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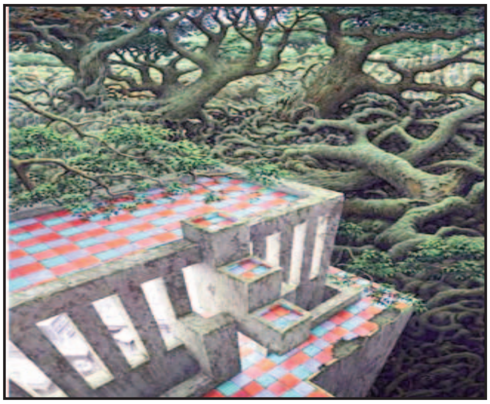
Agriculture's Direction for the Future

Much Different Than What You See Today

by Paul W. Syltie, Ph.D.

There is an old Latin Proverb that says, "You may drive Nature out with a pitchfork, but she will inevitably return".[1] This profound statement is based on the fact that all of the created world is built upon a foundation of immutable laws, principles that govern not only the physical world, but also the affairs of man in his multitude of political, social, and religious contexts. It is a proverb we may tend to forget during our everyday, oftentimes hurried lives.

This guarantee that natural laws will ultimately win the day is summed up in some of the landscapes painted by Hans Deuss, a Dutch realist who shows Nature and Culture in eternal conflict.[2] Urban buildings stand in sharp contrast with advancing foliage, trees and shrubs growing through constructions or looming in the distance. Air and water surround the architecture, and stairs lead up or down, offering a way of escape from the constricting situations, towards a point outside the picture where freedom lies. The ever-expanding city is always seen looming over the horizon like an advancing front.



The idea of nature creeping in over time to reclaim the works of men is promoted in the art of Dutch artist Hans Deuss.

The battle of man with nature seems to be a never-ending conflict, with the God-ordained commission to replenish the earth, subdue, and have dominion over it[3] taking on a sinister cast whenever mankind's tendency towards greed begins to run roughshod over these eternal laws. Nowhere is this battle so visible as in the rise and fall of nations that first respected their soil resources — the black gold of civilization — and then turned their backs on their dedicated sponsor. Thus have risen and fallen the great societies of Babylon, Greece, Egypt, Rome, North Africa, and other nations, and the less-known but no-less-vibrant civilizations of the Khmer Empire in Cambodia,[4] and teeming communities of the Amazon Basin where fragile soils were no match for farmer's exploitation.

The democracies of the Americas and Europe are not far behind in their treatment of soil resources as the 21st Century unfolds. Sir Albert Howard in the 1930s and 1940s alerted farmers around the world of the loss of soil fertility caused by the vast increase in crop and livestock production, which led to disastrous consequences such as a gener-

See The Immutable Laws, page 2

Plants and Fungi Reciprocate Favors

Rewards Stabilize Underground Biological Market

by Susan Millus

One of the biggest underground markets on the plant-nutrient trading between plant roots and fungi turns out to run on a system of reciprocal rewards for good suppliers, and less business for bad ones.

"It may have taken 450 million years to evolve," says Toby Kiers of VU University Amsterdam, "but unlike most human markets, here we have an example in which cheaters actually get punished and the good guys get rewarded."

Most land plants participate in this exchange, as threads of specialized fungi wind into plant root tissue and form structures called arbuscular mycorrhizae. About 4 to 20 percent of the carbon compounds that a plant produces from capturing the energy of sunlight flows into the fungus. In the other direction, minerals and other useful compounds flow from the fungus into the plant.

Other cross-species mutualisms have turned out to have a lopsided power balance in which one partner, often a plant, can kill a misbehaving helper. In the

See Mycorrhizae—Wonderful, page 3

The Immutable Laws of Nature!

Continued from page 1

al unbalancing of farming practices, an increase in plant and animal diseases, and the loss of soil by erosion. Howard maintained that such soil losses could be repaired only by building and maintaining soil organic matter through returning plant and animal waste to the soil, and by encouraging the mycorrhizal association.

