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Fertilizer Elements Affect Plant Disease

You Can Influence Disease with Nutrients!

By Paul W. Syltie, Ph.D.

For decades, major media and educational outlets have told people that nutrition is not very important in disease: eat what you want and you won't get sick, or at least not too severely. Likewise, farmers have often been told that soil fertility plays a minimal role in plant disease.

Yet, personal experience at both the human and plant level have persistently shown nutrition does make a difference, sometimes a big difference, in the genesis of disease. In 2007 a book entitled *Mineral Nutrition and Plant Disease* was published by the American Phytopathological Society — edited by Lawrence Datnoff, Wade Elner, and Don Huber — which pulled together many scattered studies relating plant disease to fertilizer elements. The picture presented is quite amazing and wonderfully encouraging to show that there is quite a lot a farmer can do to reduce the risk of various plant diseases.

The Nitrogen Effect

Nitrogen (N) has been investigated more than any other element in its effects on plant disease. While in general N applications often lead to more severe disease conditions, the rate of application, time of application (growth stage)

This example of rice fungal blast can result from high nitrogen applications and inadequate soil calcium levels.

form of N (NH_4^+ or NO_3^-), soil conditions, and interactions with other elements all conspire to affect disease organisms and plant susceptibility. Excess N tends to suppress plant defense responses and allow easier infection, with free amino acids increasing to provide food for attacking pathogens. Bunch rot of grapes, stalk rot of corn, eyespot and crown rot of wheat, and rhizoctonia blight of tall fescue all are increased with increasing N rates. When applied up to levels of the plant's requirements, however, diseases tend to diminish.

Side-dressing of N will avoid disease losses from high early-season applications, from leaching and denitrification. The form of N can greatly influence plant disease, but the soil environment may have more influence than on the form that is added, either NH_4^+ (ammonium) or NO_3^- (nitrate). Either N form may either reduce or enhance disease expression depending upon root exudates, tillage, organic amendments, and other factors. Nitrogen influences disease by changing plant physiology, affecting the growth and virulence of the pathogen, and modifying the soil-root environment. To reduce disease pressure with N, note the recommendations in the box below.

See All Elements Play a Role, page 2

"Superweed" Explosion Threatens Monsanto Heartlands

By Clea Caulcutt

[From France 24, *April 19, 2009.]*

The gospel of high-tech genetically modified (GM) crops is not sounding quite so sweet in the land of the converted. A new pest, the evil pigweed, is hitting headlines and chomping its way across Sun Belt states, threatening to transform cotton and soybean plots into weed battlefields.

In late 2004, "superweeds" that resisted Monsanto's iconic "Roundup" herbicide, popped up in GM crops in the county of Macon, Georgia. Monsanto, the US multinational biotech corporation, is the world's leading producer of Roundup, as well as genetically engineered seeds. Company figures show that nine out of 10 US farmers produce Roundup Ready seeds for their soybeans.

Superweeds have since alarmingly appeared in other parts of Georgia, as well as South Carolina, North Carolina, Arkansas, Tennessee, Kentucky and Missouri, according to media reports. Roundup contains the active ingredient glyphosate, which is the most used herbicide in the USA.

How has this happened? Farmers over-relied on Monsanto's revolutionary and controversial combination of a single "round up" herbicide and a high-tech

> ***"Superweeds" are plaguing high-tech Monsanto crops in southern US states, driving farmers to use more herbicides, return to conventional crops, or even abandon their farms.***

See The Perfect Weed, page 3

All Elements Play a Role in Disease

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To Reduce Disease With N ...

1. Maintain a balanced fertility program using sufficient N for optimum plant growth.
2. Make timely N applications to avoid periods of excessive N, high N loss, or predisposing environmental conditions for pathogens.
3. Use different N forms to enhance disease control.
4. Modify environmental conditions to optimize levels of the N-form that best controls pathogens and toughens plants.

Phosphorus and Plant Disease

Applications of phosphorus (P) can either reduce or increase disease development. This element has had scanty research relating to diseases, but in general P fertilization increases tissue P content and accelerates tissue maturity. Younger plant parts thus will be more protected from infection. Phosphorous also counteracts high levels of N, hastening maturity. Nematode attacks are often lessened by higher P levels, which induce more vitamin C, phenols, peroxidases, and ammonia in plant cells. Viral diseases, however, may be increased by more P in tissues, while bacterial diseases are usually reduced, such as soft rot of potatoes, where P induces high phenolic levels in peel and tuber tissues.

