

LOW COST, HIGH YIELD FARMING

By: David Larson
Larson Farm Management
Princeton, Illinois

One of my farm operators told me last week that he was about as tired as he had ever been, but farming was enjoyable again! I want to share some of the things that lead up to that statement today. In order to do that however, I need to give you a little personal background.

I returned to North Central Illinois to establish a professional farm management business after completing a bachelors program in Ag Economics at Purdue University and a masters program in Farm Management at Ohio State University. At that time I entered into a farming operation with my dad. I purchased my parents' interest in the home farm business about five years later and by 1970 I was attempting to expand the direct farming operation as rapidly as possible. We were operating about 1250 acres by the middle 1970's, most, of which we were in the process of purchasing.

Corn and bean yields were pretty good--my five-year average on corn was 164 bushels per acre, and on beans was 54 bushels per acre. However, at this time I became increasingly aware of the fact that my cost of production per bushel was too high. The large debt load that I was servicing had pushed my fixed costs to the point that my per bushel cost of production for corn was over \$3.00 per bushel even though my yield was quite respectable. I realized that I needed to reorganize the business to reduce that cost. Meanwhile, I became very intrigued with the maximum yield research that Doctors Harold Reetz, David Mengel and Jim Polizotto were doing at Purdue University. I concluded that if I could increase my corn yields to 250 or even 300 bushels per acre I could reduce my per unit cost of production because fixed costs would be divided by more bushels. I reasoned that this yield goal would not be unattainable if I put an irrigation system on the Muscatine silt loam soil that I was farming. This soil has the highest yield rating in the state of Illinois.

I must admit to you that I had never seen an irrigation system except at a distance at that time. I therefore went down to the University of Illinois and visited with several of the agronomy staff. I was advised to go out to the University of Nebraska and take an irrigation scheduling short course. I did that. When I returned home I ordered an irrigation system and began experimenting.

I immediately increased the plant population from in the range of 26,000 to 28,000 plants to 32,000 to 36,000 plants per acre. I also increased the amount of nitrogen from 180 to 200 pounds per acre to 250 to 350 pounds of actual N per acre. The response to irrigation, higher plant populations, and higher nitrogen levels was immediate. The yield jumped from 164 bushels per acre to slightly over 200 bushels. Some varieties went as high as 226 bushels per acre that first year. However, as the corn reached about 35% moisture in mid September I experienced severe lodging. I harvested that corn at 27-30% moisture but it was between 80-90% lodged.

While seeking answers to the severe lodging problem and the yield limitations that it imposed, I visited with almost everyone that would take time to look at my soil tests with me. Most of the recommendations that I received included increasing my potassium application rates. I had applied 200 to 250 pounds of 0-0-60 for the past 14 years. For the next two years, however, we added between 400 and 600 pounds of muriate of potash per acre. I must report that I saw no improvement in the standability of the corn and almost no change in the soil tests.

I was told at a Phosphate-Potash Institute soil fertility workshop, by an agronomist who shall remain nameless, that the problem I was facing was created by the fact that I did not understand base saturations as I was not interpreting my soil tests properly. He took my soil tests and calculated that I needed to add 966 pounds of muriate of potash per acre to bring my base saturation of potassium to the 5% level. The typical application rates of that product were 100 pounds per acre in my area.

I had been irrigating for three years now and my irrigated corn yield had dropped each year of the project. I was therefore feeling a great deal of pressure from my tenant operators and clients, as well as my banker, to see some results from the experimenting that I was doing. I therefore returned home, applied 966 pounds of muriate of

potash, 300 pounds of 18-46-0, and 250 pounds of anhydrous ammonia. The following summer I added an additional 100 units of nitrogen through the irrigation system.

By mid August I had nitrogen deficiency symptoms in most varieties of corn. Virtually every variety in my test plot had ears that were above my head. Almost every ear had about 3 inches of cob sticking out beyond the end of the kernels. My ground was so hard that I could stand on a tile spade and barely dig a corn plant out. I had tremendous masses of roots in the top 2 1/2 inches but almost no roots below that. I had brace roots from 3 nodes above the ground. A one-inch rainfall would create ponds above tile lines in the depressional areas. To make matters worse, I did not significantly improve standability. We harvested several varieties in one direction. That fall when I plowed with the same tractor and mold board plow that I had been using for several years I found that I had to pull it one gear lower. When I tallied my yield, the overall average for the fourth year was 169 bushels per acre. That was only 5 bushels better than my 5 year average 4 years ago, before I added the irrigation system!!