In *An Agricultural Testament*,[5] Albert Howard listed seven methods by which nature manages soil to maintain fertility and organic content.

The Laws of Nature

1. Mixed farming is the rule. Plants and animals live together, and manures are recycled.

2. Soil is always protected by plants and residues from direct action of the sun, rain, and wind, anchoring it, preventing erosion.

3. Rainfall is carefully preserved in both topsoil and subsoil

4. Forests and grasslands recycle the organic matter they produce.

5. Mineral matter required by trees, grasses, and other plants is extracted from the subsoil.

6. The soil always carries a large fertility reserve.

7. Crops and livestock look after themselves; diseases and problems are handled through self-defense systems.

I will add one more point of my own. That is, ***people are meant to tend and keep the land***, to ”subdue and have dominion” over it; to do this they must live and work *with* the creation, not be separated from it in cities.

Change or Self-Destruct!

The agricultural systems we currently see around us operate in great contradiction to the natural laws that Sir Albert Howard so eloquently summarized. Here are a few on the contradictions.

1. Lack of mixed farming. Cattle are confined to huge feedlots or dairy operations, and manure is seldom returned to the soil from which it was generated.

2. Tillage removes surface protection by plants and residues, at least for a time until a crop or weeds cover the soil.

3. Much rainfall is lost due to runoff because of lack of cover, and widespread soil compaction that prevents rapid water movement into the soil.

4. Fertilizers, mined or manufactured long distances from the farm, provide many of the nutrients used by crops rather than the subsoil; crops are continually removed, and nutrient recycling is minimal.

5. Soils are chronically short of essential nutrients, leaving reserves oftentimes limited.

6. Crop diseases are common, and are usually held at bay by fungicides and other pesticides; resistant corp varieties are developed, but often are not selected for nutritional values, the epitome of this trend being the genetically modified varieties that generate toxins which are dangerous to human and animal health.

7. Agriculture is relying more and more on petrochemicals to power bigger and bigger machines, and to produce fertilizers and pesticides that exacerbate soil compaction and the danger of an interruption in supply.

8. Few farmers produce most of the food supply. Perhaps 1% of the United States population today are actually farm owner-operators, the rest of the population living in cities or engaged in non-farm activities. Nations such as China are becoming more and more urbanized as well.

The stage is set for a large-scale collapse of Western agriculture as we know it, having strayed far from the laws inherent within the natural world. Do we already see signs of changes coming?

Farm machinery keeps getting bigger and bigger, enabling fewer farmers to operate larger tracts and reducing rural population.

Signs Are Evident

Over the past decades the number of acres under no-till has increased, a sign that many farmers recognize the importance of reducing disruptions to the soil to limit oxidation of organic matter and compaction. In 2009, no-till farming was used on about 36% of U.S. cropland planted to our eight major crops, representing 88 million acres.[6] Other forms of conservation tillage, such as ridge and mulch-tillage, would up the amount even more. While this trend is positive, these farming systems still use heavy machinery, fertilizers, herbicides, and pesticides to produce a crop; until mixed farming and better pest-resistant varieties are introduced, natural laws will be broken.

Attitudes of many farmers are changing towards more regenerative, sustainable, and organic methods. While the total acres under organic production in the United States are under 1%, yet sales of organic foods and beverages have grown from $1 billion is 1990 to $26.7 billion in 2010.[7] The greatest growth is in organic fruits and vegetables. Consumers are willing to pay 30% more for these foods than they are for the conventional fare.

Farmers raising organic foods tend to be smaller than conventional farms, contributing to a small increase in total farms over the past few years.[8] However, megafarms continue to gobble up much of the farmland across the nation, but the overall trend is toward smaller, not larger farms.