To reduce disease incidences with P, do not over apply it but try to reach optimum levels. Encourage soil biology, in particular mycorrhizal fungi, which help take up a large portion of soil P, and when fertilizer P is added use water-soluble forms. This advice works well on slightly acidic soils, but not calcareous types, where calcium quickly converts P to unavailable forms.

Potassium and Disease

Potassium (K) generally decreases the intensity of many plant diseases, but not always. Adding the element reduces vascular wilts in many fruits, forages, and vegetables, but only when it is deficient in the soil. When K is added in excess it may enhance or inhibit diseases. When N is relatively deficient for rice, K will reduce fungal blast as it is added, but when N is high the effect of K is to increase blast severity. Like for N and P, K interacts with other elements to bring about complex effects on disease, and its effects in specific situations depends on plant growth stage, variety, and cultivation practices. The mode of action for K protection of plants is thought to involve changes in protein and amino acid availability, decreased cell permeability, and reduced susceptibility to tissue penetration.

Other Elements

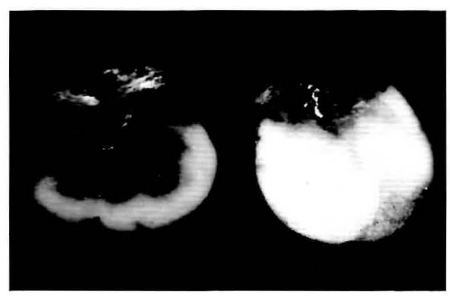
Calcium (Ca) is, along with nitrogen, the premier element in the plant's fight against disease. There is evidence that nearly all crops benefit from adequate Ca applications, be they fruits, vegetables, cereals, fiber crops, or forages. This also includes post-harvest diseases such as fungal and bacterial attacks on tubers and fruits. Calcium is an integral element for cell wall integrity; it binds to pectins and fills the holes in kinked polygalacturonic chains. These and other molecular formations inhibit fungal and bacterial pathogens. Calcium also plays a key role in signal transduction during plant defense responses.

Calcium (Ca) is, along with nitrogen, the premier element in the plant's fight against disease.

Magnesium (Mg) has an important effect on disease suppression. It will suppress *Gaeumannomyces graminus* ("take-all") in wheat, but high levels will increase bacterial spot in peppers and tomatoes. Sulfur (S) can directly affect diseases incidence and severity as a direct biocide, and indirectly by enhancing plant resistance and increasing the availability of other nutrients. Elemental S is a well-known fungicide. Resistance to disease can be enhanced by the S-containing compounds glutathione, the amino acids cysteine and methionine, certain volatile S compounds, phytoalexins, and glucosinolates.

Several micronutrients, including iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), chlorine (Cl) molybdenum (Mo), boron (B), nickel (Ni), and silicon (Si) have all been shown to be highly effective in suppressing plant diseases. For instance, Fe is complexed in siderophores, low-molecular weight molecules having a high affinity for Fe; these help the plant deter diseases. Manganese reduces bacterial infections, Zn is highly effective against fungal diseases like citrus blight, Cu enhances plant defenses against infection, and B helps lignify tissues and raise phenolic compound levels, both important in plant defense systems.

Each of the nutrient elements plays a critical role in the plant's defense mechanisms, so it is vital to encourage a plant-soil system that is able to take up these nutrients in the right amounts at the right times. By balancing macro and micronutrients with a soil fertility system such as the Albrecht system, and enhancing microbial activity so these nutrients will be made available, the farmer can go a long ways in ensuring his crops will have the optimum levels of elements of resist the ravages of plant diseases and pests. Following the principles of nature in farming will alwaysbenefit the farmer in many ways. ❐



Potato soft rot is a postharvest disease that can be greatly reduced with adequate levels of calcium and boron.

Botrytis bunch rot of grapes can be significantly reduced by adjusting fertilizer nitrogen rates to plant needs.

The Perfect Weed to Foil Monsanto

Continued from page 1

seed with a built-in resistance to glyphosate, scientists say.

