*Let's Live Magazine, January, 1958*

# Silt Loams--Nutritional Blessing of the Winds

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Any single positive answer to the question "What texture of soil is preferred?" may well be adroitly avoided until we appreciate what else may be hidden by, and associated with, that physical property. It is, nevertheless, significant to note that on the silt loams, or soils of medium texture, in the mid-continent of the United States, there is the highest percentage of the land in farms.

The wheat belt of the United States is covered with silt soils. Prairies and plains in the southern hemisphere are also of medium texture, or silt loams. It was over soils of this physical makeup that the American bison roamed. It is on soils of this texture that we grow most of our beef cattle, sheep, pigs and, not so long ago, many fine horses. It is on the silt loams that the grasses established their reputation, not only as cover against erosion by water and wind but also as the nutritious feed for growing animal muscle, for protecting animals from diseases, and for encouraging fecund reproduction.

**Soil suitability**

Soil texture determines the soil's suitability for such matters as ease of tillage, intake of water, aeration, drainage and others connected readily with physical forces. But there is much in soil texture reflecting the experience of the minerals on developing into soils under the climatic forces and consequent chemical activities. These forces include total rainfall, temperature, winds and other meteorological vagaries by which the silt loams, for example, became the surface soils over extensive areas in certain climatic settings.

It is not so much by texture, as by highly-mixed, less-weathered and much-diversified mineral contents transported from less humid to more humid areas, that the silt loams of our mid-continent have been of high nutritional value in our fields and gardens for our animals and ourselves.

Silt loams are usually deposits by the wind. Consequently, to be picked up by the air currents the mineral particles must be small; they are also separated from other particles, and must therefore come from a region of low rainfall. Little clay has been developed at their point of wind pick-up, otherwise the mineral particles would be collected into granules too large to be wind-borne.

## Wind processes

On drier areas with hot days and cool nights the wind currents are apt to be stronger and pick up particles too large to be carried when the currents slow down. By picking up and dropping fine mineral particles, the wind is a winnowing process which is carrying and segregating the minerals from our drier West to the less arid or more humid mid-continent. Silts are, therefore, on an eastward march in dust storms and are not viewed as a blessing because they rob the West of fertility-rich silt to scatter it over the semi-humid mid-continent.

The flood plains of the Missouri River, especially along its eastern quarter or more, represent fresh western materials from which fertility-laden silt can be winnowed out, carried away by the southwesterly winds, and deposited over Iowa, Northern Missouri, Illinois and adjoining states. Deep deposits of loess along the bluffs of the Missouri River testify to such origin. Flood plains of the Mississippi River serve similarly.

Experimental dust collections and study in the line of the prevailing winds to the northeast of the Missouri River for more than 15 years have shown the annual deposits to range from 750 to 1000 pounds per acre. One single dust storm in April, 1936 deposited the larger amount in 24 hours.

The mineral contents of these carefully examined deposits were commonly about 40 percent other-than-quartz to suggest that they had undergone little decomposition. They were a natural deposit of reserve mineral fertility to contribute to nature's way of fertilizing the soil. Nature applies pulverized mineral fertilizers but not soluble salt treatments.

## Weathering forces

Such a natural procedure deposits the reserve fertility on the soil's surface, where the weathering forces of solution, oxidation and carbonation are most active in readily mobilizing the essential nutrient elements out of the rock fragments of silt-size. Those weathering forces are more active than one commonly appreciates. They are what restores the productivity while there are no crops growing or while "the soil is resting," as we say. If a soil has ample clay from which the exchangeable or active nutrients have been exhausted by cultivation through the time of the plant's exchange of hydrogen or acidity to the clay, then the added silt minerals can be broken down by the acidity of the clay which serves as the agency for their decomposition. Resting a soil will restore productivity only when the silt is made up of undecomposed minerals, or those just recently added and undecomposed.

## A good question

If, therefore, silts coming from the original magmatic granite of the arid West are nature's windblown fertilizer on the more humid soils farther east, we may well raise the question as to whether or not we might wisely apply granite dust on our soils as reserve fertility or minerals to be mobilized by the acidity of our soils? This would seem a very appropriate question for garden soils or others intensively cultivated and maintained at high levels of decaying organic matter.

Not because of texture only, but because of their contents of rapidly weathering mixtures of minerals carrying all nutrient essentials, the silt loam soils are much preferred where the crops produced are to be of high nutritional value. Our gardens dare scarcely be other than that. They are a blessing if they are made up not only of the texture so favorable in the soil's physical properties but also in its fertility or creative properties for living things as well.

**(Clay, the Soil's Jobber of "Active" Elements,
will appear in the February issue.)**

*Let's Live Magazine, February, 1958*

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# What Texture of Soil is Preferred?

## II.Clay--the Soil's Jobber

**by William A. Albrecht, A.B., B.S., M.S., Ph.D.**
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Clay is apt to be considered the "dirt" of the soil. Clay is sticky when wet. It is also plastic and easily molded. Then, too, it can be slippery, as one knows whose car has gone off the pavement and into the muddy shoulder where the wheels find little traction.

Such an indictment of soil, as "dirt" or "mud," emphasizes the properties by which it soils the hands, or clothes, or the car. But while these features may seem derogatory in casual thinking, they are the very properties by which the soil holds water and fertility elements as drink and nourishment, for the growth of plants and thereby for our nutrition.

### A "colloid"

Since clay is a mineral of such extremely small particle size, to make it behave according to the surface of the mass rather than its weight (2.65 times as heavy as the water is displaces), it is called a "colloid." That word means "glue-like." Clay is sticky when wet but hard--almost like cement--when dried, hence the propriety of the term.

The behavior of holding water strongly enough for a slowly drying process gives clay a big value in holding a very thin film of water between the plant root and the clay particles of the soil around it. It is within that very limited thickness of a water film around the clay particle that the clay gives its important services as the adsorber or "taker-on" of nutrient elements, should they come along in solution from decaying substances, rock particle decomposition, or from applied fertilizers. It is, then, from that thin film, holding nutrients against loss to the leaching rainfall, that the clay is the exchanger or "giver-up" of nutrients. They are taken from there, however, by the plant root only as it exchanges for them correspondingly "active" elements in the form of their ions, most commonly the non-nutrient hydrogen or acidity. Because of the clay's immense surface in its finely divided, plate-like particles, it is an adsorber and exchanger--a jobber, not a manufacturer--of ionically active elements coming out of rock minerals as recombinable parts so separated and activated in the presence of water.

### Do not filter

While the two soil separates, namely, sand and silt, do not soil our hands and are not commonly considered "mud" or "dirt," they do not have the significant capacity to filter out, or to absorb, nutrient elements from solutions of them. Solutions applied on sands are apt to leach away to the sea. Sand and silt soils are more quickly responsive to fertilizer treatments, as shown by the plant growth. However, the fertilizer effects don't carry over into the following years.

Clay soils do not give response to fertilizer applications so pronouncedly by marked crop manifestations. But on these the salt danger from fertilizers is not so serious. Nor is salt damage so severe. Some of the active fertilizers may become "fixed." That means that some element may be held by the clay so firmly that the crop manifests no growth response therefrom. It is these speedy and pronounced performances that mark out the clay for (a) holding the solubles on itself in adsorbed-exchangeable form against loss of percolating water; and (b) for giving them up when some active soluble from the root or otherwise is exchanged for them. In these respects, the clay is the textural separate of the soil serving as the jobber of essentials plant nutrients in their active forms.

When the nutrient elements are first broken out of the rock while it is being weathered into soil, the clay, as a secondary mineral, is forming from the less soluble rock remnants, and immediately enshrouds even the smallest decomposing rock particle as a coating. This clay cover modifies the behavior of the remaining rock components in their further decomposition and development into soil.

## Rates of weathering

The differing rates of the weathering of the rock-minerals, or of the development of soils from them, under different climatic forces, means different properties of the resulting clay. Under higher temperatures and higher rainfalls, it may have proportionately less silica. It will have correspondingly more oxides of iron and aluminum in its own chemical-mineral structure. This gives it less adsorbing-exchanging capacity. It will hold less "available" nutrients for crops. It won't hold as much acidity either, consequently it does less business as a "jobber."

It was the refined study of soil acidity under research some 20 and more years ago that revealed these basic facts about the clay as the result from rock weathering, and its role in plant nutrition. Now that we have learned that a certain clay developed in a certain climatic setting has its own particular capacity of nutrient adsorption and exchange per unit weight, we can measure the soil's fertility capacity for different ions. Since these are represented mainly by the positively charged nutrients, namely, calcium, magnesium, and potassium (filling almost 90 percent of the clay's capacity together in the approximate ratios of 75, 10 and five percent respectively) in a productive soil, then when once the soil becomes highly loaded (over 10 percent) with the non-nutrient hydrogen so as to be called an "acid" soil, we know that the trouble may not be due so much to the presence of the hydrogen in the jobber's adsorbed stock of ions as to the shortage there in what would be these other positively charged ions serving as active and available plant nutrients coming from that source.

