Understanding the Soil

Introduction

For thousands of years nature has provided sustenance for all living things. This rings true today with one exception! Man with his new found technology has decided that he knows more than nature and has proceeded to manage the soil with an inept idea that "what you remove, you must replace".

This thinking is not totally wrong, but how we replace it is very important! If we add to this theory that we, "man", can copy natures nutrients without considering the effect on natures undisputable laws; then we are assuming that we are as informed as nature itself.

In this information we will explore nature's fertility cycle. We can form a new view point on how we can work with the soil and accomplish a more sustainable agriculture.

Hopefully, the outcome may lead to a better understanding of the society of the soil.

The Balance Sheet

To gain a very basic understanding of the natural fertility of the soil, we must first, have a look at the generally accepted principals of fertilizer management.

Long ago, a noted German scientist named Justis Von Liebig produced the "Balance Sheet Theory". This is the notion that the soil is just a medium that, devoid of life, is merely a storage bin of water and inorganic minerals. In 1840, Von Liebig made the observation that plant growth and yields were in exact proportion to the mineral nutrients that were removed from the soil. This would lead us to believe that the solution to soil management lies in the notion that, if we replace in any form, mineral content that has been removed, we can sustain agriculture and thereby maintain soil fertility. NONSENSE.

If this principle is accepted as fact, how can we explain nature's ability to achieve growth where man is not adding his chemical fertilizer? Why do the great forests survive and flourish? How where the grasslands of the great plains maintained before man came along? Possibly nature has more ability than we are willing to give it credit for.

If this theory was relevant, the problems of soil degradation would not be a consideration today. It has been well documented in science that Von Liebeg's theory has no foundation in nature's fertility. It leaves absent the most important consideration, which are the interactions of the biological life of the soil.

In the "USDA Yearbook 1957" Von Liebig's theory was discounted as having no basis in the overall picture of soil management. It might also be noted that Von Liebig, himself, denounced the balance sheet theory before his death.

Why has science and agricultural research establishments held so tight to this principal in its recommendation to the farming industry? Could it be possible that this theory is very comfortable to the multi-national corporations involved in the manufacture of farm chemicals?

You may be sitting in a comfortable chair at this point feeling that the writer is promoting sour grapes, but please be patient. It is well documented in western society that the science of exploitation is the most finely honed, most highly financed, best researched science in the world today. Unfortunately the steward of the soil, the farmer, is the target victim. It is also well known that most research today is contingent on private funding from these major corporations. How easy it is to come to a predetermined answer to the problems in agriculture today.

We can accept these conclusions of modern research or we can open our eyes to what scientists, who, without influence of these ingrained principals of soil management have been saying for many years.

The fundamentals of soil fertility begin with the living organisms that inhabit the soil. There is far greater abundance of life within the soil, than the total of all forms of life that inhabit the surface of the earth.

Life in the Soil

The soil is a living entity containing such diverse life forms, that the study of these organisms is one of the most misunderstood sciences of the modern world.

The organisms of the soil can be compared to our society above ground, in that every form in the soils ecosystem is dependant on others for some of its needs. It therefore gains a complexity that cannot be shoved aside. Like a community with its diverse social structure, every activity must be looked on as a part of the overall system. As essential services decline so does the strength of the community. A small town with six bake shops, but no butcher nor grocer, will not survive as a community, because some essential services are lacking. Like a chain, the ecosystem of the soil, is only as strong as its weakest link. To gain a basic understanding of this complex system, we must learn a little of the organisms that make up the society of the soil.

The microorganisms that inhabit the soil fall into five basic families:

1. Bacteria
2. Algae
3. Fungi
4. Protozoa
5. Actinomycetes

In a healthy, fertile soil, billions of microorganisms may thrive in a single gram of soil. Within this fantastic society lies the key to the survival of all life that flourishes above the surface of the earth.