Today, 100,000 acres in Georgia are severely infested with pigweed and 29 counties have now confirmed resistance to glyphosate, according to weed specialist Stanley Culpepper from the University of Georgia.

"Farmers are taking this threat very seriously. It took us two years to make them understand how serious it was. But once they understood, they started taking a very aggressive approach to the weed," Culpepper told FRANCE 24.

"Just to illustrate how aggressive we are, last year we hand-weeded 45% of our severely infested fields," said Culpepper, adding that the fight involved "spending a lot of money."

Pigweed [Amaranthus] has become glyphosate resistant in many areas and will take over fields of cotton, soybeans, and other crops.

In 2007, 10,000 acres of land were abandoned in Macon country, the epicentre of the superweed explosion, North Carolina State University's Alan York told local media.

The Perfect Weed

Had Monsanto wanted to design a deadlier weed, they probably could not have done better. Resistant pigweed is the most feared superweed, alongside horseweed, ragweed and waterhemp.

"Palmer pigweed is the one pest you don't want, it is so dominating," says Culpepper. Pigweed can produce 10,000 seeds at a time, is drought-resistant, and has very diverse genetics. It can grow to three metres high and easily smother young cotton plants.

Today, farmers are struggling to find an effective herbicide they can safely use over cotton plants.

Controversial Solutions

In an interview with FRANCE 24, Monsanto's technical development manager, Rick Cole, said he believed superweeds were manageable. "The problem of weeds that have developed a resistance to Roundup crops is real and [Monsanto] doesn't deny that, however the problem is manageable," he said.

Cole encourages farmers to alternate crops and use different makes of herbicides.

Indeed, according to Monsanto press releases, company sales representatives are encouraging farmers to mix glyphosate and older herbicides such as 2,4-D, a herbicide which was banned in Sweden, Denmark and Norway over its links to cancer, reproductive harm and mental impairment. 2,4-D is also well-known for being a component of Agent Orange, a toxic herbicide which was used in chemical warfare in Vietnam in the 1960s.

Questioned on the environmental impact and toxicity of such mixtures, Monsanto's public affairs director, Janice Person, said that "they didn't recommend any mixtures that were not approved by the EPA," she said, referring to the US federal environmental Protection Agency. According to the UK-based Soil Association, which campaigns for and certifies organic food, Monsanto was well aware of the risk of superweeds as early as 2001 and took out a patent on mixtures of glyphosate and herbicides aimed towards glyphosate-resistant weeds.

A single pigweed plant may produce 10,000 seeds or more, allowing it to propagate extremely fast.

"The patent will enable the company to profit from a problem that its products had created in the first place," says a 2002 Soil Association report.

See A Return to Non-GMO, page 7

Follow Nature's Laws for Success!

[Extracted from an article on Sir Albert Howard in the Winter 2000 issue of The Vital Earth News, Agricultural Edition.*]*

1 **Mixed farming is the rule..** Plants are always found with many species of plants and animals living together. There is never an attempt at monoculture.

2 **The soil is always protected from the action of sun, rain, and wind.** Most of the sun's energy is used in the forest and prairie ecosystems. Leaves break the force of raindrops to a mist or splatter, and roots and structural units bind the soil together.

3 **Rainfall is carefully conserved.** Much water is retained in the surface soil, and excess is gently transmitted downward through pores and cracks.

4 **The forest and prairie manure themselves.** A persistent rain of leaves or grass settles on the soil surface where scores of bacteria, fungi, and other organisms break it down to humus and plant nutrients.

5 **Mineral matter needed by trees and grass is obtained from the subsoil.** These minerals are also recycled through vegetation as it falls, and decompose on the soil surface. No fertilizers need to be added to a properly functioning system.

6 **Soils always carry a large fertility reserve.** These reserves are contained in the humus of the surface horizons as well as in the native minerals of the soil mass.

