Let's Live Magazine, January, 1961

DIFFERENT SOILS,
DIFFERENT PLANT COMPOSITIONS

Natural Laws Regarding
Soils and Plant Compositions

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part XVIII

Knowledge about the human body and its many functions has been accumulating very slowly. The additions have awaited the coming of each new science and the contributions in its particular field, at the rate of about one per century. The professions, like those of dentistry and medicine, have quickly accepted any knowledge or practice applicable in the alleviation of human suffering.

Only in the latter part of the 20th century will we probably be credited more with the addition of the science of nutrition to better health by building the body's self-protection than to the economics of the home.

We seem to forget that more than a century ago, "the survival of the fit" kinds of living things, each in a particular climatic setting, gave us the concept of evolution of the species. We have been slow to see that the different life forms fit, each into a certain place in in the climatic pattern. Such fitness comes not because of comfort according to how cold, warm, wet or dry. Rather, it comes according to the climatic forces as they develop the soil and its fertility array from the original rocks.

The soil must serve in growing plants with ample contents of proteins. Only those compounds will sustain and reproduce life. In plants, like in animals and humans, proteins must be in balance with the carbohydrates, which give calories and energy, or serve as "starter" compounds for the synthesis of proteins from them--if the balanced fertility serves accordingly.

This century may be the one when the threatening degenerations (diseases) will bring us to recognize the natural laws concerning the chemical composition, or nutritional value, of what we grow for services in keeping us healthy through natural prevention of degeneration, for which we have been hoping in vain for scientific cures.

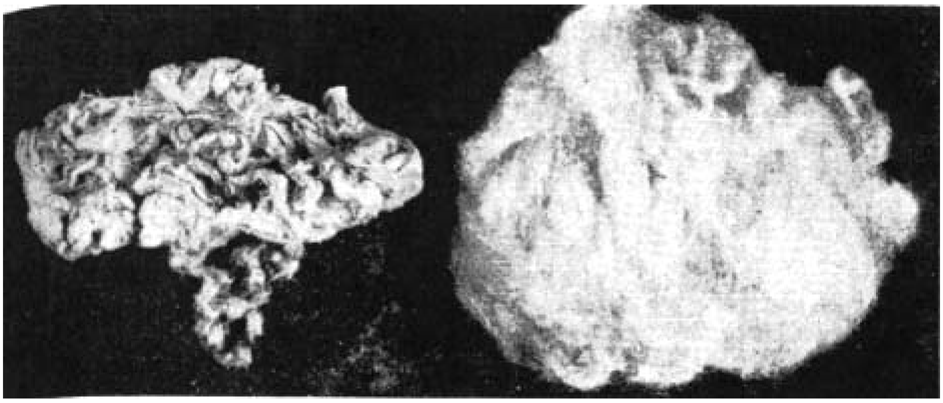
Construction / destruction principle

The first law tells us that with the increase in the climatic forces of rainfall and temperature which are weathering the original rock, there is, first, the *construction* and then, second, the *destruction* of the soil, so far as survival of more complex life forms is concerned.

In the United States this may be illustrated by going east from near-zero rainfall in the west--to give increasing soil construction in those more productive soils until one reaches the mid-continental area. Then, with more annual rainfall on going further east, there comes excessive soil development, or soil destruction, in terms of its fertility for growing both quantity and quality of proteins.

Availability ratio

The second law tells us that, at the maximum of soil construction, there is a wide ratio of the exchangeable (available) calcium to the exchangeable potassium. This is illustrated by the soils along the 98th meridian of longitude running from the western edge of Minnesota to the tip of Texas.



HAY grown on soil with a narrow ratio of calcium to potassium and fed to sheep produced the wool (left) which could not be carded after scouring. It broke into a fine powder (lower part of left specimen). Hay grown on soil with a wide ratio of calcium to potassium produced the nicely carded wool (right) to reflect the differences in this protein crop produced by the skin of the sheep.