Of the microorganisms, bacteria make up by far the greatest numbers in the society of the soil. They are diverse in species and perform many different functions in the fertility cycle. Some are involved in fixation of nitrogen, both from the air and from the break-down of organic matter. They control the nitrogen, carbon, sulfur, and iron cycles in the soil. Bacteria are also predominate in the creation of enzymes and breakdown of mineral elements into available plant nutrients.

The actinomycetes are involved primarily in the breakdown of organic matter and produce the wonderful smell of fertile soil.

Algae flourish in high moisture conditions. The blue-green varieties are very efficient nitrogen fixers. Their valuable services diminish with drying of the soil.

Protozoa are amoeba, which consumes bacteria, thereby concentrating and passing on nutrients.

Fungi are mainly decomposers and generally able to work deeper in the soil.

Microorganisms can be either plant like or animal like in from and must compete in a struggle for survival that is ever constant in the soil.

Some microorganisms are aerobic or require air to live and use elements from the air in the production of plant nutrients. Others are anaerobic or cannot live with air and live deep in the soil and produce toxins that further breakdown organic matter and mineral into usable forms.

Microorganisms have many factors determining their numbers in the soil. The most important of these is food source. Many species rely on crop wastes and organic matter incorporated in the soil. Still others may live off the remains of other dead organisms. Hence a balance is achieved by nature in limiting excess, and one of these species becoming predominant. Modern agriculture practices of using toxic chemicals have a profound effect on this balance.

It has been previously stated that some organisms are plant like in nature. If man can kill a 24 weed spectrum with a herbicide, does it not seem fair to assume that the same chemical could have devastating effects on these tiny organisms. The other problem that arises is this: any substance polluting the soil must be cleaned up by these microorganisms. As the microbes work to breakdown toxic substances their dead bodies are being used as a food source for other organisms in the soil. These toxins can be carried right through the food chain to plants and higher animals, including man.

Other methods nature uses in controlling the numbers include the build up of excrement or by-product of that organism. Take for instance a nitrogen fixing bacteria. If quantities of nitrogen are added to the soil it gives the illusion to these species that its job is complete based on the amount of by-product in the soil. The numbers of nitrogen fixing microbes can be seriously diminished, while other microbes concerned with the breakdown of this nitrogen will flourish. We have created an imbalance that may have other repercussions. What about other organisms that may use the nitrogen fixer as a food source? It would make sense that with decline in food source these organisms will also be limited. While all this is happening, remember we have some organisms that may be dramatically increased in numbers. What happens to their dead bodies? Do we now have another group of microbes

who with an expanded food supply can increase their numbers?

Playing games with nature's undisputable laws has never proven valuable and usually leads to disaster. It would serve us well to remember the links of the chain.

The soil also contains many larger life forms that carry on in this competition for survival. They include mites, spring tails, ants, millipedes, sow bugs, rotifers, and worms to name a few. In this group is the ultimate soil engineer, the earthworm. This fantastic mobile soil factory carries out many worthy functions in the soil society.

As the earthworm burrows through the soil, it carries tons or organic matter deeper into the soil and on the return trip brings up mineral from deep in the soil. Also in its travels it consumes microorganisms and organic matter. It leaves behind castings that contain five times more nitrogen, nine times more phosphorus, nineteen time more potassium, three times more calcium, and four times more magnesium, than is present in the soil surrounding it! Along with this amazing accomplishment it also leaves microorganisms that measure in numbers approximately ten times those consumed in the process. Earthworms produce their own weight in castings each day or about ½ pound per year. An acre of fertile soil can contain as many as a million earthworms. You can do your own arithmetic on the value of these services to the farmer. Nature can be forgiving if we work within its laws. Good soil management practices can stimulate a rebirth in soil organisms very quickly if the environment is improved. The Environment of the soil has been degraded to levels that are seriously threatening the soil organisms. We must now strive to gain a new perspective in dealing with the natural fertility cycle.

The Natural Fertility Cycle

To gain a new perspective on soil management we must now learn a little of how nature's system works. Although natures method of building nutrients in the soil is very complex, we will try to produce an overview in understandable terms.