As soon as harvest was completed, I took a close friend who was also farming and made a two-week trip across the Corn Belt. I traveled in four states seeking an answer to the yield barrier and soil conditions that were developing in my field. At that time I crossed paths with Dr. Carey Reams, who had studied under Albert Einstein as a young man. Reams was in his late 70's when I met him, and he had nearly a half century of experience working with a variety of crops in the southeast part of the United States. He and a student of his, Dr. Daniel Skow, explained the theory that Dr. Reams had developed and called "The Biological Theory of Ionization". It is a spin-off of the technology that brought us the Atomic Age. That visit plus several subsequent visits with Dr. Reams and several of his students have had major impact on the thoughts that I share with you today.

Dr. Reams was an Einstein-type mathematical genius. His mathematical ability was directed into biochemistry and the way it was affected by electromagnetic properties of elements as they combined to build life, as we know it in the plant, animal, and human kingdoms. Biological ionization then is the study of how energy becomes matter and how matter becomes energy on a continuous basis. Reams explained to me that when it comes to soil-plant interrelations the term energy is not being properly understood. I equated energy with fertilizers that have been or need to be added to the soil. He felt that the chemistry principles are only a part of the complete understanding--that it is soil biophysics that should be addressed. Reams explained that the energy for growing plants and animals come continually through two channels. One is the atmosphere and the other is the soil. This energy comes in three forms: heat, electricity, and matter. All matter has within it heat and electricity. It is these forms of energy that are responsible for magnetic force.

It is not my intent to explain the details of Ream's theory, but to describe some of the management practices we are adopting to take advantage of what we are learning.

I like to divide these practices into three soil stewardship areas. 1) Air and water space, 2) residue handling, and 3) nutrient application. There is considerable interrelationship between these three areas, but it has been helpful to me to look at them separately.

AIR AND WATER SPACE

I became conscious of this area when I began to take infrared aerial photos. I was shocked and surprised to observe what had happened to the topsoil of some of the best prairie soils in the Midwest. The impact that wheel tracks from fall tillage and harvest operations had on the crop the following year was very significant. I thought that any fall compaction was pretty much taken care of by the freezing and thawing to heal the compaction damage from a wet fall harvest.

Soil air levels can be increased however. They can be increased mechanically and chemically. We can increase air levels in the root zone mechanically with tools such as the rotary hoe, the cultivator, the ridging cultivator, and some other deep tillage equipment. We can increase air levels chemically with calcium.

Cultivation alone will increase yields in many years. We have discovered that when soil is ridged up on the plant with a cultivator high enough to cover the nodes where brace roots later develop that we get a 3-7 bushel yield increase. This is particularly true on full season varieties. This comes largely from increased root mass. Roots cannot grow where they don't have oxygen. The roots found in a well-aerated ridge are lighter in color, more

turgid, and have a lot more fine root hairs attached. If you look at corn roots more carefully the brace root phenomenon becomes more interesting. I have heard many different explanations. Some say brace roots are caused by salt buildup in the soil. Others say that they are caused by a magnesium/calcium imbalance. I do not have a good understanding of the factors or the combination of factors that cause brace roots, but I have dug many, many plants with and without brace roots and I know that the plumbing system is plugged in the very base of every plant that has brace roots. I have concluded they are a survival structure of the corn plant. They are a second attempt by that plant to feed itself. I have consistently observed a bigger ear on a plant with no brace roots or a plant where dirt has been ridged to cover brace roots.

Regardless of the method used to get air into the soil, I have observed that if air space is near 25% of total volume some exciting things begin to happen. We not only get a better root system; we also unlock the power of soil microbes. The December 1984 issue of The Furrow published by Deere & Company suggested that scientists are learning how to manipulate microorganisms to reduce fertilizer requirements and increase crop yields. I had not appreciated the amazing variety of plant and animal life, most of which are microscopic, that live in a fertile soil. An idea of their abundance can be gained from the following table, which shows figures for a temperate grassland soil taken from Soils and Soil Fertility by L.M. Thompson and F. Troeh.