This natural law of the soil composition is cause for the corresponding rations of these two essential inorganic elements in the natural vegetation and farm crops grown on those soils. Thus it is a natural law that there is a variable chemical composition of the vegetation according to the variable fertility of the soil, determined by the degree of soil development the climate gives it. Accordingly, the potential nutritional support of plants, animals and man goes back to the climate via the fertility of the soil that grows the foods and feeds.

Synthesis of protein

The third natural law tells us that calcium is associated with the chemical synthesis of the proteins by plants (and microbes), while potassium is associated with the synthesis of their carbohydrates. The latter process, commonly spoken of as "photosynthesis," may well be considered a supra-soil performance. Such classification seems fitting since photosynthesis is a compounding of carbon, hydrogen and oxygen--all weather-given elements taken from air and water--into carbohydrates by sunshine energy. The synthesis of proteins is a biosynthetic process: that is, one by the life processes of the plants. It seems to be a case in which some of the carbohydrates serve as the raw materials out of which proteins are made. This is brought about by combining with those carbohydrates some nitrogen, some phosphorus and some sulfur, all coming from the soil. Simultaneously, some calcium, some magnesium and several other soil-borne nutrient elements are required, while more of the carbohydrates are consumed as energy materials for this conversion process.

Protein/carbohydrate production

The fourth law, concerning the fertility of the soil in relation to plant composition, tells us that on soils under construction by the limited climatic forces or with a wide calcium-potassium ratio, the mineral-rich, proteinaceous crops or foods, as well as the carbonaceous ones, are possible. But on the soils under destruction by excessive climatic forces or those with a narrow calcium-potassium ratio, protein production is not so common--while production mainly of carbohydrates by the crops is almost universal. In the climatic setting of the former soils, nature grows healthy animals; in that of the latter soils, she fattens less healthy ones.

The natural conclusion

Out of these simple natural laws (given us by combining the climatic pedological and physiological facts) comes the principle of concern to all of us: namely, the homely fact that it is the proper nutrition of our bodies--more particularly through ample proteins or complete quality and ample inorganic elements commonly associated with the natural growth of them--that creates healthy conditions for growth, self-protection and normal reproduction.

Nature's laws, not those made by man, connect plant compositions and their nutritional services in animal and, human health with the fertility of the soil according to the pattern of climatic forces developing it from the rocks.

Let's Live Magazine, February, 1961

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

Depleted Soils--Species Extinction

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Part XIX

When nature puts her virgin climax crops of different plant species in different places, she is exhibiting the different chemical compositions of plants and their different qualities as food for any higher forms of life, according to the fertility differences in the soils growing them. Nature's crops represent each as "the survival of the fit" by way of what the soil provides as plant nutrition to guarantee that result. That was a fact Sir Charles Darwin emphasized a century ago. It is surprising that these natural laws seem to be unknown to those appointed to positions of national authority for legal enforcement of matters of human health.

That there are soil differences under the different nutritional values of the crops grown on them is indicated every time a cow breaks through the fence to get out of the pasture. She is prompted by more deep-seated causes than a mere desire to get on the other side, or to escape confinement. Careful observation of that condemned misbehavior reveals that she is usually going from the exploited, time-worn soils on the inside, to the virgin, unharvested ones on the highway or the railroad right-of-way on the outside. Little has been written concerning the cow's wisdom about the fertility of the soil growing the higher nutrition quality in the feed she prefers and which, if offered to her satisfaction inside the fence, would eliminate the need of any fence to confine her to it.

Lack of clear judgment

An unwarranted faith in the plant's pedigree seems to be responsible for the erroneous contention that the nutritional value and measurable chemical composition of the crop are constants, regardless of differences in the fertility of the soil growing it.

Along with that contention goes the belief that the differences in the soils give differences only in the crop yields as volume and weight. Such beliefs suggest that all the basic facts of ecology, and all organized knowledge added since the thinking of Darwin, or during the last 100 years, have remained in the darkness for many of whom those should be basic facts for passing judgment on matters in their areas of responsibility.