7 **Crops and livestock look after themselves.** No spray machine or vaccine is supplied in nature, only natural immunity to diseases and insects that will hold at bay the pests that are usually present. Nature's rule is "Live and let live".❐

15-Minute Soils Course

Lesson 29:

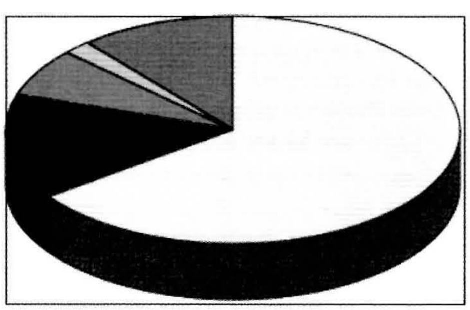
Calcium (Ca): Part I The Soil Phase

Calcium is the most abundant exchangeable ion found on the soil colloid (clay and organic matter). The element is the fifth most common in the earth's crust (3.6%), and is found in rocks such as horneblende, augite, anorthite, olivine, biotite, and gypsum, indeed in most rocks. Relatively little calcium occurs in organic matter, most occurs as mineral forms in acidic soils or carbonates (Ca CO_3) in alkaline soils. It is an essential plant element for plant growth.

20	40.078
Calcium	
839	1484
Ca	

The Exchange Complex

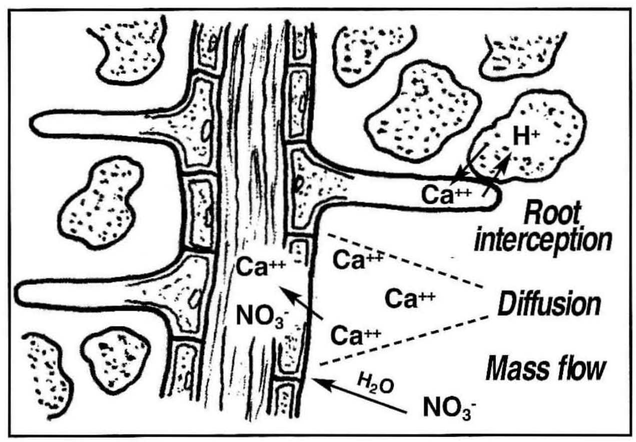
Clay minerals and organic matter possess many negatively charged exchange sites, yielding cation exchange capacities of perhaps 5 to 10 meq/100 grams in sandy, low organic matter soils, and 15 to 20 and higher in clayey, high organic matter soils. Usually, the majority of these sites are occupied by divalent calcium (Ca^{++}), since its bonding energy is higher than that of calcium, potassium, sodium, and hydrogen. The ideal proportion of calcium to other ions in around 62 to 65% of base saturation; for magnesium it is 12 to 15%, and for potassium around 5 to 7%. Research by William Albrecht, in the 1940s at the University of Missouri, showed that this ideal proportion of adsorbed cations on the exchange complex provided the best overall plant growth and soil conditions.



□ Calcium (62-65%)
■ Magnesium (12-15%)
■ Potassium (5-7%)
■ Sodium (0.5-3%)
■ Others (the balance)

Soil-Plant Uptake

In the soil solution of more acid, leached environments, Ca^{++} is about 20 to 40 mg/liter, while in arid areas it may reach 50 to 100 mg/liter. However, since calcium minerals are not very soluble most of the element is taken up by exchange reactions (root interception) on clay and organic matter surfaces with roots. Diffusion through the soil solution is also an important means of bringing calcium into roots, whereas nitrogen is delivered mostly through mass flow. Mycorrhizae are also helpful in moving calcium to roots by absorbing and carrying the ions along their hyphae to root cortex cells.



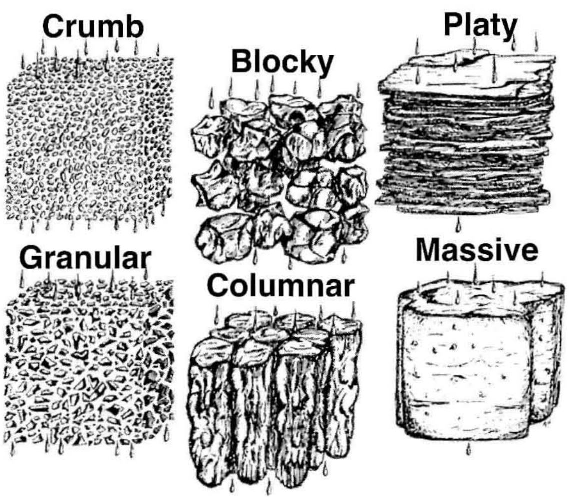
Structure Effects

Calcium has long been noted for its encouragement of soil particle flocculation, helping to create a desirable structure that is so critical for proper air and water movement through the soil. However, flocculation only modifies other factors, such as microbial polysaccharide production, in creating strong structure. Adding lime (Ca CO_3) is thus effective in improving soil granulation by improving microbial activity.