Weeds and other pests also have a way of telling us what is wrong with our methods. “Superweeds”, those that have become resistant to glyphosate as a result of years of use of this herbicide on Roundup Ready crops, are becoming a serious problem in many states. Some herbicides and fungicides are losing their

See Perennial Crops Are, page 6.

Mycorrhizae — Wonderful Soil Friends!

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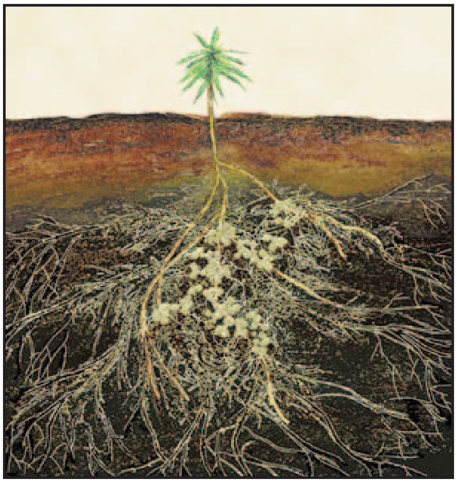
arbuscular mycorrhizal system, though, plant roots can detect which fungus threads are providing an abundance of a mineral and in turn reward them with



Vesicular-arbuscular mycorrhizae are highly efficient at absorbing essential soil nutrients and transporting them to the roots.

extra nutrients in the form of plant-produced carbon. The fungi also can detect and preferentially reward a good supplier and shun a slacker, Kiers and her colleagues report in the Aug. 12 Science.

Researchers first looked at whether a plant in the bean family, *Medicago truncatula*, could distinguish between different closely related fungi known to provide

Ectomycorrhizae are highly important especially to woody types, and set up a mutualistic association at the root tips.

different amounts of phosphorus to partners. To see, researchers let the fungi wind intimately around the plant roots and then labeled the carbon flowing through the fungal-plant snarl with a heavier than normal isotope. Analyzing RNA molecules from the fungi revealed where more of the heavy carbon had gone. The plant had indeed given more carbon to the more generous fungus species.

To see if fungi would respond likewise, researchers set up lab dishes with compartments that forced some plant roots to cheat by restricting the amount of carbon they passed on. Other roots acted as good-guy partners for the fungi. "I think we were all rooting for the underdog, hoping the world has thus far underestimated the bargaining power of fungi," Kiers says. Yes, the fungi did pass along more of their phosphorus to the generous suppliers.

Major steps in evolution often depend on the rise of ways to stabilize cooperation between organisms, says Ronald Noe of the University of Strasbourg in France, who studies biological markets.

"You wouldn't exist without mutualisms, and you would have little to eat without the arbuscular mycorrhizal fungi."

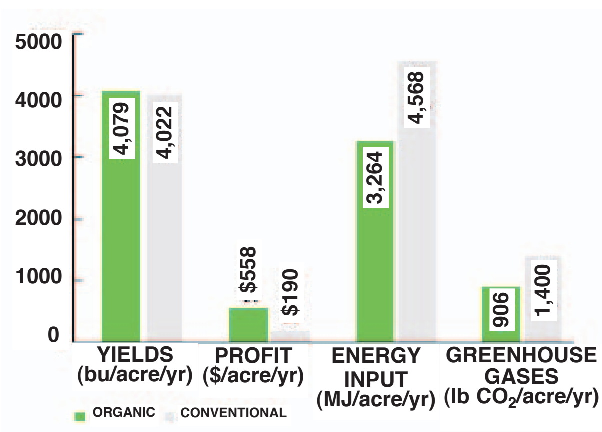
[From *Science News*, September 11, 2011; *www.sciencenews.org*.] ☐

Organic vs. Conventional: the Rodale Study

The Farming Systems Trial (FST)® at Rodale Institute is America's longest running, side-by-side comparison of organic and chemical agriculture. Started in 1981 to study what happens during the transition from chemical to organic agriculture, the FST surprised a food community that still scoffed at organic practices. After an initial decline in yields during the first few years of transition, the organic system soon rebounded to match or surpass the conventional system. Over time, FST became a comparison between the long term potential of the two systems.