Among those who till the soil there are many who remind us that it is the soil that determines the nutritional values, while the genetic factor of the seed merely sets limits to the range of variations which the soil factors can demonstrate. To say that the soil fertility is of no significance in modifying the quality of the crop may be taken as a confession of misinformation, but it dare not be taken as negation of the basic facts of nature as we learn them from ecology, plant physiology, and from animal behaviors.

Facts and rabbits

Experimental rabbits demonstrated the fact that body growth, physiology and sexual vigor varied according to the differences in the fertility of the soil growing a single plant species of forage as feed.

A CLIMAX CROP of weed-free timothy of good feed value, grown continually since 1888 (left plot) results where manure is returned annually. But a climax crop of weeds on the adjoining plot (right), also in continuous timothy but periodically replaced by weeds (Andropagon virginicus, "broom sedge") occurs where no fertility is returned. The same soil can soon vary widely in the quality of feed it grows according as man's management or that duplicating nature's is dominant.

Equal weights of the hay from four separately treated plots were offered along with a constant amount of corn. Repeated trials with lots of five rabbits (two males and three females) gave repetitions of the animals' clear-cut choices of decreasing amounts of hay consumed per day, according as the hay was grown on the same soil given increasing amounts of chemical nitrogen as fertilizer treatment. The maximum consumption of hay occurred always from the check plot of no nitrogen treatment on the soil.

As a sequel to the above trial, the same hay species from each separate plot and the same corn were fed in order to measure the body growth as gains in weight per single amount of nitrogen fertilization. It was also used to note the development or destruction of male sexual vigor.

The results showed decreasing gains in body weights as more nitrogen served as fertilizer for growing the hay. There were also decreasing amounts of hay consumed by the animal lots as more nitrogen was applied to the soil, but that was associated with increasing amounts of corn chosen rather than the hay.

These data all indicate the struggle by these animals against poor nutrition for body growth which could do little more than let the animal take more of the corn as fattening feed rather than of the supposed protein supplement in the form of high concentration of nitrogen in the hay, but not that as quality protein of choice by the animal.

Diet corrections

Since the young males had demonstrated a delayed arrival at sexual maturity, their ration was shifted to a highly complete one for growth, including many choices of feeds, so they were brought into sexual vigor. That was readily recognized by the fighting of the males if left as pairs in the pens with the young females. The positive sexual interest was tested with females in oestrus, and then each lot was put back on the hay-corn ration by which their slow growth rate had just been demonstrated.

Within the brief period of one week of feeding on the test series of hays grown on soils given the larger amounts of nitrogen as fertilizer, the loss of sexual vigor inhibited the males from mating with females in oestrus. Accordingly, one week of feeding on those hays of lowest quality for body growth was long enough to rob the males of their mating instinct; or to bring about, thereby, the extinction of the species.

Criteria for man?

Such simple facts are observable in nature by anyone who will study them. Unfortunately, for agriculture, it is being viewed at long distance as if it were only an industrial manipulation of dead materials with emphasis on technologies for mainly economic advantages. Sight seems to be lost of agriculture as a biological demonstration by the forces of nature of which man is more of a spectator than manager in complete control. It is regrettable that agriculture is so smothered under views of it as but economics, that even the appointees to high office will contend that the soil no longer represents the power of variable creation for all that lives, moves, and has its being on the face of the earth.