The breakdown of organic matter follows a complex pattern, with teeming legions of microbes, each fulfilling its own specific role. In the first stages of this cycle, called putrefaction, toxins are produced which are harmful to soil organisms and may retard plant growth. With the presence of oxygen, moisture and proper temperature this portion of the breakdown will be completed in about two weeks. If there is a lack of oxygen, due to poor soil structure this period may be lengthened. This could result in contamination of the soil by toxins such as formaldehyde, hydrogen sulfide and methane. This contamination can also occur if organic matter is incorporated too deeply into the soil. Once putrefaction is complete the decomposition stage begins. Here many organisms thrive in the struggle for life. Organisms are consuming organic matter that is digested and transformed to available plant food.

It is after this stage that the organic residues are collected in water, along with amino acids and salts of humic acid to form soil plasma. Soil plasma is a jelly like substance that coats soil particles and clay crystals to form the clay humus complex, or stable humus. The formation of stable humus is probably the single most important event in creating good soil fertility. Literally all natures' organisms must play their part in the cycle to achieve this miracle. Once stable humus is formed it becomes an efficient warehouse for plant nutrients.

The sticky humus along with poly saccharides, which are complex sugars from excrement of microorganisms, bind particles together in clusters or aggregates. It is these aggregates that give fertile soil its crumb like structure or tilth, as well as porosity.

Aggregate structures due to irregular shape of the soil particles, provide a large surface area for the soil solution to absorb or cling to.

The soil solution or liquid portion of the soil is made up of water and nutrients. This solution provides the microorganisms with an ideal habitat. Good soil structure can assure us of an increased population of these little farm hands.

Good soil structure provides us with many benefits. Due to its aggregate, or crumb like structure, it provides increased porosity. This porosity allows much greater moisture retention as well as allowing life giving oxygen penetration to greater depths. It also provides protection against erosion by both wind and water.

Nutrients and Plants

We should note at this time the various ways in which plants receive nutrition.

Minerals are held in the soil in the form of crystal lattice ions. These ions become available in nature at a continuous, but very slow, rate by weathering or biological release. Weathered ions become free ions and are stored in the soil solution. By being part of the liquid portion of the soil, they are prone to loss by leaching. Biologically

released ion's become swarm ion's and are attracted to stable humus. They are stored there and become readily available to the plant on command.

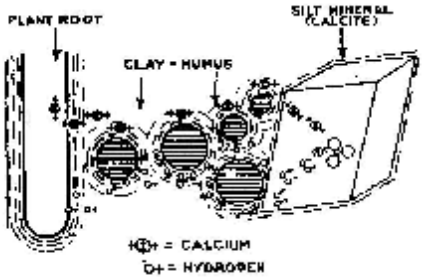
Chemical fertilizer advocates believe, for the fertilizer to be efficient it must be in a soluble form. With excessive use of salts this solubility is achieved. When in the soil solution, the mineral nutrients are in the form of free ion's. The plant then must take up water from the soil to receive nutrients. The nutrient balance for the plant is controlled by the type and amount of nutrient supplied in the fertilizer added. The plant in search of nutrients will absorb extra quantities of water in search of minerals that are not available.

Nutrients in the form of swarm ions are readily available to the plant on an exchange basis. Only the mineral desired by the plant is exchanged and thus the balance is held in the humus for future use. In this exchange system the plant use's water only for cooling and to carry out its biological functions. The plant root releases a hydrogen ion to the clay humus colloid, which in turn releases a mineral ion to the plant. The colloid then releases the hydrogen ion, which is acid in nature, to the mineral crystal lattice where through biological interaction the hydrogen or acid is used to release mineral ion to the colloid. This is commonly called the cation exchange. Some nutrients in the form of free ions are taken up by the plant in the soil solution, but these are not the key nutrients required for the process of photosynthesis.