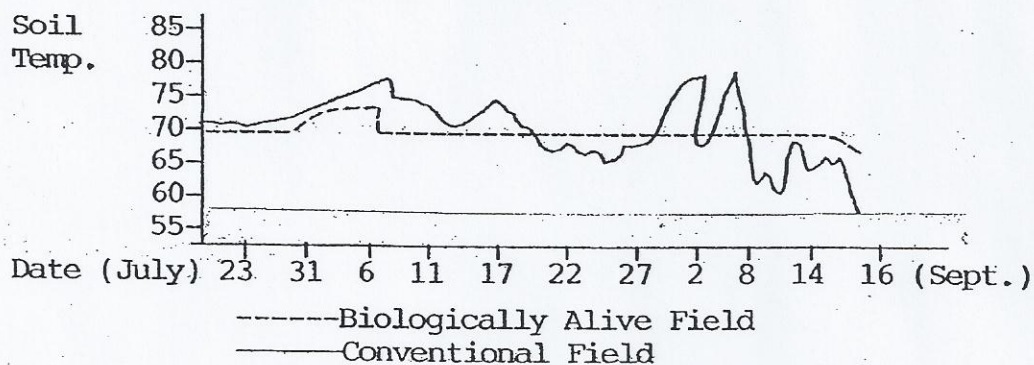
Organism	Number/Acre	Lbs./Acre
Bacteria	800,000,000,000,000	2600
Actinomycetes	20,000,000,000,000,000	1300
Fungi	200,000,000,000,000	2600
Algae	4,000,000,000	90
Protozoa	2,000,000,000,000	90
Nematodes	80,000,000	45
Earthworms	40,000	445
Insects and Other Arthropods	8,160,000	830

The three most important groups of soil organisms are the bacteria, the actinomycetes, and the fungi.

We have observed that as biological life improves in the soil we decompose last year's crop residue much more rapidly, we break down man-made toxins in the soil, we fix more nitrogen and make more nutrients available to the plants. The change in soil tilth is readily observable to the naked eye.

We have observed that good pore space in the soil will stimulate biological life in the soil. In addition soil temperatures are more stable during the growing season. To substantiate this we placed two sets of thermometers in adjoining cornfields. One field was quite biologically alive, another was not. We measured the high and low air temperatures in each field as well as the soil temperature at 6 inches depth in each field. The soil temperatures at 7:00 p.m. during that test are shown below.

Soil Temperatures in Bureau County, Illinois, 1984



Some researchers feel the more constant soil temperature found in the biologically alive field was a function of the fact that ammonia is produced as a by-product of the decomposition process. This ammonia works in the soil in the same manner that it works in gas refrigerators. The more you heat the nitrogen in the refrigerator coil the cooler the refrigerator gets.

In addition to mechanical aeration to stimulate biological life, the addition of calcium is extremely beneficial. The addition of limestone to the soil increases the soluble calcium levels and pH. It also provides soil pore spaces. Dr. William A. Albrecht, former head of the Agronomy Department at the University of Missouri, showed an illustration in one of his papers indicating that the calcium acts like little mini-magnets on the clay and humus particles; actually pushing them apart creating more pore space at the soil surface.

Soil water management has two challenges. First eliminating excess water; secondly adding water or improving the water holding capacity. We attempt to eliminate the excess water by adding tile drainage, by adding surface drainage, and by adding limestone. We attempt to increase available water through irrigation or improving water-holding capacity of the soil. Water holding capacity can be increased by improving the organic matter in the soil. Many have the feeling that soil organic matter cannot be increased or decreased from its natural state. In a 5-10 year time span organic matter can be changed. I have three sets of soil tests from one of the largest soil labs in the U.S. showing an increase in organic matter over a 5 year time span.

One pound of organic carbon can hold four times its weight in water, therefore increasing the organic matter content of the top 6 inches of the soil by 1 percent, or approximately twenty thousand pounds, will increase the water holding capacity in the plow layer by 80,000 pounds or about 4/10 of an inch.

We have discovered that subsoiling or the deep tillage of row crops at the time of the last cultivation helps eliminate excess water and helps the plant access water in the subsoil. The deep tillage opens the soil up so water can penetrate more rapidly in the event of a heavy downfall. Under dry conditions, however, that aerating allows the roots to grow deeper, through and around the hard pan and thus access the water that is deeper in the soil profile. When roots grow down against the hard pan, which is found in most of the soils in the upper Midwest, their growth rate is slowed down or they tend to grow laterally. When comparing root growth in a well-aerated soil environment we have observed as much as four inches of growth in a 24 hour period. In a compacted soil only a quarter of an inch of root growth took place in the same time period.

We cannot talk about successfully managing air and water in the soil profile without talking about Herman Warsaw of Saybrook, Illinois. Many of you have probably visited his farm and the high yield area. We discovered that he had a well-aerated zone free from any hard layer down 18 to 21 inches. In short, his sponge to hold water and nutrients was three times greater than many of his neighbors had. This helps explain his yields that are also much better.