In getting a soil ready for the planting, its higher content of clay may delay the crop season while waiting for the soil to dry. The clay may make it work up in big lumps, or give hard dry clods calling for more work before getting into seedbed condition. There may be other labor aggravations because of the clay in the soil. But when one comprehends what clay will do in a nutritional way for plants as a jobber of active essentials, if we will do our part, we shall not be troubled by the small aggravations of extra work which a clayey soil requires.

### Keep supplied

But we must keep the soil supplied with unweathered minerals like limestone or gypsum containing calcium, or with those containing magnesium, like dolomite; or those carrying phosphorus, like natural rock or colloidal phosphate, or the whole host of compounded elements in pulverized granites and other rocks.

Instead of being bothered by such details, we will do all the more to manage the soil for the best use of the high value the clay colloid has as the jobber or the promoter of most all that is concerned in making the inactive rock minerals become the active or available nutrients for nutritional crops in the field or garden.

**("Water, the Major Mineral in Sail for Nutrition,"**
**will appear in the March issue.)**

*Let's Live Magazine, March, 1958*

# Water--Major Mineral of Soil Nutrition

**by William A. Albrecht, A.B., B.S., M.S., Ph.D.**
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We have not commonly considered water as the major mineral of the earth's surface. In its service to man and animals we have not listed it as the one mineral among the others, which breaks them down physically and chemically, and takes them to itself in suspension and solution. This is done first on land and then in the sea. Within the soil and among the three inorganic soil separates of sand, silt and clay, water may well be viewed as the fourth soil separate. It is the most finely divided one, even of molecular and ionic dimensions.

## Unique

It is in its three forms of solid, liquid and gas (all possible within the temperature range of 100° Centigrade), that water is unique. It is the most active mineral in making the other minerals--including rocks as combinations of them--dynamic in the soil while they are enroute to the sea. It is true, then, that water is the major mineral of soil.

Since water is a liquid mineral at ordinary comfortable temperatures, it is the medium within and by which the many solid mineral compounds are decomposed. The action of water sets their inorganic elements free. Water puts them on their own activity for chemical combinations with others, both organic and inorganic. The magnetic minerals of the earth originally contained no nitrogen and no carbon. They had none of these two elements by which the organic, or living matter, is distinguished from the inorganic, or dead. These two organic requisites had to be taken from the atmosphere initially to be put into the soil. Water serves in reducing rocks to sand, silt, and clay, to the dust into which the moist breath of creation, containing carbon and nitrogen, is blown when that process occurs.

## Helps decomposition

Regions of rainfall, ample in both total per year and favorable distribution through the warmer, growing season, are in that favorable category because water serves to hasten sufficient rock decomposition to give the change of reserve minerals into colloidal clay; to give soluble elements at the same time which may be adsorbed on and held by the clay-organo-colloid. It also passes these elements by exchange to the plant roots for their acidity or hydrogen in the enshrouding carbonic acid from their respiratory carbon waste.

More than two-thirds of our crop production still comes from this development of soil more than it comes from the chemical fertilizers we apply for the bigger crop yields. Water in any climate favorable for agricultural production is making it favorable more because the water is serving as a chemical reagent than it is in providing crops with drink and cooling waters in the plant's stream of transpiration.

When we think of water taken from the soil by crops, we are prone to emphasize its movement from the soil into the plants and its evaporation, or transpiration, from the surface of the leaves. Also, so much is said about needing the "available" inorganic nutrient elements from the soil, one is often led to believe that these essentials are all in solution in the soil water. So, since water moves from the soil into the roots and up to the leaves to be evaporated there, we are apt to infer that the flow of water must occur to bring the fertility elements from the soil into the plant and to deposit them through evaporation of the soil.

## Facts

The facts are quite the opposite. Nutrient elements, move from the soil into the plant root because of, first, their concentrations and ionic activities in the moisture film on the soil, and second, because of the nature of the cell wall of the root hair, coupled with the metabolic behavior of the contents of that cell and the many others connected with it.

These migrations of the fertility essentials from the soil into the plant are governed by the soil's store of them and the plants physiological processes of moving them from the root hair into other plant parts. Evaporation of water at the leaf surface is not the cause of movement of "available" nutrients from the soil into the crop. The flows of plant water and of nutrients are in separate streams, independent of each other.

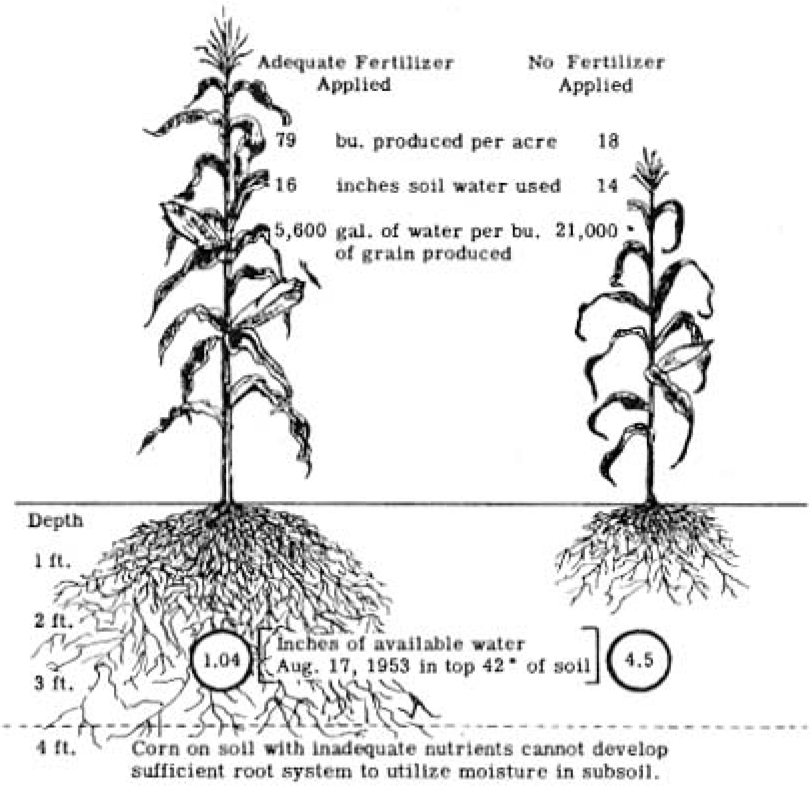
## Examples

That the water of transpiration flows independently of the nutrients may be easily demonstrated. A potted plant in the sunlight under a sealed glass bell-jar, containing carbon dioxide in an atmosphere saturated with water vapor, will grow nicely by taking nutrients from the soil without taking water by transpiration. Plants on infertile soils, especially those deficient in calcium, will transpire water from the soil and grow with an increase in bulk, but will give nutrient movement back from the planted seed supply to the soil.

In demonstrating the first of these illustrations, the transpiration stream was stopped, but yet the stream of nutrients flowed on from the soil into the plants to keep them growing. In the second illustration the transpiration stream flowed on as usual, but the nutrient stream reversed its course and moved in the direction opposite that of the flow of water. These are facts enough to prove that the transpiration of water from the leaves does not carry the nutrient elements from the soil into the plant.

## Air conditioner

Transpiration of water obeys the conditions of the atmosphere inviting the evaporation against the forces within the soil. Such evaporation serves as a kind of air conditioner to hold down the plant's temperature. It also maintains the moisture in the plant as a medium in which the inorganic elements may be ionized and chemically active. But the flow of water through the plant in the transpiration stream of this liquid mineral is not the cause of flow of the fertility elements into the plant. The flow of these for plant nutrition is quite independent of that of water going in the same direction. Here water as a mineral does not--by its physical behavior as flow--influence the other minerals to behave likewise. But by its presence as the medium it sets the stage for the elements separated from their mineral compounds to be active in plant nutrition.




NEEDS HELP . . . Water as a major mineral serves more efficiently in crop production when the other soil minerals supply ample of active fertility.

When we define soil as a mixture of inorganic matter resulting from the disintegration and decomposition of rocks and their component minerals, we fail to include water as a major mineral. Perhaps its liquid nature and its quiet behavior make its services so unnoticed that we take its presence for granted. However, as the pressure of population for production of more crops increases as the regularly stored supply of water in the soil decreases, we shall gradually recognize water as the major mineral of the soil for our nutrition and survival.

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# Water--Nature's Major Biochemical Reagent

**by William A. Albrecht, A.B., B.S., M.S., Ph.D.**
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We commonly take for granted the water we need since so many of us live in the humid soil regions. Those are areas where the rainfall (inches per year) exceeds the evaporation from a free-water surface (measured similarly). We may use water for irrigating plants in the garden or field, but for most of the agricultural crops of our country we depend on natural water in rainfall. We think of the mass of water as so many gallons or acre-inches, and of its physical properties related to temperature. We do not recognize its extensive and vital significance as a biochemical reagent in the growing garden and field plants and in all living warmblooded bodies.