With the biological actions happening steadily in the soil, addition of unwanted mineral can cause an imbalance between swarm ion's and free ions. Through the demand selection of nutrients by the plant, it receives elements in a balance formula, which combined with amino acids and enzymes trigger the mechanical and biological function within the plant cells. Only in this manner can the plant synthesize the full balance of nutrition in its cells. It would pay to remember that plants receive approximately 85% to 95% of its required nutrients from the atmosphere. This is accomplished through biological interactions such as photosynthesis.

Excessive use of salt based soluble fertilizers can severely inhibit these natural processes.

Microbial activity can be severely diminished also, as nature has built in checks to assure the balance of nutrients in the soil.



Plant nutrients, like calcium, on the colloidal clay or humus are exchanged to the plant root for the hydrogen or acidity it offers. As the colloid takes on more acidity this goes to breakdown the minerals and restock the colloid. Acidity goes from the roots to the minerals; nutrients go from mineral to the roots, all through the colloid.

Breaking Down the Structure

Soil degradation began with our ancestors, who unknowingly started the process as soon as they broke the virgin sod with the plow.

We have learned that the microbes are both aerobic and anaerobic. The action of the plow was to turn the soil over, placing the air breathing-microbes down deeper where there is not enough air, and the microbes that can not live in the presence of air up on the top, where they too will perish. This action also placed the majority of the organic materials too low in the soil to aid the fertility cycle.

If this was not enough, they cut their crops and carried them to a central spot to be threshed, cheating the microbes out of the next year's food supplies. Then after having what straw they needed for their farm animals, they cleaned up the fields by burning the straw stacks and the stubble. Soon they found they could not continuous crop the soil and started the practice of summer fallow. Now they could produce a fairly decent crop every other year. During the fallow year the farmer used extensive cultivation to keep the land black.

If you absorbed a good portion of the earlier chapters, you can see the pattern forming that is leading to our soil problems of today. Hold on we've just begun. Now we have our friendly soil microbes living off a minimum of food every other year. We can now add to this the over-cultivation that is threatening our tilth and of course destroying the

habitat of the microbes.

As the soil degraded, the life building humus was depleted, causing decreased yields and the breakdown of quality in our produce. Something had to be done! Man in his infinite wisdom, backed up by principles like "The Balance Sheet" theory, started the practice of chemical fertilization. The results were amazing and the farmer entered into an era of prosperity that may never be equaled. Fertilizer was inexpensive and reasonably easy to use. The practice lead to increased yields and the belief that more is better.

Some fertilizers have a very damaging effect on the soil and its microbial population. We will explore one such product on these pages. It is not the intention to single out one product, but in the search for information we must.

Anhydrous ammonia being a major source of nitrogen fertilizer, is one most biological enthusiasts find most harmful to a healthy soil eco-system. Anhydrous was used extensively in World War II, as a method of making soil hard for airplane runways. This was accomplished by the breakdown of the soil structure. Any ammonia type fertilizer added to soil has the devastating effect of dissolving the stable humus and placing it in the liquid portion of the soil. This places excess amounts of nutrients in the soil solution, thereby giving the anhydrous a false valuation as a fertilizer. Add to this the tremendous numbers of free hydrogen ions and you have a hydration process much similar to that in concrete. Fields with long anhydrous use become very hard and compact with very poor moisture retention. This brings on a hydroponics situation where the soil is merely a medium to hold the artificial nutrients plus the seed. Other chemical fertilizers are just as limiting on natures cycle.

As we progressed into chemical agriculture, we noticed that pest problems were becoming more prevalent. The solution seemed easy. All the farmer had to do was spray on some pesticide and his fields were clean. We have now reached the point where with the breakdown of the soil structure, the loss of porosity causes anaerobic soil conditions.

Anaerobic soil conditions occur when the life giving oxygen cannot penetrate the soil. Such conditions are evidence of increasing salinity areas, hard pan conditions, and soil that has seemingly lost its fertility. When the aerobic microbes cannot survive, the breakdown of organic matter must all be achieved without the aid of oxygen. Also the final breakdown and passing on of nutrients to plants cannot be achieved.