Why is calcium so effective in helping create floccules, but not potassium or sodium? The *zeta potential* of the ion is the key. A cation with dual positive

15-Minute Soils Course

charges, like calcium, is small and has little hydration water, so is held tightly to the colloid surface, reducing the zeta potential and allowing flocculation. Sodium, on the other hand, is larger and very hydrated, increasing the zeta potential of the colloid-cation system and repelling particles. Calcium will help build the structure types shown below, except for "massive", which is a typical structure of high sodium soils.



Correction of Deficiencies

The usual amendment for calcium deficiency in acidic soil conditions is lime, but to maintain proper calcium-magnesium levels the type of lime to add is important. If calcium is below 62% base saturation, and especially if magnesium is over 18%, then high-calcium lime should be added; if magnesium is less than 12% base saturation, then dolomitic lime $(Ca,,MgCO_3)$ should be applied. Since fineness of grind dictates the speed of availability, a good grade should be used, such as 40% or more through a 100 mesh screen.

One should be aware that the addition of nitrogen fertilizers to soils lowers the pH and tends to deplete calcium from the soil system. To replenish this loss the farmers must add calcium as shown in the table in the upper right corner, or risk losing productivity.

Also be aware that in high-calcium, high pH soils, phosphorus can be tied up in calcium

Fertilizer	$CaCO_3$ to add per ton*
Anhydrous NH_3	**2,960 lb**
NH_4NO_3	**1,180 lb**
$(NH_4)_2SO_4$	**2,200 lb**
DAP	**1,400 lb**

***Calcium Carbonate Equivalent.**

phosphates. On the other hand, by adjusting pH toward neutrality on acidic soils, adding calcium tends to make all nutrients more available.

For situations where excessive ions such as magnesium or sodium need to be leached out, gypsum $(Ca\ SO_4)$ is useful, since the sulfate ion will leach out in percolating water and carry with it other ions, especially those held the most loosely like sodium. Thus, gypsum is called "land plaster" when used to leach sodium from saline and alkali soils.

We have only touched the surface on calcium, the most common element on the soil exchange complex.

See What You Learned

1. Calcium is one of the prime elements of plant nutrition. T or F
2. The forms of calcium used by plants are.
a. Exchangeable ions b. Soil solution ions c. Rock ions
3. The process by which calcium causes soil particles to aggregate is called ________________.
4. Calcium is usually the most abundant ion on the soil exchange complex. T or F
5. A proper range for calcium on the exchange complex is ____ to ____ %.
6. If sodium has accumulated to high levels in an arid soil and inhibits plant growth, which fertilizers would be good to apply?
a. Lime b. Copper sulfate c. Gypsum d. Anhydrous ammonia
7. Bonus problem. Explain briefly why anhydrous ammonia lowers soil calcium levels.

Answers: 1. T; 2. a, b; 3. flocculation; 4. T; 5. 62, 65; 6. c; 7. Refer to the article.

Is Ecological Agriculture Productive?

By Lim Li Ching, Researcher
Third World Network, November, 2008

[Evidence from specific ecological agriculture interventions, and the bibliography, are deleted from this article.]

Evidence from Global Modelling

A recent study examined a global dataset of 293 examples and estimated the average yield ratio (organic : non-organic) of different food categories for the developed and developing world. For most of the food categories examined, they found that the average yield ratio was slightly less than 1.0 for studies in the developed world, but more than 1.0 for studies in developing countries.

On average, in developed countries, organic systems produce 92% of the yield produced by conventional agriculture. In developing countries, however, organic systems produce 80% more than conventional farms.

"... the data suggest that leguminous cover crops could fix enough nitrogen to replace the amount of synthetic fertilizer currently in use."