**Major mineral**

Water is the first major mineral which our plants take from the soil. It is combined chemically with the atmosphere's supply of carbon dioxide. The process gives the major synthetic product of plant growth, the sugars and the initial process for conversion into other products. Sugars, and several organic compounds chemically similar to them, are called carbohydrates. This means carbon plus hydrate, or water. These two are combined in equal ratio. The carbohydrate compounds lose water when heated. Heated sugar first becomes carmelized. With more heating it becomes black carbon. On final burning in the air this abundant organic element gives off a large amount of heat. This makes the sugars the major energy-giving compounds in the plant's biochemical processes, just as sugars, starches and carbohydrates are the major energy-foods for our animals and ourselves. They represent the sun's chemically stored energy to be digested and released within the plant tissues (similarly in our bodies) when oxidized or burned in the plant's biosynthetic processes, or those carried out by life for its own maintenance.

Water combines with carbon dioxide at the ratio of six molecules of each. This gives a simple sugar when the leaf carries on its photosynthesis under the energy supplied by the sun and the catalytic help of chlorophyl.

**Amount necessary**

Our emphasis on the amount of water required to grow crops is a natural emphasis, when plants pile up their carbohydrates so rapidly as increase of bulk. In using irrigation, we choose to grow those crops composed mainly of sugars, much vegetative bulk and watery or juicy contents. For it is only by marketing such quickly produced and highly carbohydrate products that the requisite larger monetary returns, by sale of the costly irrigation water, can be realized.

Other elements of mineral origin are usually not so plentiful, nor so active and well-balanced in the partially developed, often sandy soils. In such soil regions, the water is the major biochemical reagent in food synthesis, and the food products are mainly sunshine, air and water, or energy foods. The bio-synthetic performances by plants of converting the carbohydrates into proteins are not so prominent under naturally arid conditions, or on those soils given only water as soil treatment by irrigation.

## Fats

Fats in the seed or plant, as stored energy, are also made by chemical reduction of sugars. Fats are digested in the plant's use of them by processes (as in our bodies) in which the water, a mineral, is again the major biochemical reagent. We have not emphasized water enough in its biochemical importance to realize that this liquid mineral is the major reagent in organic and living processes, much as it is the major mineral among the other minerals contributing to nutrition (via the soil) of plants that synthesize energy foods for their own growth and the growth of all else that is nourished by them.

## Facts to remember

When we see water doing so much to give large crop yields of energy foods we need to remind ourselves that even energy foods from photosynthesis cannot be produced except by the living substances, namely proteins. And we must remember that proteins are not synthesized directly by the sun's energy, but by life processes requiring sugars for energy and for starting compounds, not forgetting all the soil fertility originating in minerals other than water. While photosynthesis may be using sunlight with an efficiency of 30 percent in piling up carbohydrates as bulk and energy values, the biosynthesis of proteins as living substances represents the use of sunlight with an efficiency of only three percent. The plant, much like an older, fattening animal, gains weight rapidly by piling up stored energy in the carbohydrates, but its protein production is slow, like a young animal growing muscle and living tissue.

## Plants and sunlight

Plants combine the simpler elements into compounds by using the sunlight. Plants alone are unique in this respect. By it they make energy food and protein food values on which man and animals are dependent. Microbes are also dependent on the plants for carbon or energy food values. By decomposition of organic matter for energy, the soil microbes again use water as a soil mineral to decompose plant remains. Thus they set free carbon and all the other elements to let them make another cycle of service in growth and decay again. For this service, water as a mineral again plays the role of hydrolysis, etc., in the biochemistry of microbes as it does in other life forms. Carbon released as carbon dioxide by microbes is then united with water to make carbonic acid, nature's most universal acid for decomposing rocks and their constituent minerals for plant nutrition.

In the soil, water is the mineral giving major chemical and biochemical services, seemingly unheralded and unsung. Perhaps a better understanding of water will do much to help us manage soil for the production of crops to better advantage of these in our own nutrition.


MINERALS FAILING . . . Yields of continuous wheat cropping go up and down in alternate years, demonstrating that soil minerals other than water are failing in their supplies and activities. Productivity in the last 32 of 68 years is determined by soil minerals other than water.

*Let's Live Magazine, May, 1958*

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# Cows Know Nutrition

**by William A. Albrecht, A.B., B.S., M.S., Ph.D.**
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Wild animals evidently know their own proper nutrition for good health. They are not reported as exterminated by epidemics, though their numbers may be reduced by disease. Domestic animals also tell us of their wisdom in nutrition when they break through the fence to go from the time-worn farm soil to virgin territory on the highway or the railroad right-of-way.

They will also leave the feed in one manger or rack for another, choosing the one of potentially higher nutritive value. They will select the better treatment or medicine from among several for an ailment, a dysfunction, or a deficiency, even to improving on the advice of the veterinarian, if we cooperate in their making of such decisions.

**A fact**

That such seemingly uncanny behavior is a fact has been reported by Mr. E. M. Poirot of Golden City, Mo., a farmer-naturalist whose keen observations and logical thinking about animals make him emphasize agriculture as a biological performance first, and an economic one as a sequel.

In the dry season of 1955, when grass in his virgin prairie pasture was offering no verdure in early August, there was a serious and sudden outbreak of typical "pinkeye" (infectious ophthalmia). This affliction of watery, pink, and seriously irritated eyeballs occurred in about half the herd of 300 Holsteins. It showed no discrimination as to the animal's condition, age, or sex, except that the suckling calves seemed to be immune. Under the drought, and the animal impatience with flies and heat, naturally the irritation from dust, the possible injury from crowding under shade, and the customarily suspected infections would be called to mind first in the diagnosis.

**A different way**

Such was the thought-path followed by the veterinarian who recommended the treatment of each eye with terramycin. But it was not the path of thought taken by Mr. Poirot. He recognized quickly all the hazards of handling so many animals in the roundup, in putting them through the chutes, and in tying and treating each with the antibiotic, especially in the heat of summer.

He reviewed his knowledge, accumulated in the past 35 years, of both wild and domestic animals and recalled the adage, "To be well fed is to be healthy." He set up, as a postulate for test, the converse: An affliction like pinkeye might well be a case of nutritional deficiency, especially of trace elements of the soil, even if only an indirect effect.

Approximately 35 years ago Mr. Poirot had undergone the struggle of dosing the animals and had borne the losses of eyes and animals in spite of professional help, which included vaccines made from cultures from the infection in the animals' eyes. Five years later he had carried out his own homespun research with lumpy jaw (Actinomycosis, reported to be caused by Actinomyces bovis) and discovered that it was prevented and cured by providing the cattle with compounds of the trace element iodine mixed in their salt. He has been using this preventive and cure ever since. He deems it necessary because his soils are seriously deficient in both the major and trace elements of fertility, which may cause important changes in the crops they produce.

**Experiment**

About 20 years ago the use of copper sulfate for internal parasites provoked the question, "When internal parasites are not killed, but are driven out alive by such dosage, might not the real cause of their extended stay in the alimentary tract be connected with deficiency of copper as nutrition?" As a result, the feeding of copper sulfate, when there was no verdant feed, had been his regular practice until about 10 years ago when the copper, at the rate of 10 parts, was combined with one part of cobalt, with some added iron compound. All was combined with ordinary salt.

Long before the concern about the deficiency of trace elements in his soil, Mr. Poirot had discovered the lack of calcium, magnesium, and phosphorus in the grass and soil of his virgin prairie. His cattle selected one of four hay stacks from which to feed. About one-sixth of the hay came from an area given calcium and phosphorus as soil treatment eight years before. Since observing the cattle's choice Mr. Poirot has kept calcium and phosphorus in salt form where the animals could get it, with steamed bone meal as a separate offering along with ordinary salt for its sodium and chlorine.

It was these past experiences which led him to set up the most recent exhibition of cows as diagnosticians when they demonstrated again this winter that pinkeye is not of infectious origin (though the eyes are infected), but has its origin--on his farm--in deficiencies of possibly one or all of the three elements, cobalt, copper and iron.

A severe outbreak in the dry summer of 1955 reminded him that he had not been offering the cattle this trace element mixture. Upon putting it out for them again the trouble was cleared up in a little more than two weeks. Then, after another period of no feeding of these elements the reappearance of the affliction suggested separation of the different trace and major elements a bit farther in the animals' discriminations.

**Cattle's choice**

Bone meal, mono-calcium phosphate, tri-phosphate of magnesium, muriate of potash, ordinary salt, and a mixture of copper, cobalt, iron and salt represented the separate offerings. The cattle chose the cobalt-copper-iron-salt mixture and the bone meal, preferring these to the other forms of phosphates and of salt. The cows were correct in their diagnosis and prescription, since again the pinkeye disappeared with no loss of either eyes or animals.

Cattle can teach us, if we will let them, that they can diagnose, prevent and cure their dysfunctions caused by the deficiencies which we so readily label "disease."

And very slowly do we seem to realize that nutrition is dependent, via the inorganic elements, on the soil that grows the organic combinations which we use as food and feed. By this implication our gardens should have first consideration as the home source of health because of nature's help in providing good nutrition.

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# Soil Organic Matter--
## Builder of Climax Crops

**by William A. Albrecht, A.B., B.S., MS., Ph.D.**
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Soil organic matter, along with the mineral content in sand, silt, clay and water, has much to do with which particular texture of soil will be preferred for a certain phase of gardening or field crops. Discussion has been previously presented to emphasize the differences in the soil's nutritional services to plants because of differences in soil's mineral texture.