This has lead the modern farmer into a no win situation where his input costs are surpassing his potential earnings from his crops. He will need to try and start treating the cause of the problem rather than using a band aid approach. His thinking must go beyond the next crop and into the next generations' crops. Unfortunately he is not receiving much help from modern research. These research facilities, fueled by major corporations with vested interest, seem to be working the problem backwards, which is paying them quite handsomely. They keep developing newer and more efficient chemicals and chemical resistant strains of crops to deal with the degrading conditions. Why are we not trying to correct the causes of our problems instead of just dealing with the results?

While this practice carries on, the farmer meanwhile is looked on by the rest of society as a crier and wanton polluter of our environment. These wonderful new pollutants that are developed by research become the ultimate responsibility of the farmer. The absurdity of the whole situation is the North American farmer pays billions of dollars a year to lead further degradation.

Pests & Weeds

It has been well documented in science that pests attack the weak in natures plan for perfection. This constitutes the law of natural selection or survival of the fittest. As the wolf or lion in the wild selects the sick and crippled animal, so does the insect select the unhealthy plant. This theory also holds true for weeds. As our soil degrades, nature provides us with a warning, like a flagman on the highway, that something is wrong. When the natural fertility declines leaving an imbalance in the soil, nature brings forth weeds to try and bring the balance back. This is accomplished through the ability of certain weeds to flourish in deficient conditions. Weeds are great transportation systems of soil nutrients, long tap roots reach to the subsoil seeking needed minerals. When the weed dies and is incorporated into the soil it carries the nutrient into the ecosystem.

Farmers who have adopted natural systems of soil management have found that weed and insect problems decrease to negligible levels as the soil balances itself.

Rebuilding the Structure

Now that the farmer is caught up in an ever tightening spiral of soil degradation and increased input costs, how can he step out into a more sustainable system of agriculture? He will need to reshape his thinking and attune himself with nature and ask the question; what would nature do here? Man will never better nature as he is part of nature himself. We need to be in balance with nature in all facets of industry not just agriculture.

Hundreds of farmers, farming millions of acres around the world have found such a system. Some call it biological farming, others biodynamic farming. What ever the label, it is working for those who have adopted a more natural method of soil management.

Previously we have looked at the causes of our problems, now let's look at some solutions. Some farmers may use various techniques but most programs are very similar.

The first requirement is an analysis of the problem on each individual field. The major concern in rebuilding the soil is the percentage of organic matter contained in the soil. If the organic levels are from 1-3 percent, some measure must be taken to replenish the level. Incorporation of manure or other organic wastes are one way of achieving this. If this material is not available it may be necessary to grow a green manure crop. If you are summer fallowing this can be accomplished on the fallow year. If continuous cropping, it can be achieved by planting and harvesting an early crop for feed, and then planting a fast growing crop such as German oil radish. Good green manure crops include: sweet clover, lupines, sorghum-sudan grass or rye. The establishment of increased organic matter is of the greatest importance as it is an absolute requirement for building stable humus.

A gradual reduction of fertilizer and herbicide usage is best as soils that have become accustomed to chemicals, will not produce an acceptable crop if eliminated altogether right away. As each crop year goes by you should be able to incrementally reduce fertilizer and chemical sprays.

Start planting your crops with the use of microbial soil inoculants to insure that microbial populations can reach levels that will carry out the necessary functions in the fertility cycle. The application of a good quality carbon high in nutrients, minerals, trace elements and humic and fulvic acids as a good source of both organic matter and a means to boost the rebuilding process of humus.

A simple and inexpensive bio-augmentation will get your soil on the road to recovery much quicker. Biological farming has been and continues to be developed by farmers and private researchers in pursuit of a more responsible approach to sustainable agriculture. The closer we work with nature and within nature's laws, the easier and more profitable it becomes.