Let's Live Magazine, March, 1961

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

Soil Organic Matter Mobilizes The Phosphorus for Plants

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part XX

Scientific studies are uncovering what seems like a natural protection against excessive salts in the soil, via the soil organic matter and the living soil's microbial population. Nature uses the inorganic elements mainly as inclusions within larger organic-complexes. This has demonstrated itself as a means of moving more inorganic fertility of the less soluble nature from the soil into the plant and about within it. This emphasizes *the availability of the insoluble.* Now we have discovered in the laboratory the process which we call *Chelation** --whereby, an inorganic ion is stably fixed within a larger organic molecule so that both are taken into the plants for their better nutritional service there. We now comprehend what has been nature's way by which the insoluble fertility of the soil has become the available to the microbes and the plants during the past ages. But only slowly are we putting science under nature's secrets by which she grows better crops by returning more organic matter back to the soil.

** Chelation Phenomena--Annals, N.Y, Acad. of Sciences. 88: Art. 2, pp. 281-532, Aug., 1960. Report on Conference of Dec. 7 and 8, 1959. Franklin N. Furness, man. ed.*

The means of chelation

Chelation is the term that interprets what observations in agricultural practice have often suggested. It is a widely recognized fact, for example, that both the soluble and the insoluble phosphates (particularly the former) are more effective for improving the crop when first mixed with barnyard manure. Also, the simultaneous applications to the soil of ammonium salts and soluble phosphates will mobilize more phosphorus into the plants for better crop growth. Sodium nitrate applied in combination with the latter does not. Calcium nitrate in place of the sodium even reduces the mobilized phosphates, as compared with what occurs when soluble phosphates are applied alone.

The element nitrogen, the common symbol of our only living compounds, i.e., the proteins, is prominent in bringing about the chelation of calcium, magnesium, iron, cobalt and a list of other elements, as examples. It is the nitrogen, in particular, that serves to connect the inorganic elements more stably into the large organic unit of the final complex that results from chelation. It suggests the proteins, and other forms much like them, as the major means of chelation which robs the inorganic elements of their common property and chemical activity which we usually emphasize about them--namely, their solubility and their ionization, respectively.

Chlorophyl and blood

This concept of chelation should not stretch our vision beyond its elastic limits when chlorophyl, the green coloring matter in every leaf, is an age-old illustration of nature's use of chelated magnesium. In its chemical composition, this photosynthetic agent represents about one part of the inorganic in about 40 of total organic for building sugar from water and carbon dioxide under the sunshine's energy. Magnesium is similarly chelated in a long list of other enzymes of both plants and animals.

Hemoglobin in our blood is a case of chelated iron with about one part of it in 50 parts of organic matter. This is the means for taking up oxygen from the air in the lungs to be carried by the blood stream and given up to the tissues while the iron is not ionic.

Then cobalt is also chelated into vitamin B_{12} in a similarly wide ration of the inorganic part of the complex. The importance of this chelation compound was discovered by chickens taking to the cow's droppings, long before we as chemists had any vision of it. Natural chelation under the dynamics of organic matter and microbes, may be expected to illustrate itself more widely now that much research work is studying it, and to increase our appreciation of this one of nature's secrets, now that the chemistry has given foundation and pattern for our visions of the chemical aspects a bit more fully.

(Continued in April)

Let's Live Magazine, April, 1961

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DIFFERENT PLANT COMPOSITIONS

Soil Organic Matter Mobilizes The Phosphorus for Plants

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
Prof. Emeritus of Soils, College of Agriculture, University of Missouri, Columbia, Mo.
(Continued from March)

Natural chelation*, under the dynamics of organic matter and microbes, may be expected to illustrate itself more widely now. (**Chelation* is the process by which an inorganic ion is stably fixed within a larger molecule, so that both are taken into plants for their better nutritional service there.) Much research work is studying it. To increase our appreciation of this one of nature's secrets, chemistry has given foundation and pattern for our visions of the chemical aspects a bit more fully.

The commercially available chelator, *ethylene - diamine - tetraacetic - acid* (EDTA), was put into soil of no-iron content along with one half of the plant's roots. The other half was in similar soil given iron as well as ample phosphates, to make both less available according to their solubilities. Yet this commercial chelator was taken by the plant roots from the one half of the soil. It served to mobilize the iron from the other half into the plant roots and to correct the chlorosis of the plants which occurred under similar soil conditions omitting the applications of this special chelator. (1)

(1) P. C. deKock, "Influence of Humic Acids on Plant Growth," Science 121:474, 1955.

