowa State University Extension, Iowa State University, Ames, Iowa, 2012.
2, See 1.
3. Foliar applied Fertilizer, *www.ecochem.com.*, 2012.
4. See 1.
5. See 1.
6. Greenfeed 27/75-0-0, *Greenfeed Product Bulletin*, Caltec, Modesto, California, 2008.
7. See 1.

15-Minute Soils Course

Lesson 35:

Chlorine, Cobalt, Molybdenum, and Nickel ... Essential in Tiny Amounts

Chlorine (Cl)

17	35.453
Chlorine	
-100.98	-34.6
Cl	

Chlorine is ubiquitous in nature, primarily as the chloride ion (Cl^-). It is the anion of sodium, potassium, and other positively charged ions throughout the environment, producing salts found in all soils and water. In plants, chlorine constitutes 2 to 20 mg/gram of dry weight, but the requirement for growth is 10 to 100 times lower.

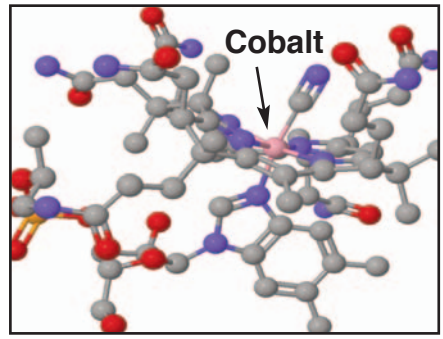
Functions of Chlorine in Plants

1. Photosynthetic oxygen evolution. Splitting of water in photosynthesis needs Cl.
2. Pumping of ions across cell membranes. Chloride is essential in the moving of protons across the vacuole membrane (tonoplast).
3. Stomatal regulation. Chloride, along with K^+ and other ions, is required for the opening and closing of stomata on leaf surfaces.
4. Osmotic regulation. Since chloride is a major plant anion, it moves in water across cell membranes and maintains cell turgidity.

Because chlorine is so common, hardly ever is a plant deficiency noted.

Cobalt (Co)

Considered as a toxic element in high enough quantities, cobalt is essential for the fixation of nitrogen in the root nodules of legumes, and also in the root nodules of non-legumes, such as alder trees. In the nodules, the coenzyme cobalamin (Vitamin B_{12}) is formed, having cobalt coordinated to four nitrogen atoms at the center of a porphyrin molecule, much like magnesium in chlorophyll or iron in hemin. The enzymes methionine synthase, ribonucleotide reductase, and methylmalonyl-coenzyme. A mutase are all cobalamin-dependent, and they are responsible for the relationship of cobalt supply, nodulation, and nitrogen fixation.



Cobalt is coordinated by nitrogen (N) atoms to form cobalamin, an essential molecule for N fixation.

27	58.933
Cobalt	
1495	2870
Co	

While cobalt apparently has no direct effect on plant metabolism, its effects on nitration of animals and man is well known. Vitamin B_{12} — cobalamin — is essential in the growth and health of all creatures. While ruminants can manufacture it from cobalt added to the ration, humans cannot manufacture it and require the presynthesized vitamin.

Molybdenum (Mo)

This element is usually found in the form of the molybdate anion (MoO_4^{-2}), and very little of it is required in plants (only about 0.5 ug/g of dry tissue). Its functions in plant nutrition relate to its changes in valence as a metallic activator of enzymes, All of the enzymes of which it is a

Molybdenum Fertilizer	Mo, %
Sodium molybdate [$NaMoO_4 \cdot 2H_2O$]	39
Molybdenum trioxide [MoO_3]	66
Ammonium molybdate [$(NH_4)_6Mo_7O_{24} \cdot 2H_2O$]	54

15-Minute Soils Course

cofactor are involved in oxidation-reduction reactions, so molybdenum is closely involved with nitrogen metabolism.

42	95.94
Molybdenum	
2617	4612
Mo	

Molybdenum is required for nitrogen fixation in both legume and non-legumes, especially in root nodules. it is a part of the nitrogenase enzyme complex, in particular nitrate reductase which contains flavin, heme, and molybdenum. During nitrate reduction, electrons are transferred directly from molybdenum to nitrogen.

A molybdenum deficiency in white clover is characterized by yellowish green leaves, as seen on the right.

Apply only 6 to 12 oz/acre broadcast (effective only at a pH above 5.6), 1 to 3 oz/acre foliar, or 0.5 to 1 oz/acre of sodium molybdate on the seeds. Applications on soils above pH 6.5 may reduce yields.