### Soils differ

When a soil is sandy it is made up of more than half sand. The same figure holds for silt if it is a silty soil. But the soil takes on decidedly clay properties when no more than 20 percent is made of that extremely fine separate. When it comes to organic matter, the soil is improved decidedly in its nutritional services to plants and microbes when the two preceding figures are interchanged and represent the organic fraction. It would be a great blessing to all nutrition, that is, microbes, plants, animals, and man, if all our soil could contain five percent organic matter. In Missouri the average figure of this component for all soils is as low as nearly two percent.

### Need for minerals

Productive soils must have minerals, that is, rocks as aggregates of minerals, decomposing or separating their inorganic compounds and setting free the elements of these compounds. These elements must go into action, some into solution, and some adsorbed in the clay, to move their own energy so they may be taken up by the plant root. If soils are to be productive they must be more than a pile of pulverized rock with water poured over it. They must have some organic matter. This must support the microbes. The soil must be a truly living soil.

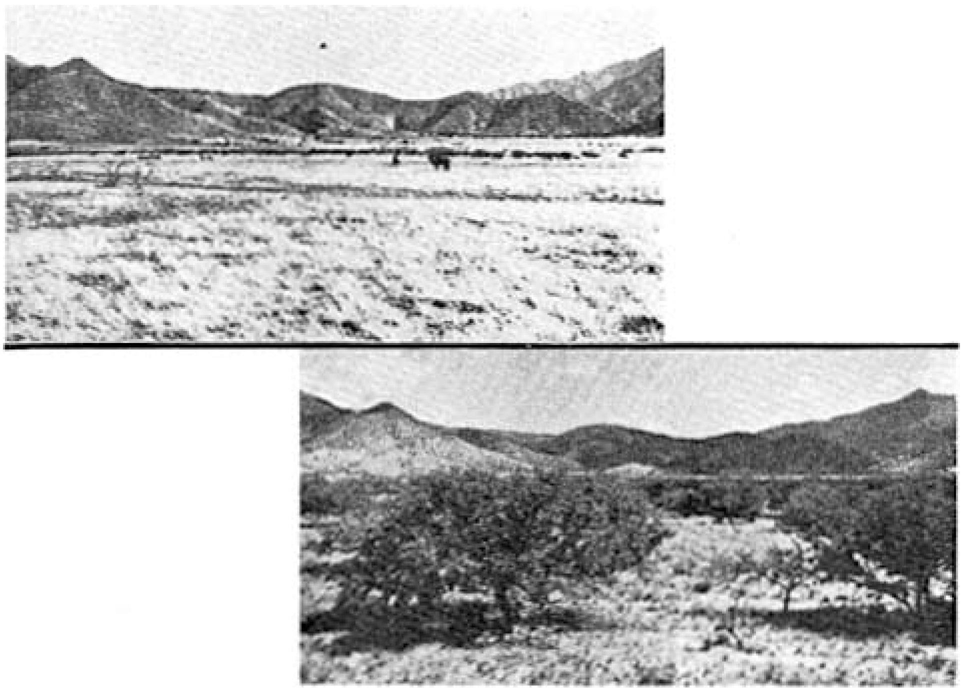
Even when nature starts off with volcanic ash, freshly belched from the hot interior of the earth and scattered as dust, there is eventually some single plant taking a foothold on it. After one plant grows for one season to make seeds, more plants grow during the next, because the death of the first plant and the decay of its small amount of organic matter contribute to the inorganic soil helpful organic compounds which start building the soil for better plant growth. Each succeeding season makes its additions of organic matter. This better plant growth results from the soil's own kind of organic matter carrying its own selection of the particular combination of inorganic fertility which grows its own particular species. By returning the organic matter with the ash elements combined in it to the soil, each season builds up and retains more inorganic fertility in an organic combination improved by the amount taken from the soil during that season. Each year returns more extensively the specific organic matter which should represent the reconstitution of the same species of plant more rapidly than is possible in any other setting.

Thus nature--in man's absence--has grown each of its various separate plant species into what is called an "ecological climax," or where one crop fits healthily and profusively into a particular location. It fits there better than any other kind or species would.

### Residues important

In such a pure, healthy stand of a virgin crop we have emphasized the inorganic fertility, such as calcium, magnesium, potassium, phosphorus, sulfur, iron, and all the trace elements so well balanced for the crop in that ecological climax. But we have forgotten the residues returned annually for their specificity of the inorganic compounds serving so directly in the nourishment of the new crop each year. We must think more than of just "ash" as plant nutrition if we are to duplicate nature's performance in growing abundant vegetation, which naturally protects itself from fungus or bacterial afflictions, or from annihilation by insect ravages, and reproduces itself by putting forth seed abundantly.

The home gardener has always started his soil preparations with the application of animal manures and of composts. The history of gardening is built on organic matter. The tempting tastes and delectable qualities of vegetables rest more in that simple fact than we appreciate. High quality of vegetables will not tolerate much salt content of the soil growing them.



BEFORE AND AFTER . . . The climax crop in this Santa Rita Mountain Valley (upper photo, 1903) was a cattleman's paradise of protein-rich grass. But after continued grazing (lower photo, 1943) interrupted the regular return of the organic matter of that crop to the ecological climax was only widely scattered mesquite trees.

**Unsatisfying situation**

Yet in applying soluble fertilizers with the seeding we are offering the prospective plant the maximum of solubles at the seedling period when within the seed's storage is the maximum for take-off, even in the absence of soil. The seed is also designed to put roots into the soil in search of nourishment even before it puts out stems, leaves, or the showy plant part. Such fertilization placed near the seed at the time of planting offers less and less of itself for plant nourishment as the roots go deeper or farther from the point of this soil concentration. Can such a situation be as satisfactory as scattering through the soil the decomposed matter from the decaying roots of the previous crop? Or as the crop residue plowed and cultivated into the soil?

Organic matter dropped naturally onto the cultivated soil surface for a continuous natural cropping to annuals, or left under the canopy of perennials, soon serves to loosen the soil to significant depth. It serves to invite the many small forms of life, like worms and insects, to incorporate the leaf mold into the soil to a significant depth. It opens the soil to the maximum for action by all the microbial forms living within the soil and dependent on the atmospheric oxygen for their respiratory activities of organic combustion.

Undisturbed by man, and with the organic matter going back to the soil annually while the crop keeps growing into a better exhibition with each successive year, we see how nature builds healthy, insect-free crops into a climax. These are the crops which we should take as the ideal for our own crops if we expect them to give us nutrients.

As soil managers we may well ponder nature's plan of putting back into the soil the maximum of organic matter. In this she is doing much more building of the organic than she is of the inorganic fertility of the soil. Her practice is just the reverse of ours in this respect. It may well challenge our thinking more about organic matter in the soil, which will be better for our crops and for us too.

*Let's Live Magazine, July, 1958*

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# Soil Organic Matter--

## Fertility and Crop Needs

**by William A. Albrecht, A.B., B.S., MS., Ph.D.**
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Sunshine," we say, "makes the crops grow." So, as the days become longer, comes the growing season. After midsummer, with the shortening of the days, there is the gradual closing of this season.

Considered so simply, we are prone to believe that growth is due wholly to sunshine applied to plants as light and heat. We forget that all plants depend on the soil, the organic content of which indicates the season by timing its decay and delivery of its active fertility with relation to the temperatures the sun affords.

### Sun's function

The light of the sun functions through the chlorophyll (the green enzyme of leaves)--to produce the sugars, starches, and other carbohydrates. These are produced more abundantly as the longer days give more light. Carbohydrates are truly the plant's food, just as they are part of the food used in our bodies. In the plant, too, they give energy by being respired in the cells. Sunshine energy serves to create sugar which becomes energy food in the plant cells.

Plant cells truly grow, or increase their living tissues, (proteins) in the absence of light by growing at night as well as by day. Growth is the result of the cell's conversion of some carbohydrates into proteins, while other carbohydrates are turned into energy for that process. Carbohydrates are "starter" compounds into which nitrogen, sulfur and phosphorous are combined to bring about the living, protecting and reproducing tissues which we include in the terms "proteins." These are not synthesized by the sunlight. Proteins are biosynthetic and not photosynthetic. It is their nitrogen content in particular by which proteins are distinguished from the carbohydrates.

### Heat doubles speed

Heat applied to any of nature's chemical reactions serves to double their speed for each 18°F (10°C) increase in temperature. Thus the season's growth comes about because of the rising temperature which speeds the plant processes, providing, of course, that the soil offers increasing amounts of both organic and inorganic fertility along with the advancing season.