With the average yield ratios, the researchers then modeled the global food supply that could be grown organically on the current agricultural land base. They found that organic methods could hypothetically produce enough food on a global per capita basis to sustain the current human population, and potentially an even larger population, without putting more farmland into production.

Moreover, contrary to fears that there are insufficient quantities of organically acceptable fertilizers, the data suggest that leguminous cover crops could fix enough nitrogen to replace the amount of synthetic fertilizer currently in use.

This model suggests that organic agriculture could potentially provide enough food globally, but without the negative environmental impacts of conventional agriculture.

Evidence from Reviews of Ecological Agriculture Projects

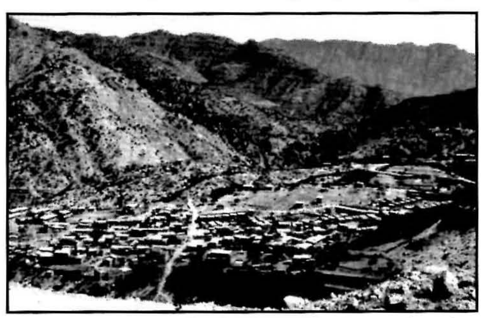
In a review of 286 projects in 57 countries, farmers were found to have increased agricultural productivity by an average of 79%, by adopting "resource-conserving" or ecological agriculture .

A variety of resource conserving technologies and practices were used, including integrated pest management, integrated nutrient management, conservation tillage, agroforestry, water harvesting in dryland areas, and livestock and aquaculture integration into farming systems. These practices not only increased yields, but also reduced adverse effects on the environment and contributed to important environmental goods and services (e.g., climate change mitigation), as evidenced by increased water use efficiency and carbon sequestration, and reduced pesticide use.

The work built on earlier research, which assessed 208 sustainable agriculture projects. The earlier research found that for 89 projects for which there was reliable yield data, farmers had, by adopting sustainable agriculture practices, achieved substantial increases in per hectare food production; the yield increases were 50-100% for rain-fed crops, though much greater in a number of cases, and 5-10% for irrigated crops.

Disaggregated data show:

- Average food production per household rose by 1.7 tonnes per year (up by 73%) for 4.42 million small farmers growing cereals and roots on 3.6 million hectares.
- Increase in food production was 17 tonnes per year (up 150%) for 146,000 farmers on 542,000 hectares cultivating roots (potato, sweet potato, cassava).
- Total production rose by 150 tonnes per household (up by 46%) for the larger farms in Latin America (ave. size 90 ha).



Studies in ecological agriculture in the Tigray Region of Ethiopia have shown that compost produces much higher yields than does chemical fertilizer.

The database on agricultural sustainability (comprising the 286 projects) was reanalyzed to produce a summary of the impacts of organic and near-organic projects on agricultural productivity in Africa. The average crop yield increase was even higher for these projects than the global average (79%): 116% increase for all African projects and 128% increase for the projects in East Africa.

"On average, in developed countries, organic systems produce 92% of the yield produced by conventional agriculture. In developing countries, however, organic systems produce 80% more than conventional farms."

For Kenyan projects, the increase in yield was 179%, for Tanzanian projects 67% and for Ugandan projects 54%. Moreover, all case studies that focused on food production in this research where data have been reported, showed increases in per hectare productivity of food crops, which challenges the popular myth that organic agriculture cannot increase agricultural productivity.

Conclusion

It is clear that ecological agriculture is productive and has the potential to meet food security needs, particularly in the African context. The International Assessment of Agricultural Knowledge, Science and Technology for Development concurs that an increase and strengthening of agricultural knowledge, science and technology toward agroecological sciences will contribute to addressing environmental issues while maintaining and increasing productivity.

Moreover, ecological agricultural approaches allow farmers to improve local food production with low-cost, readily available technologies and inputs, without causing environmental damage. ❐

Plants Communicate With One Other!

By Paul W. Syltie, Ph.D.

It may come as a shock that the corn and soybeans in your fields, and the trees in your woods, are jabbering to one another! According to Sylvia Hughs (*New Scientist*, Sep. 29, 1990), acacia trees pass along an "alarm signal" to other trees when antelope browse on their leaves. Acacias nibbled by antelope produce leaf tannin in quantities lethal to the browsers, and emit ethylene gas into the air that can travel up to 50 yards and warn other trees of impending danger. These other trees then step up their tannin production within 5 to 10 minutes.