We selected corn and soybean production as our research focus because large tracts of land, particularly in our region and the Midwest, are devoted to the production of these crops. Corn and soybean acreage comprised 49% of the total cropland in the U.S. in 2007. Other grains made up 21%, forages 22% and vegetables just 1.5%.

Throughout its long history, the FST has contained three core farming systems, each of which features diverse management practices: ***(1) a manure-based organic system, (2) a legume-based organic system, and (3) a synthetic input-based conventional system***. In the past three years of the trial, genetically modified (GM) crops and no-till treatments were incorporated to better represent farming in America today. Results and comparisons are noted accordingly to reflect this shift.



- **Organic yields match conventional yields.**
- **Organic outperforms conventional in years of drought.**
- **Organic farming systems build rather than deplete soil organic matter, making it a more sustainable system.**
- **Organic farming uses 45% less energy and is more efficient.**
- **Conventional systems produce 40% more greenhouse gases.**
- **Organic farming systems are more profitable than conventional.**

[From *www.rodaleinstitute.org/fst30 years*] ☐

15-Minute Soils Course

Lesson 34:

Copper (Cu): a Major Micronutrient

Though copper is one of the least abundant of the micronutrients — comprising only 2 to 100 parts per million (ppm) of the soil — it performs a wide array of functions in plants. It exists mainly as sulfides and hydroxy-carbonates, and local soil variations in Cu content can be great. Copper also is found in soil organic matter, but is held tightly and is quite unavailable. It shares many similarities with iron, forming stable complexes and having easy electron transfer.

29	63.546
Copper	
1083	2567
Cu	

Copper levels in the soil solution are very low, about 1 ppm to 1 ppb, while plant tissues concentrate it to about 10 ppm. Although plant Cu levels are extremely low, little is needed to perform its many functions.

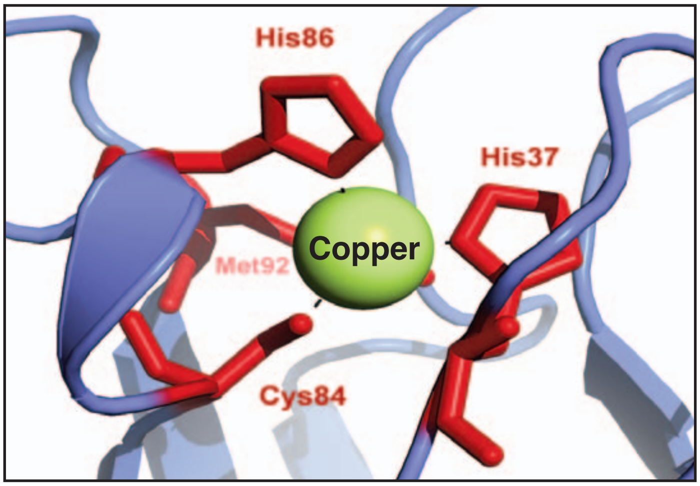
In grains, Cu deficiency leads to weak stems and lodging.

Copper can exist as Cu^{++} or Cu^{+} in the soil, but Cu^{+} is very unstable and converts to Cu^{++}, the form that is taken up by plant roots. Mycorrhizae also take up this ion and transport it to the roots.

Factors Affecting Copper Availability

Copper is usually available in sufficient quantities to achieve high yields, but in some cases deficiencies can occur.

- **High soil pH.** As for certain other metals like iron, zinc, and manganese, copper availability may be limited by a high soil pH, above 7.5. Acidic conditions solubilize copper.
- **Organic matter.** Copper is readily and tightly complexed by organic matter; high organic matter and peat soils reduce Cu availability.



More than 50% of the copper in chloroplasts is bound to plastocyanin (above), where it builds the final structure of the enzyme. "His", "Met", and "Cys" are amino acids.