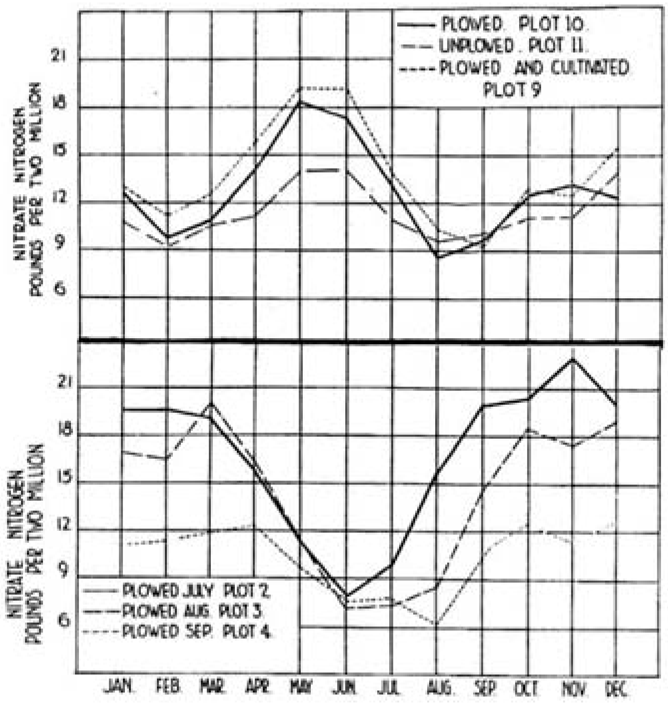
The increasing amounts of fertility of the soil timed with the mounting temperatures of the advancing season, depend on the increasing rate of decay of organic matter in the soil.

*This is the activity by which the crop growth of the soil is determined.*

It is timed with the rising temperature to increase more of its released inorganic elements and organic compounds for increased plant nutrition. It is the real cause of the more rapid plant growth through more abundant plant nutrition from the soil, and not so directly from the sunshine. This increasing decay in the soil is, then, synchronized with the plant growth, since it is the cause of it.

Tillage speeds the decay processes to hold the nitrate amount at higher levels when the supply of organic matter allows. The organic matter of the soil is the major support of crop growth.

The decay releases nitrogen, sulfur, and other elements serving the plant in its manufacture of proteins from part of the carbohydrates. Such release results from the microbal struggle to get their energy foods and food for growth while they "decay" or digest the organic residues.




NITRATE NITROGEN . . . Amounts of active nitrogen (pounds per two million on plowed acre) report the seasonal decay cycle of soil's organic matter under a corn crop (upper curves) with different tillage, and under a winter wheat crop (lower curves) with the soil plowed at different months of the season.

## Decay

Fortunately, this element remains chemically inactive when combined in soil organic matter at the lower temperatures under which the microbes are inactive. But its decay starts in and undergoes mounting rates of change from organic to inorganic form in ammonia and nitrates, both taken readily by plants. This process of nitrification, then, is in a large measure the seasonal support or control of natural plant nutrition and growth, since it means protein which is life to the microbes first and to the plant second.

It is the organic matter that gives release also of much carbonic acid from microbal respiration of the carbon simultaneously with the release of the nitrogen. This increase in the soil acids speeds up the breakdown of the rock fragments and their minerals to release more active inorganic fertility. This means more efficient protein construction for better plant growth.

## Soil study

The study of the soil's nitrogen supply in the form of nitrates tells us that wheat, corn, and other crops including those in the garden, grow not only because the light and heat of the sun fall on the plant's leaves, but because the sun's heat is applied also to the moist soil. This brings on more rapid organic decay to recycle the fertility elements, especially the nitrogen, in higher speeds and amounts by which the more rapid crop growth is determined, provided the nitrogen is in balance with larger supplies of other fertility essentials.

Plants, along with soil microbes, struggle to get proteins, or to live. Only as the seasonal conditions offer the chance to make more protein can there be more growth of the crop.

Such is the natural seasonal cycle bringing about crop growth. That cycle is timed according to plant growth, since it is the natural supply of active fertility coming from the decay of the inorganic matter in the soil.

*Let's Live Magazine, August, 1958*

# Soil Organic Matter--
## "Constitution" of Soil

**by William A. Albrecht, A.B., B.S., MS., Ph.D.**
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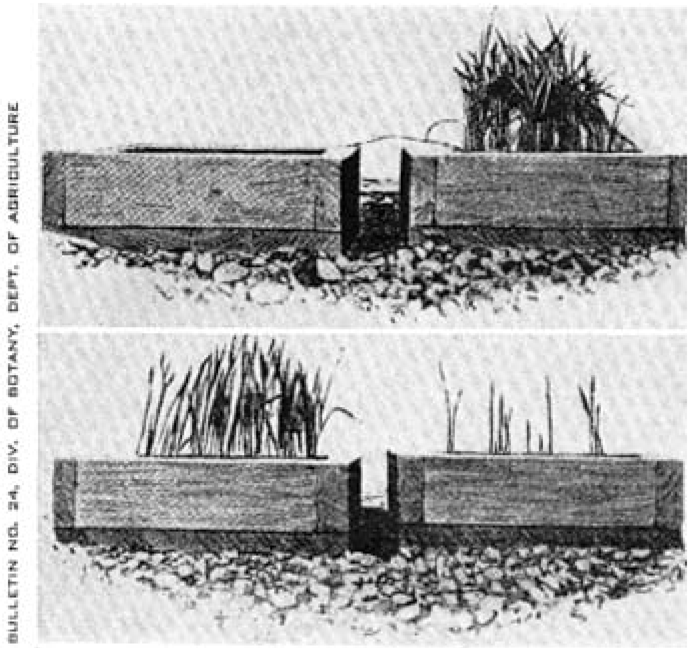
*(The two figures used in this article were published in 1902 in a booklet entitled, "Fertility and Fertilizers," extolling the safety of fertility and fertilizers from animal matter over salt fertilizers "sown in the rows" or "mixed with the soil." -- Ed.)*

In a severe illness we place faith for recovery in the help of the physician or surgeon first. But if hope grows dim and they too become concerned, they offer consolation by telling us that we have a good constitution. Fortunately for many a patient, his recovery often depends on his "constitution," or what may be defined as his ability to survive in spite of the doctor and not because of him.

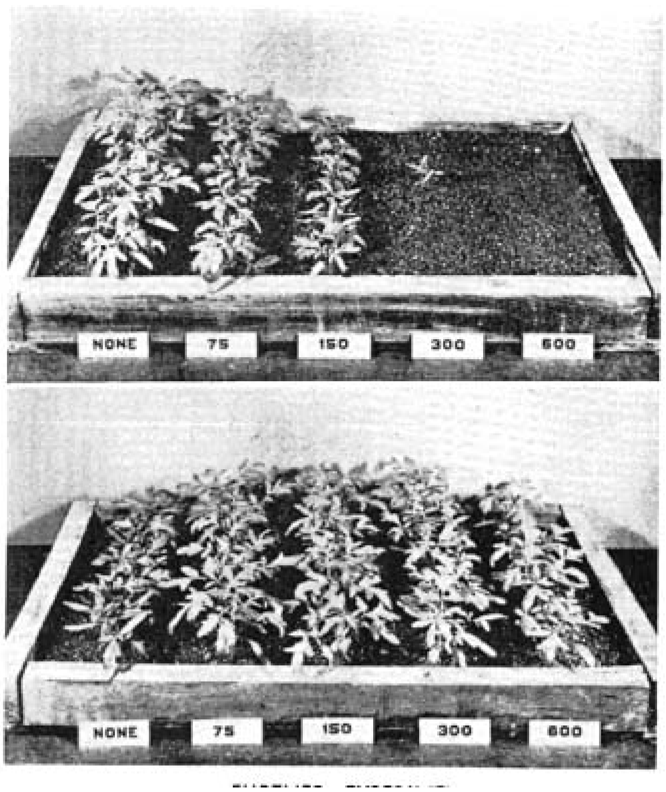



EXPERIMENT . . . Illustration on top (No. I) shows wheat experiment with potash. In trough on right wheat was check drilled. In left trough potash was sown in rows. Lower illustration (No. 2): wheat experiment with mixed fertilizers: muriate of potash, nitrate of soda and dissolved phosphate. In the right trough fertilizer was sown in the rows, in the left it was mixed with the soil.

## Soil processes

Any living soil must also have a good constitution in the form of an adequate supply of organic matter, preferably grown much as it occurs in an ecological climax of nature. By the presence of that organic phase, the microbial activities are the soil's metabolic processes by means of which it recovers from chemical shocks, like heavy applications of salt fertilizers. Through the combination of organic matter, as energy and growth foods, and the microbes multiplying as successions of hidden crops of themselves, the soil keeps on living and nourishing our crops in spite of us doctors of the soil more than because of us.

Heavy dosages of chemical salts dare not be used as fertilizers with the planted seeds because of the danger of killing their growth and thereby giving crop failure. The placement of such salts in the soil--far enough away from the seeds to escape that damage--is challenging the crop engineer's mechanical ingenuity. This fact is indicated by the variety of planting and seeding machinery offered now with special fertilizer attachments. If such salts will damage the seed, shall we not consider what a shock such concentrated applications must be to the microbial life in the soil area surrounding the seed and the growing seedling? (See Illustration 1 and 2.)




FURTHER EXPERIMENT . . . Here the increasing amount of ammonium sulfate drilled into the rows with the seeding of tomatoes (No. 3. upper flat) demonstrated how little of this salt destroyed the crop in contrast with the amounts of superphosphate similarly handled (No. 4, lower flat).