To understand how to manage soil air and water one needs to understand how water moves in the soil. Walter H. Gardner published an excellent article in 1979 in Crops and Soils magazine illustrating those principles:

Under unsaturated conditions, water moves into soil in all directions in response to attraction of particle surfaces for water and cohesive forces between water molecules, which result in water occupying the small pores. Gravity acts on the water to cause slightly greater movement downward, but the absorptive forces of the soil dominate. Water has been applied at the center of the model (Figure 1). In stratified soil--soil with various "layers"--the size of the pores in the strata affect water flow. If an advancing wetting front encounters fine materials, the resistance in the extremely fine pores may slow the movement (Figures 2 & 3). But the water nevertheless, continues to move. If the wetting front encounters coarse materials, water movement stops until the soil becomes nearly saturated.

In other words, water is able to move into a hard pan or clay pan from a coarser soil material, but the rate of movement through such a layer is slow because of the resistance to flow encountered in extremely fine pores. Thus, even though such layers readily become wet they can seriously check deeper penetration of water. Water tables often build up over such hard pans or clay layers. Under dry summer conditions water movement upward into the root zone is also retarded in the same manner by the hard pan.

Straw or crop residues, if turned under in layers through plowing, act much like coarse sand layers in impeding the downward penetration of water. However, if straw or organic materials are mixed with the soil they help to

maintain open and porous conditions, which favor rapid intake of water (Figure 4). A vertical channel filled with straw or other organic material and maintained open to free water at the surface will help to transmit water deep into the soil. However, if such a channel is covered with soil it does little or no good in transmitting water (Figure 5). The photo in figure 6 depicts the plow pan existing in many Midwest soils. Root growth, as well as water penetration often is restricted by such plow pans. (See Figure 1 at end)

RESIDUE HANDLING

I used to believe the only way to handle residue was to bury it-the deeper the better. I am becoming more aware of the long-term ramifications of that practice. The soil erosion that was taking place, even on the deep, dark prairie soils with 2% and 3% slope was very significant. Realizing this, we tried the opposite extreme; no till. We found that it worked well on the lighter soils and in more rolling situations. No till practices on the poorly drained, dark soils have not produced as good results as other systems. We have found that a compromise somewhere between the two extremes is most desirable.

When I began to look more carefully at what was happening to the residue that we turned under, particularly with the big plows that were pulled very deep, I discovered much of that residue had been turned into an anaerobic zone in the soil. It seems to undergo a kind of pickling process instead of a decomposition process that produces nutrients for next year's crop. We now attempt to keep that crop residue in the aerobic zone in the soil. If the aerobic zone is deep in a given soil, deep tillage is acceptable. If it is only 2-3 inches, however, you need to work the residue into only the top 2-3 inches of soil. Stop and consider where a fence post rots off. It is always where the air and soil meet. Therefore that must be the point where the greatest amount of rot or decomposition takes place. We feel that an ideal system of residue management is one that incorporates the trash shallow in that aerobic zone. We have experimented with several tillage tools including disc chisels, heavy discs, and slot chisels. One tool that is working extremely well in a transition period is a stalk shredder with a tillage tool mounted in the back. Crop residue is broken up and incorporated shallow where maximum aerobic decomposition can take place.

NUTRIENT APPLICATION

Energy for growing plants comes through two channels: one is the atmosphere and the other is the soil. Until I understood that, I never fully appreciated the story that I read as a freshman agronomy student:

A seventeenth century Flemish physician, Von Helmont, planted a willow tree in a large wooden tub. The little willow tree weighed in at 5 pounds. Soil used in the experiment scaled in at an even 200 pounds. The tub was then covered so that only a small hole for the tree trunk and one for water remained. Five years later the tree was not only larger, it now weighed 164 pounds. Obviously, reasoned Von Helmont, if a willow tree picked up the difference between 5 pounds and 164 pounds then the soil remaining in the tub should weigh only 41 pounds. Potting materials were reduced to oven dried soil for the post growth weigh in. The results proved Von Helmont hopelessly wrong. After contributing to the tree's growth for five years the 200 pounds of soil had lost only 2 ounces. Von Helmont pondered the problem in deep consternation, could it be that all of this growth came from the water that he had given the tree all of these years?

We of course now know that the air contains carbon, hydrogen, oxygen and nitrogen. All of these elements are a part of cells. The air is indeed a very important source of energy to grow plants. The other source of energy of course, is the soil. The plant does not live off of fertilizers or plant foods in the soil but rather lives off the energy that is given off as the various types of plant food elements interact in the soil. Energy is released because of resistance. From an energy point of view, anions and cations work against each other in a resistance reaction and energy is given off as a result. The energy given off from this process is what the plant lives on. In other words when two elements come together they must go through a synchronization process to allow each to give off enough energy so they can coordinate their electromagnetic fields to bond into a new molecular arrangement.