- **Flooding and reduced root growth.** Excess water, compaction, or other factors reducing root growth will also inhibit copper uptake since the element is immobile in the soil.
- **Reduced mycorrhizal growth.** Excess soil phosphorus, compaction, and pesticide applications that reduce mycorrhizal extension will also reduce copper transfer to roots.
- **Nutrient interactions.**

High soil Zn: reduces Cu uptake.

Functions of Copper in Plants [based on enzyme activation]

1. **Catalysis in photosynthesis and respiration**
2. **Building amino acids and making proteins**
3. **Metabolism of CHOs, proteins, and lipids**
4. **Formation of lignin in plant cells walls, giving structural strength to cells and stems, and insect and disease resistance**
5. **Improvement of flavor**
6. **Enhancement of storability and sugar content**
7. **Promoting pollen formation and fertilization**

15-Minute Soils Course

Copper deficiency in wheat leads to poor pollination and seed development, as for the two left-hand heads.

Copper toxicity often begins with a dark green leaf that later becomes chlorotic from induced Fe deficiency.

High soil N: with marginal Cu levels, may lead to reduced Cu transport to growing tips.
High soil P: can reduce mycorrhizal activity, and thus Cu uptake.
Low soil N: can decrease overall plant growth and reduce nutrient uptake, including Cu.

Overcoming Copper Problems

Copper is immobile in the plant, so a Cu deficiency produces chlorotic new tissue at growing tips. Growing points may even die, and in cereal crops lead to excessive tillering, or to excessive branching in dicots. Some vegetables will display a blue-green color before chlorosis appears. Weak stems due to reduced lignin in cell walls will lead to lodging, especially with cereal grains. Weak cell walls also encourage insect and microbial pests. Reduced seed or fruit yield, even failure to flower, may result.

Copper Fertilizer	Cu, %
Copper sulfate monohydrate [$CuSO_4 \cdot H_2O$]	35
Copper sulfate pentahydrate [$CuSO_4 \cdot 5H_2O$]	25
Cupric oxide [CuO]	75
Copper chloride [$CuCl_2$]	17
Copper EDTA chelate [CuEDTA]	8 - 13

Excessive copper is a serious problem because soil Cu is hard to remove. Toxicities cause dark green leaves followed by induced iron chlorosis (white, thick, short leaves). If toxicities occur, iron applications may help.

Before applying a Cu fertilizer by sure it is needed. Use accurate soil testing methods and recommendations. If a Cu fertilizer is required, use 1 to 10 lb/acre of actual Cu broadcast, 1 to 5 lb/acre in-row, or 0.1 to 0.25 lb/acre foliar.

Always strive to build soil organic matter levels through regular additions. In this way mycorrhizae will proliferate to move the element to the root, and a more vigorous root system will absorb more of the element.

Crops Highly Responsive to Copper			
Alfalfa	Carrots	Lettuce	Spinach
Barley	Cabbage	Oats	Sudangrass
Blueberries	Celery	Onions	Tomatoes
Beets	Eggplant	Parsnips	Watermelons
Broccoli	Flax	Rye	Wheat

See How Much You Learned

1.Copper is critical for photosynthesis. T or F

2. Nearly all of the benefits copper gives to plants are due to its role in plant biological catalysts, called ________________.

3. High soil levels of which of the following nutrients can reduce copper uptake? a. Nitrogen b.Zinc c. Phosphorus d. Potassium

4. Name two common copper fertilizers: __________________, ____________________.

5. It is impossible for copper to improve the standability of a crop. T or F

6. Very high soil organic matter often _____________ copper availability to plants.

7. Which of the following are deficiency symptoms of copper? a. Chlorotic new leaves b. Poor pollination c. Many flowers d. Excessive tillering

Answers: 1.T; 2. enzymes; 3. a, b, c; see the table; 5. F; 6. reduces; 7. a, b, d.