More significant, however, was the additional demonstration which added water-leachings from a highly organic soil, as a substitute for the manufactured chelator, EDTA, only to find that this natural substitute served in iron mobilization for the cure of chlorosis just as the EDTA did. Such facts help us to visualize the services by the soil microbes in their absorption of the "salt shock" when ammonium phosphate is added to the compost heap; when its soluble inorganic nutrient elements are taken into insoluble, much larger organic complexes; and when, thereby, both parts are made more available as nutrition entering the roots of the crop plants. We are gradually visualizing that, *within the soil, the organic fertility as chelating is dominant over the inorganic in about the same ratio as the combustible organic part of the plants is dominant over the incombustible, the inorganic, part there.*

Organic phosphorus more efficient

That such ratios prevail--relative to the advantage of making the insoluble become the available, via the soil organic matter--was recently demonstrated by some research using barley as green manure for feeding radio-active phosphorus into a crop of soybeans, according to the unpublished data from the research studies by Vernon Renner of the Missouri Experiment Station.

"HOT" BARLEY, because of its radio-active phosphorus, grown by V. E. Renner, and turned under as green manure for soybeans. The barley mobilized its phosphorus from that source 100 times more efficiently than the soil did.

Barley plants were grown on sand cultures with a controlled nutrient medium containing radio-active phosphorus. They were harvested, dried, pulverized, sampled for chemical anaylses, and then that pulverized organic matter was mixed thoroughly into the soil--in the ratio of one part of the former to 500 of the latter. This represented the common field rate of two tons of this dried green manure per two million pounds of soil per acre per plowed depth.

The soybeans were harvested after a growth period of 60 days. Chemical analyses were made to determine their contents of total phosphorus and of the radio-active phosphorus. This would, via radio activity, determine the phosphorus contributed to the soybean roots by the green manure applied to the soil. The total phosphorus, minus the radio-active part, would determine the phosphorus coming from the soil, which was a mass 500 times as large as the applied organic matter in the barley as the green manure. This separation of the phosphorus given by the organic matter of the soil from that given by the larger--originally more inorganic part of the soil--showed that one part of the phosphorus taken into the soybeans was radioactive, therefore, taken from the green manure turned under. Five parts of the phosphorus taken into those soybean plants were not radio-active, hence were taken from the original soil.

Thus, it is established very clearly: when the phosphorus coming from the barley as organic matter which was only part, while the soil was correspondingly 500 parts, yet phosphorus from those two sources respectively went into the plant in the ratio of one to five; the phosphorus from the soil organic matter was just 100 times as effective in feeding the insoluble but-yet-available phosphorus to the soybean plants as the soil was when its soil test (by the extracting chemical reagent) reported the soil "high" in its available phosphorus.

Creation's starting point

Some of our pioneer agronomists, as able chemists and scholars, may have had a vision of nature's unique phenomena of the chelation of inorganic fertility of the soil by the organic matter, and the microbial processes connected with it, in what they considered "the living and creative soil." Nearly a half century ago, Prof. A. W. Blair of New Jersey said, "It is well known that by judicious use of lime and vegetable matter on the soil, reserve of locked-up mineral plant food may be made available." [(2)]

Others spoke about maintaining the soil fertility and a permanent agriculture, by returning organic matter to the soil in combination with natural rock fertilizers. [(3)] Those pioneers did not visualize productive permanence in soils treated with water-soluble salts. They were pointing to the importance of the organic matter for soil productivity in the years ahead.

(2) A. W. Blair, "The Agricultural Value of Greensand Marl," Cir. 61, p. 3, New Jersey Expt. Station, May 15, 1916.