Fortunately, the microbes, the organic matter and the clay of the soil can--and must--take the shock if there is to be a forage or vegetable crop saved for us. Yet under such soil treatment, we are not much concerned about keeping the microbial forms growing and thus more organic matter going into the soil as its constitution.

## Soil shock

When we dose ourselves with aspirin, for example, as relief from fevers, headaches and other symptoms of our body's more deeply-seated troubles, we dare not forget that the relief is bought at the price of shocking and overloading many organs and their processes in disposing of the drug. These processes are called upon to decompose, or resynthesize, the drug chemically in the liver; to carry it in the blood stream; to pass it through the kidneys (not without possible damage); and eventually to eliminate it in the urine, the skin or by other routes.

In the soil body, too, the biochemical processes are similarly marshalled to overcome the shock of heavy salt dosages much as the human body must overcome them from drugs.

The first body part of the soil that helps to reduce the salt damage is clay. It absorbs the component parts of the salts in order to take them out of solution and reduce their damaging effects. But in doing so, other essential elements held in the clay for microbial and plant nutrition, may be put out of retention as help to the crop. And the clay becomes unbalanced by the excessive stocking with the few applied elements replacing the extensive natural combinations of both known and unknown essentials already in it.

## Second help

The soil's second shock-absorbing help is the supply of decaying organic matter. This is the more effective defense against salt injury to planted crops, and against serious imbalance in the clay's essential or nutrient elements. Fertilizing, or salting, the soil's organic matter brings about different processes by different kinds of microbes coming pidly and will dominate; some of the salt is taken into their bodies, recom-bined with the soil organic matter and reduced in its "salting" effects. Following that change in the soil conditions, some other species will profit by the resulting products and will dominate and bring about another step in the chain of processes absorbing the shock. These successions of domination by different microbial crowds continue as long as there are organic matter reserves and salts left to feed new generations, coming about every hour in the growing season, and thus representing the *active constitution* of the soil. It is because of the soil organic matter and its guarantee of the microbial processes by these "shock troops" that our field and vegetable crops, following salt treatments of the soil, live so often in spite of us rather than because of us.

## Least dangerous

Fortunately, not all fertilizer salts are so severely disturbing or dangerous. Least dangerous among them are those carrying salts of phosphorus. This element, changed from rock to soluble acid combinations in fertilizer production, combines quickly with calcium, iron, or aluminum in the soil to become less soluble. The chemist says, "It reverts." While it is not so shockingly dangerous, it is correspondingly difficult to keep it in a form available to the plants. We therefore need to apply it more generously for its fertilizing services. (See illustrations 3 and 4.)

More disturbing are the salts of nitrogen, either in the ammonium or the nitrate forms. The same is true of salts of potassium. The increasing concentrations of these two elements going into the modern fertilizers have brought on increasing trouble in placing such salts in the soil at "safe" distances from the seed at planting time. When mixed fertilizers were used some 50 years ago under the label of 2-12-2, (two percent ammonia, 12 percent of phosphoric acid and two of potash), there was little shock danger as compared with what is considered the lower concentrations today of 12-12-12, with as much of each of the two dangerous salts as of the one less dangerous.

It is significant to note that the present annual consumption of fertilizers is showing an increase mainly in those states where the soils are still higher in organic matter. Where the soils are lower in this respect and in fertility in general, which brought fertilizers into practice in these sections many years ago, there has been a decline in the annual use of mixed fertilizers. Shall we finally come to believe that this means such concentrated salts are safe treatment only where there remains enough organic matter for the living soil to survive in spite of the soil doctors?

**Still hope**

There is still hope, however, for our use of commercial fertilizers when the soil organic matter and the microbes working it over can take up the shock to the soil well ahead of the crop, and so prohibit the salt damage. This fact suggests that we can compost the salt fertilizers with most any kind of organic waste--even sawdust--either in a pile above the soil or in a mixture within the soil, well in advance of the crop that would be hurt by salts applied directly with its seeding. Also, we can grow green manure crops, give them heavy fertilization, and turn them under to bring the fertilizers to harvested crops, after the fertilizer salts are worked and reworked into the organic matter supplying the crop, by rotting as an organic fertilizer. Salt shocks are taken up safely when given first to this fertilization crop and then to the microbes when the extra organic matter is put back into the soil.

Yes, we can use salt fertilizers if we have organic matter enough in the soil by which it and the microbes give the soil a good healthy constitution to stand up under occasional necessary prescriptions of salt treatments by the soil doctors. But we must maintain a living soil, and this is possible only if the organic matter is well maintained in it.

*Let's Live Magazine, September, 1958*

# Soil Organic Matter--
## Mobilizer of Inorganic Soil

**by William A. Albrecht, A.B., B.S., M.S., Ph.D.**
Chairman, Department of Soils, College of Agriculture, University of Missouri, Columbia, Mo.

Since plants at their best growth, in what we call a natural ecological climax, reach that freedom from weeds in a pure stand, and self- protection against diseases and insect pests only after their residue-returns of many successive generations have accumulated their effects, we certainly ought to look to the many organic matters as well as the inorganic ones that will serve as fertilizers of our soils. Good gardening has always called for plenty of manure applied regularly.

One might well believe that there are benefits from returning organic matter to the soil, because just that much more "ash" material is in the cycle of growth and decay, to be supplemented by the annual increment coming as addition from the mineral reserves in the soil. All of this means more inorganic fertility for growing the next annual crop. We emphasize only the inorganic elements in that cycle, like calcium, magnesium, potassium, phosphorus, sulfur and other ash elements. We do not point out the organic compounds like amino acids, carbohydrates, ring-carbon structures and others, which are given back to the soil in crop residues as help in growing better as well as bigger crops.

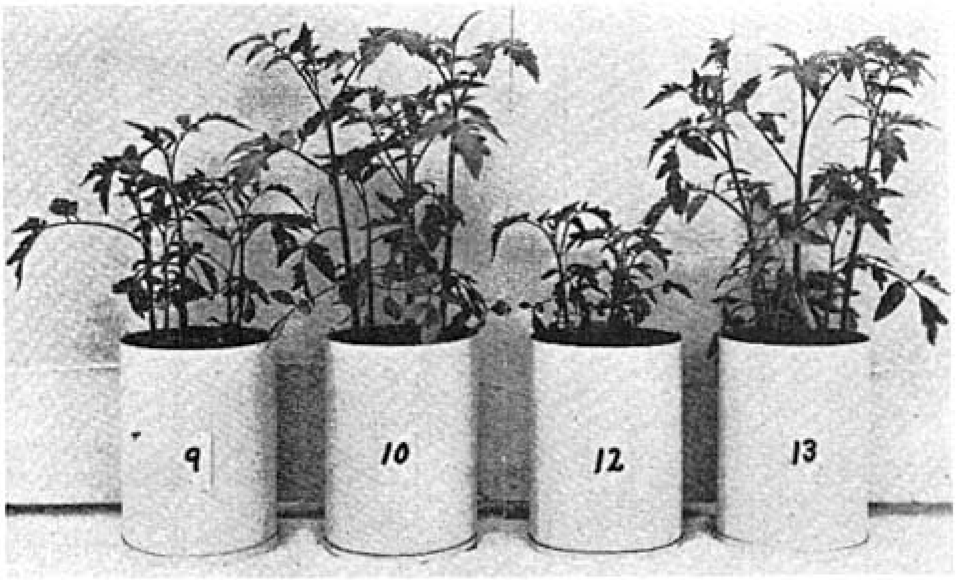
### "Chelation"

Nor do we imagine that the organic compounds may be the agency through the chemical combination with which some of the essential inorganic elements are more efficiently moved from the soil into the roots of the plants. That decaying organic matter may supply organic compounds going into the plants, and may carry the inorganic elements along in an organo-inorganic combination, is a rather unique phase of plant nutrition only recently recognized, hence considered new. It is spoken of as "chelation."

We have long viewed the movement by the inorganic nutrient elements from the soil into the plant root as due to their high concentrations on the clay or in the soil solution. Like a mathematical equation, we habitually read from left to right, or we emphasize the need for raising the concentration of the fertility on the clay to drive that reaction to the right, or into the root. We forget that an equation is the same truth when read from right to left. We have not considered the possibility of lowering the concentration in the root as a way of increasing the gradient in that direction by such means, or a means of aiding the root in its moving the elements more effectively into the plant through better use there.

We have not envisioned the plant as it might have organic compounds--of its own synthesis or absorption from the soil--in its roots which are literally "taking" the fertility elements away from the colloidal clay rather than having the clay thrust them into it.

PROF. A. R. MIDGELY, VT. AGR. EXPT. STA.




LET'S LIVE/SEPTEMBER 1958

EXPERIMENT . . . Mixing the soluble phosphate fertilizer with the manure first, then mixing that combination into the soil (10 and 13 in illus.) gave better growth of tomato plants than resulted from mixing each of those treatments into the soils separately (9 and 12 in illus.) at depths of 3 inches (9 and 10 in illus.) or at 6 inches (12 and 13 in illus.).