We attempt to build all fertilizer programs to create the electromagnetic field that will be most beneficial to a specific plant in a particular growth phase.

MANAGEMENT PRACTICES

We used to apply all of our plant nutrients in the fall of the year and plow them down. When we did this we found that we had very rapid early growth and a deep almost blue-green color in our early plant growth. Since we have been putting most of our plant nutrients on later in the growing season, and in different forms, we have observed some differences in how our crops look. They have a lighter color green earlier in the growing season, but in September we still have a green, healthy looking crop while many of our neighbors' fields are totally fired and the stalk is dead. We really like to see a dry husk and a green plant. This almost always means high-test weight and good field dry down.

We are using 28% as our primary nitrogen source. We like this source because it is half nitrate nitrogen and half ammoniacal nitrogen. We do require our operators to get set up so they can handle it in bulk and do their own spreading. There is no one best nitrogen source. In addition to 28% solution we also use ammonium sulfate and ammonium nitrate. We use much less anhydrous ammonia than we used to.

M.M. Mortlund wrote an article entitled "Reactions From Ammonia in Soils" in Advances in Agronomy. In that article he states the immediate effect of an injection of anhydrous ammonia or application of an aqueous solution of ammonia, is to create a very alkaline reaction in the vicinity of the application. He then gives several examples:

Original pH	pH After Ammonia
6.0	8.1
5.0	6.2, 7.1
4.9	6.5, 8.0
7.3	8.8, 9.5
8.1	10.1, 10.6

That article and others went on to point out that ammonia in high concentrations might be expected to affect the soil microbial population. Further, we have read articles suggesting that ammonium hydroxide, which is formed as anhydrous contacts moist soil, has a strong solvent action as well as a hydrolytic action on organic matter. Thus the application of anhydrous ammonia might be expected also to result in solubilization and the hydrolysis of certain fractions of the soil organic matter. In other words, causes them to precipitate and create some hardening in the soil.

We are spreading a great deal more lime than we used to. We like finely ground limestone. We also prefer low magnesium lime on many soils. This fine lime does create spreading problems. We have mixed the fine lime with liquid manure and water to form slurry to facilitate handling. This has worked very well. We like to apply smaller amounts, 500 to 1000 pounds of lime, on a more regular basis.

When planting row crops we like to use row support fertilizer. We also band 28% over the row as the herbicide carrier. Many of our operators are using 5-10 gallons of 28% as a herbicide carrier. As I indicated earlier, we want to cultivate all row crops so banding herbicide works well.

We also sidedress part of our fertilizer when we are cultivating. Again, we use a lot of 28% solution. We attempt to stabilize the 28% with ammonium thio-sulfate and cane molasses. This also gives us some sulfur. We also use other water-soluble dry fertilizer products in our sidedressing program if we need to add additional phosphorus or potassium.

We recommend deep ripping between rows. This is normally done when the crop is between 18-24 inches in height. This process weatherproofs our crop by aerating the soils, fracturing the hard pan and enabling the crop to access subsoil moisture. In some cases we sidedress fertilizer at this time also. When doing the deep ripping we want to be sure that we are going deep enough to fracture the hard pan, but we do not want to have so much soil disturbance that the plant rootlets are damaged. Note: This operation should not be done in a wet year.

We are using post emergence herbicides, particularly in the case of soybeans. When the post emergence herbicides can be banded as well as activated with fertilizers we find that they become very economical and effective.

In summary then, our fertilizer use practices are an attempt to spoon-feed the crop what it needs, when it needs it, as we move through the growing season. We want to be very careful to add only what the crop requires and in a form that is readily available to the crop but not harmful to the soil biological life.

REFERENCES

Albrecht, William A. The Albrecht Papers, Volume I. Kansas City, Missouri: Acres U.S.A., 1975

Beddoe, A.F. Biological Ionization as applied to Farming and Soil Management Principles and Techniques. Fort Bragg, California: Agro-Bio Systems, 1986

Bohn, Hinrich L.; McNeal, Brian L. and O'Connor, George A. Soil Chemistry. New York: John Wiley & Sons, 1979

Gardner, Walter H. How Water Moves in the Soil. Madison, Wisconsin: American Society of Agronomy, Inc., 1979

Schriefer, Donald L. From the Soil Up. Des Moines, Iowa: Wallace-Homestead Printing Co., 1984

Tompkins, Peter and Bird, Christopher. The Secret Life of Plants. New York: Harper Colophon Books, 1973

Willis, Harold. The Rest of the Story About Agriculture Today. Madison, Wisconsin: A-R Editions, Inc., 1983