Crops Highly Responsive to Molybdenum		
Alfalfa	Cauliflower	Soybeans
Broccoli	Clover	Spinach
Brussel sprouts	Lettuce	Sugarbeets
Cabbage	Peas	Tomatoes

Nickel (Ni)

The element nickel is essential for many species of bacteria, and has now been proven to be essential in the nutrition of all plants. It is present at 1 to 10 ug/g of dry weight. However, there is normally plenty of it in the soil, so deficiencies are not noted. Toxicity of crops to the element is a much greater concern.

28	58.69
Nickel	
1453	2732
Ni	

So far, only the enzyme urease has been found to contain nickel. Urease is essential for breaking down urea in soils and in plant tissues. Nickel has been shown to be an intermediate in N metabolism, so is important in this process. Adequate nickel insures good seed viability, germination, and seedling vigor, and is required throughout the life cycle of the plant.

These rhizobium nodules on Austrian winterpeas require molybdenum and nickel to fix nitrogen.

See How Much You Learned

1.Rhizobium bacteria require molybdenum to fix nitrogen. T or F

2. Nickel has been found to be essential for the enzyme _____.

3. Which elements are very seldom found to be deficient in soils? a. Chlorine b.Nickel c. Nitrogen d. Cobalt

4. What nutrient is critical in animal nutrition that requires cobalt? _____.

5. Toxicity to the crop is much more likely with nickel and cobalt than a deficiency. T or F

6. Chlorine is necessary in photosynthesis because the element helps split _____.

7. Crops highly responsive to molybdenum include a. Alfalfa b. Corn c. Cabbage d. Peas

Answers: 1.T; 2. urease; 3. a, b, d; 4. cobalamin, or Vitamin B_{12}; 5. T; 6. water; 7. a, c, d.

Our Vital Earthworm Friends...Usually

By Paul W. Syltie, Ph.D.

Why are earthworms so important for soils? Let us take a look at several reasons.

Soil Structure

Earthworms have been called "ecosystem engineers". Much like human engineers, earthworms change the structure of their environments. Different types of earthworms can make both horizontal and vertical burrows, some of which can be very deep in soils.

These burrows create pores through which oxygen and water can enter and carbon dioxide can leave the soil. Earthworm casts (their feces) are also very important in soils and are responsible for some of the fine crumb structure of soils.

Decomposition and Organic Matter

Earthworms play an important role in breaking down dead organic matter in the process of decomposition. This is what the earthworms living in your compost bin are doing. Earthworms living in soils also decompose organic matter. Decomposition releases nutrients locked up in dead plants and animals and makes them available to living plants. Earthworms do this by eating organic matter and breaking it down into smaller pieces, allowing bacteria and fungi to feed and release nutrients.

Earthworms are also responsible for mixing soil layers and incorporating organic matter into the soil. Charles Darwin referred to earthworms as "nature's plows" because of this mixing of soil and organic matter. This mixing improves the fertility of the soil by allowing the organic matter to be dispersed through the soil and the nutrients held in it to become available to bacteria, fungi, and plants.

Earthworms ... friends most of the time.

Bacteria and Fungi

Earthworms have a positive effect on bacteria and fungi in soils. Where earthworms are present there are more bacteria and fungi, and they are more active. This is important as bacteria and fungi are key in releasing nutrients from organic matter and making them available to plants. Earthworms are also an important source of food for many other animals that live in soils.

The Dark Side of Earthworms

Indeed, there are numerous benefits of earthworms as they impact soil physical, chemical, and biological properties. Yet, a growing body of researchers are beginning to view earthworms as ominous, exotic intruders.

Research suggests that earthworms become voracious and destructive when they invade forests, often in ever-widening circles around ponds where for decades fishermen have been dumping unused worms.

Nobody is proposing to remove earthworms where they are already established. That would be daunting, or impossible, said Dr. Paul Hendrix, a professor at the Institute of Ecology at the University of Georgia, but it may be feasible, he said, to shield other areas.

In ecosystems that developed without worms they can actually cause harm. For example, the ecology of northern forests often depends on a thick layer of leaf litter remaining on the ground throughout the year. Earthworms remove that leaf litter by converting it to topsoil, and that seemingly benign action can so completely change the chemistry and biology of the forest that native plants and trees cannot grow there. ☐ [From the Earthworm Society of Britain and Don Zaidle, Texas Fish and Game, April 19, 2012]

Grass Fed Beef Is Healthiest

By Paul W. Syltie, Ph.D.

For decades the mantra of conventional nutrition has been that beef and other red meats are bad for your health, due to high levels of cholesterol and saturated fatty acids. It turns out that these scientists are right on one count: the beef from feedlots, where animals are fed lots of grain products, hormones, and antibiotics, is not so good for you.