Perennial Crops Are Superior

punch because soil organisms that break them down have adapted to their regular application, and are breaking them down quickly after application. Alternatives to chemical fixes include mechanical cultivation and hand weed removal, accomplished much easier on a small scale by small farmers ... but better yet by using perennial crops that need not be sown every year. Perennial cereal grains and corn could be developed, and crops could be raised in the proximity of population centers so that perennials would be locally gown, used fresh, or stored and used within a community. Does growing broccoli in California and shipping it 3,000 miles to the East Coast, as is often done today, make sense?

There is a growing awareness by the public that good food is essential for health, and organically grown food, often produced on small farms, is superior to the conventionally grown fare. Moreover, a movement has grown to demand the labeling of genetically modified foods in stores, as evidenced by an upcoming referendum in 2012 on the issue in California.[9] That awareness has been driving the sustainable/organic agriculture movement, and has spilled over in many ways to the political arena, where changes ultimately need to begin. Public policies need to encourage small farmers, and production methods must generate high quality, high yielding crops. After all, begetting optimum health of the population ought to be the primary concern of farming.

It should be the concern of every one of us — farmer and non-farmer alike — to have land use conform with the laws of nature. As farmers, we can do what we can to produce high quality, open-pollinated varieties with maximum nutrient density, and limit tillage and pesticide use. Organic production is a great start if one can be weaned away from the chemical treadmill and make the transition. Those of us not directly involved in farming can grow a garden, raising fruits and vegetables of top quality — fresh from the soil — for our own families.

Public policies need to encourage small farmers, and production methods must generate high quality, high yielding crops.

Ultimately the movement of agriculture to a truly sustainable system that conforms with nature's laws will require local, state, and national leaders who adopt policies that encourage the flow of citizens back to the land, where they can build families profitably on a few acres. To totally conform with nature's laws the use of herbicide, pesticides, and heavy machinery — the petrochemical formula — will need to be replaced with a non-petroleum paradigm.

Are we willing to face the problems of our fragile food production system that could easily be disrupted by an oil crisis, electric grid meltdown, plant disease, or weather crisis? The needed changes will not come easily, but they are necessary, for if we do not make them soon the pitchfork will assuredly be turned on us ... and we will see the trees and shrubs growing up through cracks in the pavement of our deserted cities, as Hans Deuss in his art prognosticates.

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Perennial Grains Are Nearly Here!

Recently three scientists from USDA's Agricultural Research Service (ARS) joined colleagues from The Land Institute, several U.S. universities, Australia, and China on a paper in the prestigious journal *Science* [25 June 2010, Vol. 328, No. 5986, pp. 1638-1639] summarizing the potential benefits of perennial grains to global food security and the environment and explaining how recent advances in crop breeding may speed progress toward this challenging goal.

ARS funding for research on perennial grains is modest, but some new directions are aimed at understanding the genetic basis of perennialism and developing genetic resources to breed perennial grains. For example, Buckler's lab is working to identify novel genes in eastern gamagrass, a perennial relative of corn. Holland is starting to design a breeding scheme to intercross corn and teosinte, another perennial relative. ARS scientists in Nebraska are looking into other perennial grasses. Dr. Hulke is evaluating perennials in the USDA sunflower germplasm collection for disease resistance and agronomic traits that could be bred into cultivated sunflowers.

Other scientists have tapped grant programs of our National Institute of Food and Agriculture for some of their work on perennial grains, including research plots and on-farm trials of perennial wheat varieties at Washington State and Michigan State universities, testing at Iowa State of the perennial legume Illinois bundleflower, and some of The Land Institute's work on intermediate wheatgrass. A National Research Council report described perennial grains as a potentially "transformative" approach to advancing sustainability, but cautioned that it could take 20 years to develop varieties suitable for widespread planting. Considering how long we have been improving annual crops, that actually doesn't sound so long! [From USDA Blog, *blogs.usda.gov/2011/02/15/*] □

Your Own On-Farm Nitrogen Fertilizer

by Paul W. Syltie, Ph.D.

