Why Minerals In Fertilizers

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PLANTS are stationary. They cannot travel. Their foraging area is limited to the root system. The soil within the range of the roots should be rich in mineral plant foods.

One of the secrets of growing cultivated plants is to stall-feed them.

The more restricted the root area of each individual plant, the harder the struggle for sufficient mineral solvents to perform the functions of growth, and the greater the need for sanitary growing conditions.

Grass is planted thick and the roots develop great competition in the soil for space to grow. It should therefore be fed oftener than plants with more space. Many millions of grass plants die on each acre in one season on account of this underground warfare, and frequent applications of mineral plant foods relieves the pressure and saves the plants.

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Mineral plant foods are related to soil sanitation. Dr. John M. Coulter reported several years ago "that roots of certain plants excrete substances which impede further root activity. If this phenomenon proves to be general, as now seems likely, the invasion of new soil areas by roots may make possible their escape from the substances which they give off or which arise by subsequent decay.

"Even in the case of cultivated crops, it is probable that fertilizers are of less value as sources of plant food than in their action upon soil constituents and in counteracting the noxious effect of root excreta or of decaying vegetation. Certain root enzyms are oxidizing agents of much importance and assist in the destruction of deleterious soil compounds; however, when these compounds are present in excess, the oxidizing action becomes lessened and the addition of nitrates and of other fertilizer salts is of great value."

It would be difficult for us to imagine how organics in a fertilizer would effect this result mentioned by Dr. Coulter since the trouble he speaks of is due to excreta from roots and from decaying organic matter.

The discovery that the application of plant food to the soil is vitally related to the health, growth and development of the root system of plants, and that the expansion of the root system is vitally related to the capacity of plants to make carbon compounds and increase yields, has given us one of the principal keys whereby we may unlock the energy of nature and regulate plant growth. It is this kind of information that caused Ville, the French investigator, to declare that—

"The modern system of scientific agriculture has for its foundation the artificial production of plants by the help of simple chemical compounds in defiance of all the traditions which the old system has handed down to us." For he says, after years of research as Director of the Experiment Station at Vincennes, France; "We are therefore led to the following conclusion; that by the aid of simple chemical products, and by the exclusion of all unknown substances, a maximum crop may be obtained from all plants, in any place and in any condition of soil; further by varying the quantity of these products, the work of vegetation may be regulated almost like a machine, the usefulness of which is in proportion to the fuel it consumes."

Organic matter is often considered the vitalizing part of the soil. In reality, it indicates that at some time in the past there was an ample supply of mineral matter and intense plant activity. That organics still exist in the soil also indicates that plants still have access to minerals to keep up the manufacture of organic compounds.

A gradual decline of organics in cultivated soils indicates a corresponding decline in mineral solvents, and a lessening of the capacity of plants to grow organic matter. When these mineral solvents are restored, organic matter begins to accumulate. Moving organics from one place to another is often used as an expedient for saving time. It offers plants a good environment when used in large quantities, but it only stays off the final crisis.

ORGANICS ARE USEFUL IN IMPROVING SOILS

MY INVESTIGATIONS do not permit me to undervalue organics in the soil. In quantities they improve its physical properties. To apply manures as nitrogenous fertilizers has long been the custom among thrifty farmers. When it can be had at a cost in keeping with its behavior in the soil, it should be applied and not wasted.

When we use organic nitrogen in a mixed fertilizer on a 50-50 organics and inorganics basis, we do not accomplish what we have thought. For instance, if the mixture is made up of 400 pounds of some organic matter per ton, and we apply 500 pounds of the mixture per acre, this would average 100 pounds of the organics per acre or about 1/3 ounce per square yard, or 1/27 ounce, or less than a thimble full to each square foot of soil.

This could not possibly influence the physical properties of the soil, when there are already five hundred to two thousand times this amount in the same soil area. If it is a slow acting nitrogen we are seeking, we have many times this amount in the organic matter already stored in the soil.

There is no doubt but what we will for a long time be able to buy organic nitrogen, and when it is used as a fertilizer we should use it with a full knowledge of what it is and what it does. According to Sir John Russell, the plants rarely ever get more than 50% of the total nitrogen of organic compounds. In the decay of the material the bacteria of the soil get a heavy toll, and much of the nitrogen also goes off in the form of gas. The higher plants get what is left after this heavy toll has been taken out.