Grain-fed beef contains higher than normal levels of omega-6 fatty acids. The ratio of omega-6 to omega-3 fatty acids should be about 2:1 in beef animals feeding on a natural diet of grass and other leafy forage. When corn and soybean products are added to the ration, that ratio jumps to about 25:1, highly out of natural balance and apt to trigger inflammation and accelerated degenerative diseases in humans who consume the meat.

Saturated fats and cholesterol are essential to the health of all of us. In fact, the typical person eats only about one-sixth of the required cholesterol each day to meet the body's needs; the rest must be manufactured by the body. These lipids are essential for overall cellular health, and play major roles in regulating neurological, cognitive, and hormonal functions in people. A diet deficient in these biochemicals causes reduced immune and sex function, accelerated aging, and brain degeneration.

The meat of grass-fed animals is also rich in carnitine—which aids in fat metabolism—and carnosine, which is a powerful antioxidant that improves muscle, brain, and cardiovascular function.

Compared to poultry, which eat significant amounts of grains, grass-fed beef is the superior food for all of us! ☐

You Control More Than You Think!

By Paul W. Syltie, Ph.D.

We live in an age of determinism, wherein many behavioral scientists claim that you are what your DNA is coded for, and there is little you can do about it. Your life is prescribed, and you may as well just lay back and accept your fate.

Thankfully, science has shattered the central dogma of molecular biology, proving that determinism—the belief that your genes control your health—is false. You actually have a tremendous amount of control over how your genetic traits are expressed by changing your thoughts and altering your diet and your environment

The emerging science of epigenetics teaches us that determinism is false. "Genes do not determine human outcomes – *it is our responses to our environment that actually determine the expression of our genes". K. Eriksen*

In 1988, the experiments of John Cairns demonstrated even primitive organisms can evolve "consciously," as DNA changes in response to its environment. The cell's "consciousness" lies in its membrane, which contains receptors that pick up various environmental signals. This mechanism controls the "reading" of the genes inside the cell

The work of Dr. Bruce Lipton and other epigenetic researchers shows that the "environmental signals" also include thoughts and emotions—both of which have been shown to directly affect DNA expression.

Contrary to the Newtonian belief in your body as a biological machine, epigenetic science reveals that you are an extension of your environment, which includes everything from your thoughts and belief systems, to toxic exposures and exposure to sunlight, exercise, and, of course, everything you choose to put onto and into your body. Epigenetics shatters the idea that you are a victim of your genes, and shows that you have tremendous power to shape and direct your physical health

The good news is that to a great extent you are in control of your genes. You can alter them on a regular basis, depending on the foods you eat, the air you breathe, and the thoughts you think. It's your environment and lifestyle that dictates your tendency to express disease, and this new realization is set to make major waves in the future of disease prevention, including one day educating people on how to fight disease at the epigenetic level. When a disease occurs, the solution, according to epigenetic therapy, is simply to "remind" your affected cells (change their instructions) of their healthy function so they can return to being normal instead of diseased cells.

You can begin to do this on your own, long before you manifest a disease. By leading a healthy lifestyle, with high quality nutrition, exercise, limited exposure to toxins, and a positive mental attitude, you can encourage your genes to express positive, disease-fighting behaviors.

This is what preventive medicine is all about. It's not about taking any one particular nutrient as a supplement to fix one specific "part" of your biological machinery. It's about looking at the entire body as a whole—body, mind, and spirit— and encouraging the entire organism to work together as a well-tuned whole. The science of epigenetics is helping pave the way to this new understanding. ☐

[Taken in part from Falling for This Myth Could Give You Cancer, *mercola.com*, April 11, 2012, and K. Eriksen, The Science Of Epigenetics—How Our Minds Can Reprogram Our Genes, *wakeup-world.com*, March 26, 2012.]

Are You Willing ...

... to stoop down and consider the needs and desires of little children?
... to remember the weakness and loneliness of people who are getting old?
... to stop asking how much your friends love you, and to ask yourself whether you love *them* enough?
... to bear in mind the things that other people have to bear in their hearts?
... to trim your lamp so that it will give more light and less smoke, and to carry it in front of you so that your shadow will fall behind you?
... to make a grave for your ugly thoughts and a garden for your kindly feelings, with the gate open?
Henry Van Dyke, *Bits and Pieces*, 12-13 - 1990.

Statement of Purpose

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Vitazyme produced excellent responses for corn and soybeans at the University of Missouri in 2011. Despite a severe hailstorm on July 3, the soybeans recovered and recorded an 8 bu/acre increase (52 bu/acre) along with more seeds per plant (+47%), more pods per plant (+48%), and increased weight per plant (+44%), plus higher nutrient levels. Both corn and soybeans had lower free amino acid levels in tissues, meaning less pest stress. The corn had 20% fewer broken stalks from the hail.

University of Missouri. Vitazyme treatment (right) increased crop response substantially.