(3) C. G. Hopkins, "Soil Fertility and Permanent Agriculture," 1910, Ginn and Co., Boston & New York.

Let's Live Magazine, May, 1961

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

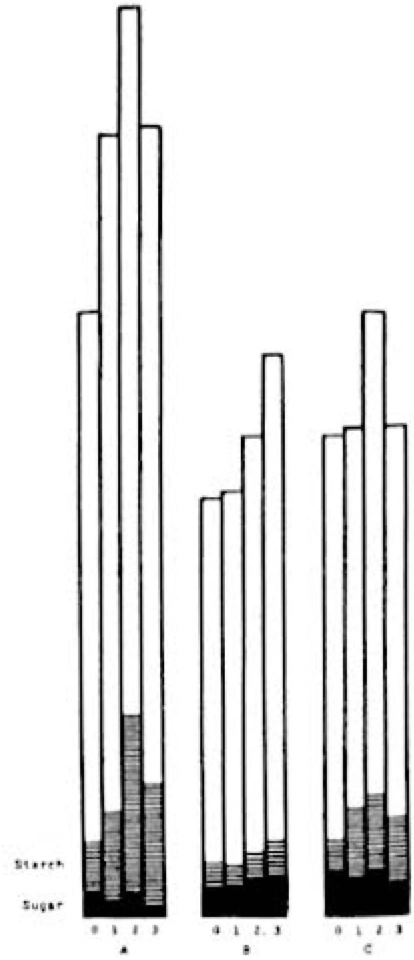
Depleated Soils Change Sugar, Starch, Proteins and Yields of Crop

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
Prof. Emeritus of Soils, College of Agriculture, University of Missouri, Columbia, Mo.

Part XXI

Those who contend that a given plant does as well on any soil on which it grows as it would on another soil (except for the volume or weight of crop produced) have a wrong understanding of the nature of plant inheritance.

In one experiment, potassium (potash), recognized as an essential factor for the plant's production of carbohydrate and needed often for increased yield of plant material, was added in various amounts to all but one of four plots of soil which were otherwise alike. Seeds from the same mother plant were used to give a constant genetic background. Of three crops, the first was not given legume bacteria for nodule production, while the seeds for the other two were treated with bacteria which established prominent root nodules. (*See A, B, C graph illustration.*)



THE THREE BAR GRAPH GROUPS show the effects of different soil treatments on three successive crops of soybeans: A, B, C. The bar height indicates the total yield of dry matter from a given quantity of seed. The solid section represents the sugar in the crop as determined by analysis. The cross-lined section represents the amount of starch.

Within each group, the seeds used were identical. The soils used were identical except for increasing amounts of added potassium proportional to the number 0, 1, 2, 3. Note that soil treatment differences affect not only the total yields but also the relative ratios of sugar and starch to each other and to the total yields. This demonstrates clearly that soil characteristics do have a marked effect in determining the nutritional qualities of the foods grown on it.

In terms of *crop yields,* the first crop was a bountiful one, varying in quantity with the amount of applied potash. Nevertheless, in terms of total nitrogen, it gave back no more in the total crop (both tops and roots) than what was in the seed originally planted.

Capacity for nitrogen

The second crop took nitrogen from the atmosphere to increase nitrogen in the plants over the total in the planted seed. However, the third crop did not give more nitrogen than was present in its seeds because removal of the preceding crops of plant tops and roots had *depleted the soil* to such an extent that even with the root nodules, the third crop was not able to utilize atmospheric nitrogen. The third crop gave larger dry matter yields (plant material with moisture removed) than the second. Although the seeds planted for the second and third crops were identical in every way, *nutritional properties of the crops were quite different because of differing soil characteristics.*

In the same experiment, measurements were also made of the sugar and starch amounts in the various crops. The results (*see graph illustration*) show that within each identical and identically treated seed group, *soil* characteristics had an important effect on the sugar and starch proportions in the crops. (In the diagram, "B" and "C" indicate the seeds that were inoculated with nodule-forming bacteria; the "A" seeds were not so treated.)