There is a popular belief that the one virtue of organics is that they do not leach. Our knowledge of the law of the decay of plant residue clearly shows us that organics leach upward in the form of gas, far more than minerals leach downward in the

soil solutions. Prof. John B. Smith of the Rhode Island Experiment Station reports in Soil Science, Nov. 1928, page 247:

"Nitrates moving downward after leaching rains were often retained in the subsoil layers, and at such times the quantities there present were in excess of those remaining in the surface layer, under midsummer conditions. Nitrates and nitrites leached from the upper soil layers were returned by the upward movement of soil water to replace that lost from the surface by evaporation." This is probably what happens to most of the soluble nitrogen in a fertilizer mixture when not taken up immediately by plants, especially if there is an abundance of water shortly after it is applied.

The superphosphate in the mixture according to Hall, Stoddart, and others, "dissolves in the soil water and *permeates* the soil, so that when it is *precipitated* it is throughly *distributed*" down to about 7 or 8 inches below where it is applied. This precipitate is many times finer than tricalcium phosphate and much better mixed with the soil, and when once precipitated is fixed.

Potash, though not quite so completely retained, descends further down, becomes well distributed in the soil and there is practically none of it lost in seepage water.

Organics that are grown in the soil are better placed than those applied to the soil. Of the hundred pounds or more produced daily on each acre, it will be understood that about half of it is beneath the soil in the form of stocks, stolons, roots and root hairs, and well distributed in the soil. There can be no more interesting study to a lover of plants than the infinite ramification of the roots, and in this connection I have some charts that I will show when I have finished my paper.

We estimate from information taken from scientific records that each hundred pounds of a good mineral fertilizer will produce at least an additional ton of organics, and will leave this in the place where it will do the most good. An increase of ten bushels of corn per acre would mean an increase of total organic matter of more than a ton of some varieties of corn.

CHEMICAL ELEMENTS EXIST IN THE SOIL

We have learned in another connection that for the production of plant life, it is necessary that the soil have certain chemical elements. These exist in some degree in all soils. Plant foods also exist in all organic matter, as it requires as much plant food to produce a mother plant as it will require to produce an offspring of the same size and kind.

Thirty-one chemical elements have been found in plant ash, and of these, ten are considered essential to plant growth. Five or six have been applied to the soil economically as fertilizers, which in the true sense may be considered inorganic materials of natural or synthetic origin. Organics are frequently used in fertilizer mixtures, and when so used are sold in the name of fertilizer. These same organics when sold separately go under other names such as manures, blood, bone tankage, activated sludge, cotton-seed meal, guano, night soil, and the like.

The principal difference between organics and inorganics so far as plant growth is concerned is that organics must be reduced to inorganics before they can be used by the plants, while soluble inorganics are used directly by plants. Except in simplified or inorganic form, organic compounds have practically nothing to do with plant growth. Except to maintain an even supply of soil water, and to influence soil temperature, they are not related directly to plant activity and plant growth.

Soil containing a high percent of humus can be used frequently to advantage, to smooth over or to level the surface of lawns and gardens and golf greens. But it should always be remembered that it has a very low percentage of plant food elements and should not be substituted for mineral solvents commonly found in fertilizers.

Organic fertilizers—when compared in plant food constituents with an equal amount of minerals and soluble nitrogen even at a higher cost do not always produce comparable results. The Pennsylvania Experiment Station reports in Bulletin 230 that "work was conducted on three farms in 1926 and eight farms in 1927 to compare high-grade fertilizer with manure as affecting the yield and quality of tobacco. The yield from fertilizers costing $35.00 was 82 pounds per acre more than that from 15 tons of manure valued at $67.50 per acre. The gain in yield at less cost per acre is accompanied by a distinct improvement in the quality of tobacco."

FERTILIZER INDUSTRY FOUNDED ON ECONOMIC PRINCIPLES

THE fertilizer industry was founded on economic principles. The history of the industry shows that it has changed the course of the argricultural destiny of many countries. It has doubled the yield of bread plants, and the meat-producing capacity of the soils and thereby saved the agriculture of England, Germany, France, Belgium, Holland and Denmark. It has been the one possible avenue by which these countries have met their agricultural emergencies for the past 75 years.