Most farmers are aware that nitrogen can be fixed in the soil by symbiotic organisms such as *Rhizobium*, *Frankia*, and *Azospirillum*, and also by nonsymbiotic species like *Azotobacter*, *Klebsiella*, and cyanobacteria. However, in most conventional agricultural systems these organisms fix less nitrogen than required by corn, wheat, and other non-legumes.

There are many ways to increase the production of on-farm nitrogen by these microorganisms, like including more legumes in rotation with non-legume crops, crops such as alfalfa, clover, beans, or lespedeza. Alfalfa in rotation can generate 440 lb/acre of actual N per year, a very high contribution indeed. If a stand of alfalfa is plowed into the soil, it will provide ample nitrogen for a high-yielding corn crop the following season, and greatly reduce the need for fertilizer N besides greatly improving soil structure and permeability.

There is another approach to generating nitrogen fertilizer on the farm that is currently being investigated by a company called N-Ovation. Based in Savannah, Illinois, this technology company is researching the possibility of using microwaves to manufacture nitrogen fertilizer directly from the air.

Traditionally the Haber-Bosch process is used to produce nearly all nitrogen fertilizer, but the cost is high because natur-

Growing alfalfa and clovers is still the method of choice to generate on-farm nitrogen, but microwave technology, once perfected, may have merit.

al gas is utilized. The Norwegian company Norsk Hydro 100 years ago made nitrogen fertilizer using artificial lightning from their power generation facilities. This method, known as the Birkeland-Eyde process, formed nitrogen oxides that were then bubbled through water to produce nitric acid, from which fertilizers could be made.

Building on the idea of using lightning to break the double bonds of N_2 molecules, Joe Haas, a farmer from Carroll County, Illinois, and Gary Frederick, a childhood friend and retired aerospace engineer, worked to devise a system of moving a tractor driven machine through the field that fires bolts of lightning into the soil. Although the cost of such a method would be prohibitive with today's costs — more than $3,000 per ton — the idea seemed sound.

They tried heating the dinitrogen molecules with microwaves, incorporating parts from kitchen microwave ovens, and have built a device that shows promise. Rather than using continuous transmission, they are utilizing pulsed microwaves like for radar which have been shown to be up to 10 times more efficient in dissociating N_2. Their goal is to build a system that is affordable, rugged, and capable of producing nitrogen for under $1,000 per ton. It might even use energy supplied by windmills that could provide the N needs of a 1,000 acre operation, with a payback time hopefully less than five years. ☐

[Excerpts from *The Furrow*, Dec., 2011]

KEEP ON WORKING!

Don't wait for the inspired moments; work every day or you may miss them. Little by little you may find that your best work in a sense creates itself, your hands functioning almost without conscious control. You may come to wonder how much is really yours and how much mysteriously part of some universal force.

Wheeler Williams, *Bits and Pieces*, August, 1972.

"... and that you study to be quiet, and to do your own business, and to work with your own hands, as we commanded you; that you may walk honestly toward them that are without, and that you may have lack of nothing". I Thessalonians 4:11-12.

"Let him that stole steal no more, but rather let him labor, working with his hands the thing which is good, that he may have to give to him that needs". Ephesians 4:28.

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. If you would like to receive future issues of this newsletter or product information, simply fill out the form on the right and mail or Email it to us.

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Vitazyme has been performing excellently with all crops in 2011, and in Viet Nam and Cuba has performed exceptionally well on coffee. Increases for four trials in Dak Nong Province were 8 to 27% (0.3 to 0.6 ton per hectare) higher than the untreated controls, giving increased profits of up to $1,023 per hectare. In Cuba, coffee responses were equally impressive. Nursery plants responded very well, and Vitazyme raised profits by up to $4,427 per hectare on established plantations.

***Viet Nam*. Note the great improvement in coffee bean yield with Vitazyme.**