Conclusions

These observations show the serious error of those who argue that soil is of no importance in determining the nutritional value of the crops grown on it. It is the soil which determines nutritional value. The genetic factor present in the seed and transmitted to the growing plant merely sets limits to the variation ranges the soil factors can produce. To argue, as have government officials, that the soil--however deficient in natural fertility--is of no significance in determining the crop quality is a confession of misinformation, not of scientific knowledge.

Tests with rabbits

Experimental work with rabbits has shown that body growth and body physiology, even the maintenance of sexual vigor, varied according to differences in the soil fertility on which their feed crops were grown.

Tests were made with hay grown on soil with no nitrogen, and other hay grown on companion lots, otherwise the same, which were treated with various sized doses of commercial fertilizer nitrogen.

In repeated trials with lots of five rabbits (two males and three females), the animals were offered equal amounts of four different hays along with constant quantities of corn. The rabbits chose mostly the check plot hay which had no nitrogen treatment, and consumed decreasing quantities of hay crops grown with larger amounts of chemical nitrogen used as fertilizer. Thus the rabbits demonstrated an ability to recognize differences in the nutritive values of the same plant species in the several crops grown on a differently fertilized soil.

Protein needed

Naturally the animals which chose to eat less hay showed smaller gains in weight than the others. Thus the properties of the soil samples and the forage grown on them had an indirect but definite effect on the characteristics of the animals.

The data indicated that the animals were struggling with poor nutrition and body growth. They avoided the supposed protein supplement in the artificial, high-nitrogen content form hay, which, though it was nitrogen, did not correspond to the high quality protein which they needed. The unbalanced nutritional feed quality obtained by some of the rabbits even produced sexual infertility, which was not present when the animals were on a diet known to be complete for growth.

Respect for nature

The facts that have been outlined will be observed in nature by those who do not have preconceived ideas about plant growth. Unfortunately the professional agriculturalist often views the effects of soils on the plant's growth with a distant outlook, as if the only problems were those of industrial manipulation of dead materials, with emphasis on the various technologies for economic advantages only. People who approach agricultural research in this way have lost sight of agriculture as a biological demonstration by the forces of nature, where man is more spectator than manager in complete control of soil and produce.

Such unrealistic views of agriculture have led to expressions and views by high government officials that soil is but a chemical and physical agent for the production of larger quantities of crops. They seem unaware that the soil of our planet is a complex material developed through many centuries, having the power of creation, not only for plants, but for everything that lives, moves and has its being upon the earth.

HIDDEN IDEAS IN UNOPENED BOOKS

Mobilizing The Natural Soil Potassium

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Students of zoology learn that the life history of the individual's devolpment is an epitome of the history of the species. In the development of our knowledge, we seem to follow a similar pattern when our education is apparently the repeated experiences of our predecessors. None of us can start learning fully equipped with the total knowledge accumulated before we came. Each must repeat and re-learn. Early recognition of that necessity should make us cautious. It should help us to learn by less costly methods and high-priced experiences.

Help in just that respect is the aim of education. Reports are in print and volumes in libraries are available. A study of them lets us learn through the costly experiences of others, by paying no higher price than reading about and comprehending the "how" and "why" of them.

Records extensive

Man has been growing crops for ages. Records of those behaviors of nature are extensive. But for too many of us those facts are hidden ideas because they remain buried in unopened books.

The nutritional qualities of what we grow, the variation in the chemical composition of vegetable or field crops, and other factors that make up the quality of food, were shown to vary with the fertility of the soil in a series of preceding articles. Yet there are many who contradict those facts (but do not refute them with evidence).