While the industry was founded on economic principles, I have kept in mind in the present discussion the fact that this convention is composed of members interested in the use of plant foods for beautifying the garden and the landscape. You think of fertilizer for aesthetic purposes, but you will recall that Victor Hugo who said that the fertility of Latium and of all Italy had been lost through the great sewer pipes of Rome, also said that "the beautiful is as useful as the useful."

Almost 250,000 species and varieties of plants have already been discovered and named by Botanists. This large number of kinds of uncultivated plants is the result of the organized power of the plant kingdom to adjust itself to the simpler chemical elements and get the most out of the environment.

Artificial plants or cultivated plants present a somewhat different problem. They have been coaxed and petted and helped and fed and made to do many things inconsistent with the blind forces of unaffected nature. By the constant aid of man they have been adjusted to man's needs—and often at a terrible cost to the species and variety of plants.

FIELD AND GARDEN CROPS NEED ATTENTION

FOR instance, most of our better field and garden crops if left alone would in a single season pass forever from the face of the earth. They would not be equal to the struggle for existence. Their enemies in the plant and animal kingdom would pounce down upon them and deal a death blow at one swing of the pendulum of fate. But man brings them under his dominion and fights back the enemies of certain plants. In this way, he dictates to nature on what terms these plants may live. This

he does in his own interest and for his own satisfaction.

In the early development of agriculture, farm manures and all kinds of organic matter constituted the sole source of plant improvement. Then came the gypsum, lime and ground shell age, whereby these elements supplemented the farm manure program. Then Lawes and Gilbert and Von Liebig hit upon the dissolved bone and the superphosphate theory. It was also left to Von Liebig to explode the "humus theory" of soil fertility.

Up to that time it was thought that the humus in the soil was used directly by the plant as food. His investigations showed that "as plants die down they necessarily enrich the soil with humus, but this humus as such, forms no part of the food-supply." Up to the time of these discoveries there was a steady decline in yield and quality of farm and garden products. In recent years the soils program has included a revision of our studies on plant growth, including the mineral theory of plant feeding, and as a result production has been gradually increasing.

The late Dr. John M. Coulter shortly before he died, read a paper before the American Association for the Advancement of Science in which he said: "The application of physics and chemistry to plants is fundamental in effective crop production, and has been an important factor in the revolution of our agriculture." In the development of modern agriculture nothing is so significant as the plant-feeding program. It was considered by Dr. Shaler of Harvard University as being the most significant of the winnings of the past three quarters of a century.

The fertilizer industry has kept close to the plant feeding program in order to be guided by experimental research in the manufacture and sale of plant foods. In this age of research and extension in the field of agricultural education, there are experts in all the states and counties, who advise farmers, gardeners, florists, on all kinds of subjects, including soils, crops, fertilizers and management. It goes without saying that such public servants should be fully advised on the physiology of plant feeding, for it is indeed a great responsibility to

advise growers on such a vital and fundamental subject.

There can be no doubt but that any manufacturer can prepare mixtures with any percentage of organics, and good business demands that this be done if the ultimate consumer insists on it. But for reasons that I have tried to set forth in this paper, sound soil science demands that the entire trend of the business shall be in the direction of minerals. This trend has been evident for several years and that is the reason why the great French Scientist said near the end of the 19th century:

"The day is approaching when the only true manure will never be produced on a farm, but in those vast chemical manufactories where phosphates are broken up, rendered assimilable, and mixed with potash, or with sodic nitrate or ammonium sulphate, so that everyone, great and small, may obtain the maximum crops the earth is able to produce."

This is truly a great vision which has fought its way through clouds of prejudice, but which now seems to have won the battle, for most of the Experiment stations have adapted their soils and fertilizer programs to the theory of mineral plant foods. They have adopted the general work of plant physiologists, setting forth the facts that plants take into their systems:

Phosphorus, Nitrogen, and *Sulphur* in the forms of phosphates, nitrates and sulphates of some basic element, usually calcium;

Potassium—as carbonates, phosphates, nitrates and sulphates;

Calcium—as bicarbonate, phosphate, nitrate and sulphate;

Carbon—in the form of carbon dioxide;

Oxygen—in the form of water and free gas.

With these facts before us, we have recast our plant-feeding program to secure the best and most economical results. To base our manufacture of plant foods on any other than these chemical manures or mineral fertilizers would be to turn back the wheels of progress, and to make it still more difficult for agriculture, horticulture, floriculture, to compete with business, commerce, industry in a modern world of scientific research.