### Fact established

That organic compounds in the roots are serving in that fashion has recently been established by experimental demonstration. Plants are their own chelators, if their roots combine organic substances with those inorganic from the soil for mobilization of the latter into the roots more efficiently.

Emphasis has recently gone toward the commercially synthesized compound ethylene-diamine tetra acetic acid (EDTA) as a ready combiner with iron. Prepared in the laboratory, that combination as a whole is absorbed by, and translocated within, the plant to cure its chlorotic condition. More iron moves under such chelation than is moved in solution or otherwise from the soil into the plant without the EDTA.

The unique service of this complex EDTA compound as a chelator, or organic combiner with the inorganic, to move more of the latter from the soil into the crop, was demonstrated by P. C. de Kock of the Macauley Institute for Research, at Aberdeen, Scotland. He grew the sunflower plant with the root system divided between two containers, supplying the iron in one and the EDTA in the other, only to get healthy plants by that combination. They become chlorotic if only the EDTA was omitted from that arrangement.

What particular interest his test has in connection with natural organic matter of the soil, was his demonstration by means of the same technique that a water-extract of peat used on the one-half of the root system as a substitute for the EDTA served similarly to improve the plant's absorption of the iron by the other half of the roots and to prevent chlorosis. Without the treatments by the peat extract, the plants became chlorotic.

**Unique function**

Such facts establish a rather unique function for soil organic matter, when by its decomposition it gives compounds which need be taken up by only some of the roots and thereby serve to help other roots--which are neither nourished by nor even in contact with it--to take up more inorganic elements, like iron, from soil area not stocked with any organic matter. This suggests that a few focal points of decaying organic matter in the soil may render more extensive benefits for better nutrition from the inorganic part of the whole soil than we appreciate.

Dr. H. E. Hampton, of Texas, demonstrated by his research at the Missouri Experiment Station that merely putting legume bacteria on the roots of soybean plants made these take the inorganic nutrient elements off the clay to a larger degree of exhausting that supply than they were taken by uninoculated roots of similar plants. The inoculated soybean plants, which were producing more protein from atmospheric nitrogen through inoculation, were literally "taking" the fertility away from the clay. They suggested that inorganic fertility was taken and held by the inoculated root with a greater energy than was true for the roots of the less proteinaceous soybean plants behaving (in the absence of nodule bacteria) physiologically like non-legumes.

When iron is so insoluble, but yet is chelated within the roots by EDTA which was fed into other roots (and also into the plant tops) of the system than those in contact with the iron, we can visualize that other less soluble elements, like phosphate, might be chelated too; that might be expected, since that element serves more effectively in plant nutrition when it is plowed under with leguminous green manures or barnyard manure.

From natural form It is also taken from the natural mineral form, rock phosphate, more effectively by a crop of red clover, a legume, than by barley, a non-legume. It is of more help to non-legumes when put into the soil as an advanced mixture with manure than when each of the two is separately mixed into the soil.

When our animals do better by grazing on an herbage mixture of non-legumes and legumes, shall we ascribe the benefit wholly to more crude protein from the leguminous nitrogen in the mixture? Might it not be due to a more complete and abundant array of the inorganic elements (both major and trace) of mineral origin as well as those organic which the legumes represent coming from the soil?

As we observe more closely and study more diligently, we find more and more evidence that the soil organic matter contributes in particular details to the better nutrition of the plants. Chelation is unique evidence of that fact, since it has demonstrated that not only are large and complex organic compounds (EDTA) taken up from the soil by plant roots, but also, such compounds are the help within the roots by which the plants can feed more abundantly on the supply of the inorganic elements in the soil. This certainly is good reason why we should build up the soil organic matter for better nutrition (organically and inorganically) of our garden and field crops, and for our own better nutrition even if it were in terms of only the elements of mineral origin.

*Let's Live Magazine, October, 1958*

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# Soil Organic Matter--
## Includes Much "Et Cetera"

**by William A. Albrecht, A.B., B.S., M.S., Ph.D.**
Chairman, Department of Soils, College of Agriculture, University of Missouri, Columbia, Mo.

The pig, like other animals, teaches us by example rather than by propaganda. Since we are not prone to mimic what might even appear as wisdom in the behavior of a lowly animal, it has taken us almost a half century to become a nation of carrot eaters. During all those years the pig was selecting yellow corn with its precursor compounds of vitamin A in preference to white corn, deficient in those. Scientists refused to put much stock in the farmers' reports years ago about the pigs' choices connected with the higher nutrition qualities of those selections. So the pig was eating yellow corn for all that the scientists listed as food values "et cetera" (and others). The pig selected for the "et cetera" much more than possibly we realized.

### Recent findings

It has been those "et cetera" compounds, in connection with nutrition, which science has been discovering more rapidly in the years since the first vitamin was found. More and more essential organic compounds are being listed under the category of "essential." More and more hormones are classified by their functions and chemical structures. New antibodies against disease are coming to light and late ones are replacing earlier listings. Organic chemistry is the field of extensive elucidation of what must have been in the food as "et cetera" when we said, "The requirements for our nutrition are the carbohydrates, fats, proteins, inorganic compounds, et cetera."

### Essential elements

For plants, the study of soil fertility about a half century ago listed the essential elements to the extent of only 10. These included: carbon, hydrogen, oxygen, nitrogen, (all originally from air and water, but also from the soil as organic compounds) phosphorus, potassium, sulfur, calcium, magnesium iron, "et cetera" (all from the minerals of the soil initially but also from the organic compounds grown on and returned to the soil). In that day of ash analysis of the plants to be matched against the inorganic fertility elements of ash coming from the soil minerals, not much emphasis was put on "et cetera." But with the addition to the plants' requirements of the trace elements, namely: manganese, copper, zinc, boron, molybdenum, chlorine and cobalt for the blue-green algae, "et cetera," we are realizing that our listing of essential inorganic elements is not a matter in its finality. Rather, our minds must be open to the possibility that natural processes may be using qualities of other elements so small that they escape our methods of detection and accurate measure. As late as this year (June 1958) there appeared a report that "Additions of organic materials to soil will influence the availability of the trace metals to plants."

### Omissions

Unfortunately, in teaching facts of nature we omit the "et cetera" all too often. We are prone to emphasize what we have listed and what we know. We are more anxious to exhibit our wisdom than to admit our ignorance. Yet the admission of the latter about things natural would not belittle us. Rather, it would extol nature and all that we need yet to learn if we are to cooperate with her in managing agricultural production (creation) more successfully for the survival of all the species of life we like to see propagated.

By example, nature has been teaching us that a crop without man's aid or interference grows to a climax of pure stand, of little disease or insect attack, and of fecund reproduction through the help of the accumulated organic matter built up from its own remains of year after year. Because we do not know the specific organic compounds in the soil going into the crop and causing the weed exclusion, the absence of fungi and insect pests, or the high seed yields, we close our minds to the remarks of the man who emphasizes the use of more organic matter because he believes it the cause of these advantages in the survival of the crop in its ecological climax. We say, "He has no scientific proof that soil organic matter, or the practice of what he calls 'organic gardening and farming' can give healthier crops with larger yields of higher nutritional values."

### An old practice

In our scientific thinking we are apt to omit "et cetera." In their unsophisticated view of the growing things, the practical gardener and farmer magnify that "et cetera" part. The simple fact that we do not know specifically and to the accuracy accepted as the standard for scientific reporting, should not prohibit our starting the growth of our knowledge from empirical matters in which there is still so much "et cetera" beyond what little we know. Such a method of propagating knowledge in practice preceded by centuries the published knowledge we include in what is called "science."

**(Continued in November)**

*Let's Live Magazine, November, 1958*

# Soil Organic Matter--
## Includes Much "Et Cetera"

**by William A. Albrecht, A.B., B.S., MS., Ph.D.**
Chairman, Department of Soils, College of Agriculture, University of Missouri, Columbia, Mo.

**(Part 2)**

It is unfortunate, that with so much emphasis on the science of academic and classroom origin, we are prone to believe that organized knowledge about nature (which is a common definition of science) coming from observation, experience and practice in agriculture, is not to be trusted as truth or as fact. But even the scientist's offerings of organized knowledge meet with skepticism and refusal of acceptance when he, for example, extols the use of salts of nitrogen because they make the crop so much greener, grow so much taller, and even be richer in "crude" protein. Such a scientific exhibition meets with skepticism from nature herself, that is from grass-eating animals like the cows and the rabbits. The former refuse to eat such grass if the nitrogen comes from their own urinary droppings. The latter refuse to eat the grasses fertilized with only the salts of nitrogen common in fertilizers.

### Nature closes mind

Such is a case where nature, as it were, closes her mind to the claims of the scientist, satisfied as he is to measure the high nitrogen content of the forage resulting from soil treatment with nitrogen salts and to claim it of high protein content. Animals are skeptics of his claims. They classify them as propaganda. Apparently the animals know more clearly and accept more readily the scientist's "et cetera" than they do his specific listings.

Unfortunately, much is emphasized as science for only its monetary values. Too often the "et cetera" are not listed or mentioned because they do not contribute to the collection of fees and profits accordingly. . . .