Ed Wagner (*Seattle Sun Times*, Feb 12, 1989) said that "If you chop down a tree, you can see that adjacent trees put out an electrical pulse". He showed this pulse on a chart recorder. "These trees know within a few seconds what is happening." Wagner has measured the speed of these signals — which he calls "W waves" — at about 3 feet per second, making them non-electromagnetic.

Another researcher, P. Gunkel (*Omni*, Dec., 1982), demonstrated that trees attacked by caterpillars sounded an alarm

that other trees in the vicinity could detect. The alerted trees then proceeded to make their leaves harder to digest. This signal affected trees as far as 200 feet away. By surrounding the affected trees with plexiglass he was able to stop the signal transmission, showing the message must be a chemical emitted into the air.

Building on the work of H.S. Burr from the 1940s, Y. Miwa in Japan placed electrodes into the trunks of trees — 250 at a time — and measured voltage differences every 2 seconds. An amazing synchrony was discovered. "In each [primeval] forest there were several groups of between 20 and 50 trees showing a similar pattern of changes in their potentials, each of which contained about half a dozen species. Neighboring trees were the most likely to be synchronized, but the groups did not have rigid boundaries. The membership of the groups was also not fixed: between the first and second days of recording; individual trees ''joined' and ''dropped out''".

We have only begun to understand the interrelationships and communications among plants, but we do know that their roots are usually interconnected by mycorrhizal hyphae. Can it be that these plants even pick their friends? ❒

A Return to Non-GMO Crops?

Continued from page 3

Returning to Conventional Crops

In the face of the weed explosion in cotton and soybean crops, some farmers are even considering moving back to non-GM seeds. "It's good for us to go back, people have overdone the Roundup seeds," Alan Rowland, a soybean seed producer based in Dudley, Missouri, told FRANCE 24. He used to sell 80% Monsanto "Roundup Ready" soybeans and now has gone back to traditional crops, in a market overwhelmingly dominated by Monsanto.

According to a number of agricultural specialists, farmers are considering moving back to conventional crops. But it's all down to economics, they say. GM crops are becoming expensive, growers say.

While farmers and specialists are reluctant to blame Monsanto, Rowland says he's started to "see people rebelling against the higher costs."

— Laughter — Good Medicine!

Always laugh at yourself first. Everybody has a ridiculous side, and the whole world loves to laugh at somebody else. Laugh at yourself first, and the laughter of others falls off harmlessly as if you were in golden armor.

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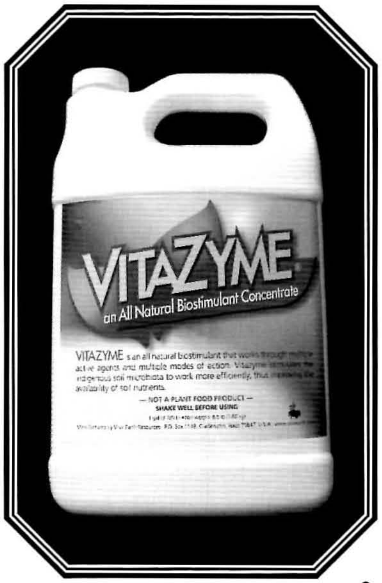

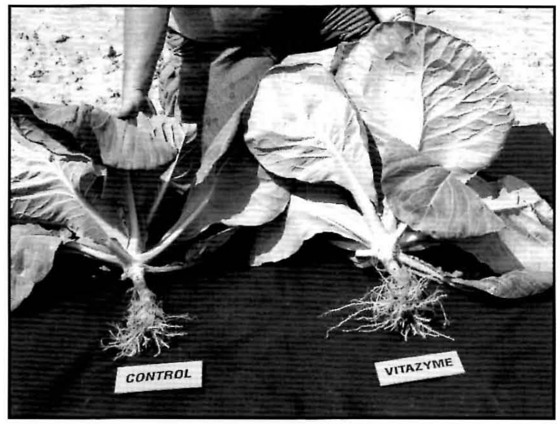

Vitazyme treated Cabbage in New York gave larger roots, leaves, and yields.

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