We are made gullible on one hand by much that is claimed to be science; yet on the other hand, we are often made so skeptical by it that we are prone to exclude all empiricism until so-called science in commerce establishes the details of its potential value by continued repetition in announcements.

### Fear of "germs"

Organic matter in the soil is an illustration of that situation. Through empirical knowledge of experience and practice, its services to the crops are known to be very valuable. But through fear of diseases emphasized in study of fungi, and bacteria found on crops, the use of decaying organic matter is not considered as near a sanitary fertilizing procedure as is the use of chemical salts. We have built up a fear of "germs." Because organic matter, like manure, cannot be reported as carrying certain specific organic substances in specific percentages, and serving in specific plant functions, we say it cannot be shown to be a true fertilizer. Its use is not considered a fertilizing act, but it is viewed as only a case of disposal of a barn waste.

But the pioneer guano user of our South insisted that the bird droppings from Chili were superior as fertilizing help for his crops to the saltpeter from the same place. About 50 years ago, one of the present day producers of commercial fertilizers distributed the company catalog with claims for their "pure animal matter fertilizers", and pointed out (with plant illustrations) the injury by the salt fertilizers when applied with the wheat seeding.

**No enthusiasm**

Because we do not have enough scientific explanation of the particular functions of all that is serving in organic fertilizers; and since they are not abundantly available for sale at a profit; there is not much propaganda to bring us to study their effects. Our minds are, therefore, closed to the enthusiasm of one who is an "organic gardener." Even if the healthier plants in an ecological climax are examples of crops organically grown; and if animals are teaching us, by example, that fertilizing with nitrogen salts in their own droppings does not necessarily mean more choice protein, though it may mean more nitrogen in the crop, we are slow to realize that organic matter may make many of the same contributions made by commercial fertilizers "et cetera." We do not yet appreciate the "et cetera" as something that may be better nutrition in what is yet unknown to us but well known to nature.

Perhaps the day is not far distant when, instead of growing crops for their maximum removal from the soil in that form, we shall grow crops for their organic matter to be returned to the soil on, say, half or less of our cultivated areas. By that we can go fifty-fifty with nature and use the organic fertilization to let us work with nature in maintaining living soils rather than work against her to maintain dying and nearly dead ones.

*Let's Live Magazine, December, 1958*

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# Soil Organic Matter--

## Farm Manures Help Maintain It

**by William A. Albrecht, A.B., B.S., MS., Ph.D.**
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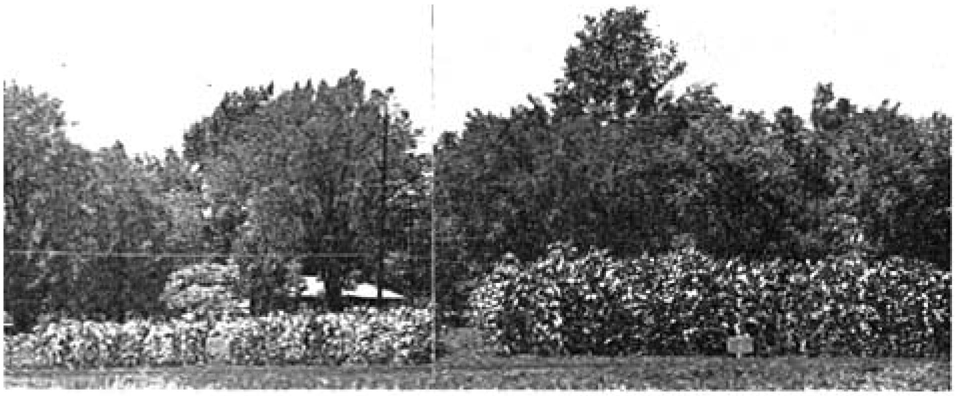
**(Part 3)**

The use of "fossil" organic fuels in their various forms, like coal, kerosene, gasoline, and other volatile, readily combustible materials for agricultural power, to replace that of horses and mules, has brought about the highly exploitative attacks on the natural reserve organic matter of our surface soils. This has resulted for two reasons: (a) more power and speed are applied to the tilling of the soil more deeply and vigorously to hasten the combustion of the reserves of microbial energy materials; (b) less organic matter is returned in the animal feed residues as manure, modified and improved as nutrition for the soil microbes and plants by the addition of the chemically more complex and varied waste products of the animal's physiology.

### Reasons

The first of these reasons has been widely recognized as an unavoidable result of the high labor costs demanding such speed to raise the output per man. The second reason has been generally disregarded. Manure handling has always been considered a distasteful sanitary chore incidental to keeping animals housed and penned, more than it has been appreciated as an essential, biochemical contribution to the nutritional quality of feeds and foods grown on manured soil. Also, it simultaneously does much to maintain the organic matter in its fertilizing services. (Photo)




STRIKING RESULTS . . . Farm manure (six tons per acre annually — right) demonstrated its effects (July, 1958) in the upkeep of soil productivity under corn continuously (69th successive crop) in contrast to that of the soil under similar cropping but no manure (left). The same noble hybrid seed on both plots didn't overcome the difference in the soils due to manure and no manure.

Chemical studies were made of the soils after 67 years of (a) no manure on one set of plots, and (b) six tons per acre annually on another. Each set in such contrasting pairs had been under cropping to (a) wheat, (b) corn, (c) timothy annually, and also to (d) a four-year rotation of corn, oats, wheat, and clover, and (e) a six-year rotation of corn, oats, wheat, clover, timothy and timothy. From these data, it is clearly evident how much the use of barnyard manure has contributed to help in the upkeep of the organic matter supply in those soils. (See Table I).

TABLE I
Soil Composition--Due to Barnyard Manure after 67 Years. Sanborn Field, Columbia, Missouri

| Crop | Treatment | Organic Matter % | Phosphoric Acid, lbs/A | Essential M.E. Ca | Cations Exchangeable Mg | Cations Exchangeable K | Cation Exchange Capacity M.E. | Hydrogen M.E. |
|---|---|---|---|---|---|---|---|---|
| Wheat | Manure | 2.4 | 189 | 2140 | 306 | 348 | 16 | 8.5 |
| Wheat | None | 2.1 | 77 | 1900 | 360 | 312 | 16 | 9.5 |
| Corn | Manure | 2.2 | 202 | 3350 | 565 | 414 | 17 | 6.0 |
| Corn | None | 1.4 | 62 | 2600 | 462 | 239 | 15 | 8.0 |
| Timothy | Manure | 3.0 | 201 | 2650 | 216 | 273 | 15 | 4.9 |
| Timothy | None | 2.3 | 15 | 2100 | 140 | 144 | 15 | 4.8 |
| 4-year Rotation | Manure | 2.7 | 151 | 3850 | 245 | 307 | 18 | 4.8 |
| 4-year Rotation | None | 2.0 | 38 | 3230 | 245 | 307 | 18 | 4.8 |
| 6-year Rotation | Manure | 2.5 | 94 | 2600 | 210 | 233 | 16 | 4.5 |
| 6-year Rotation | None | 2.0 | 22 | 2866 | 108 | 113 | 16 | 4.6 |

## Results

Under cropping to wheat continuously, the manured plot of soil had 2.4 percent of organic matter, when the unmanured one had only 2.1 percent. The former was three parts richer over 21 parts, or higher by one-seventh. Under corn continuously, the manure plot was higher in organic matter after the 67 years by four-sevenths. Under timothy sod continuously, the increase figure was nearly one-third; under the four-year rotation, it was over one-third; and in the six-year rotation, one-fourth, or next to the lowest, which was the soil under wheat. These were the effects from using manure when in all of these cases the entire crops had been removed and no crop residues were returned.

## Help from manure

As additional significance, there is the help from barnyard manure in the maintenance of the inorganic part of the soil fertility. This was shown by the ash analysis of the soil for phosphate (phosphoric acid, $P_2O_5$) and for some of the cationic essential elements, namely: calcium, Ca; magnesium, Mg; and potassium, K. It is also significant to note the help from manure in keeping up the soil's exchange--absorption capacity (cation exchange capacity), in which the organic matter is more active than the clay. Also the lowered soil acidity resulting from the use of manure, as measured by the amount of exchangeable hydrogen, in the soil after 67 years, deserves attention as a modified soil condition not commonly appreciated in connection with this soil treatment. Contrasting values in each of the above cases of the elements cited for manure and no manure (Table I) show clearly that manure has fertility values we do not commonly emphasize.

## Demonstration

After nearly three score and ten years of manuring, this treatment demonstrates that, in the matter of soil maintenance, it has values for (a) upkeep of the supply of reserve organic matter; (b) holding up the soil's content of phosphorus even when manure is relatively low as a fertilizer for this essential element; (c) preserving the supply of active potassium; (d) maintaining the exchangeable magnesium; (e) preserving the supply of active calcium; and (f) helping to hold down the excessive concentration of acidity as hydrogen. Manuring the soil has been doing these things for years under merely the belief in it as a good practice, and long before science gave us these few tabulations of what we can prove in favor of farm manure. In the organic matter of the soil as part of the nutrition of microbes, plants, animals and man there is still much in the realm of good practice and much remains yet for science to prove and to explain.