Studies of Curry and Smith

It is appropriate to unearth from their burial some of the above principles of variation in the chemical composition of crops according to the soil and its fertilizer treatments. They have lain forgotten since 1914 in Bulletin 170 of the New Hampshire Agricultural Experiment Station. At that date, Messrs. B. E. Curry and T. O. Smith reported their studies of the hay crops, demonstrating the wide variation in their concentrations of potassium according to the varied fertility of the soil.

These men did not take kindly to the" idea of using commercial fertilizers to add potassium to those granitic soils when those with clay contained, in total, the equivalent of 2 and 3% of potassium oxide per acre per foot of depth. "Some very sandy soils have been found which contain as much as 1%, of potassium oxide (equivalent). Such soils carry a considerable amount of minerals in connection with the same," they reported.

They conducted experiments on about a dozen soils, using hay crops for test plants. They measured (a) the yields as pounds per acre; (b) the concentrations of potassium (as potassium oxide) in the dry matter; and (c) the total potassium removed by the crops when the soils were given (1) no fertilizer treatment, (2) Chili saltpeter or sodium nitrate, (3) saltpeter and potassium sulfate, (4) saltpeter and acid phosphate, and (5) saltpeter, acid phosphate and potassium sulfate.

Facts presented

Using the average values of their data from that many soils, their records presented by graphs in the accompanying chart set out these facts:

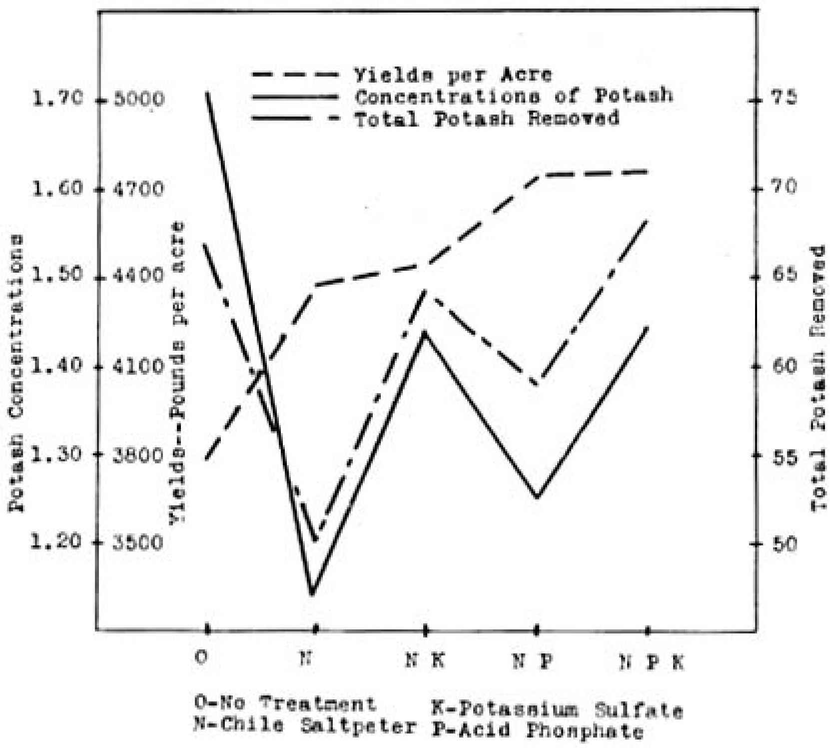

FIGURE I . . . Variations in yields of hay, in its concentrations of potash, and in the total of that removed in the crop annually--according as different combinations of fertilizers were applied. (Data published 1915, Bulletin 170, New Hampshire Agricultural Experiment Station. B. E. Curry and T. O. Smith.)

(1) No proportional relation could be established between the yields and the percentages of potash in the crops.

(2) The amount of potassium removed shows clearly that as the yields increased the potassium taken increased.

And (3) The other nutrient elements applied as fertilizers to the soil served to lower the hay crop's concentration of potassium in some cases, and to increase it in others, even though each element added served to increase the crop yields. Nitrogen added singly served most to lower the concentration of potassium in the crop. Phosphorus used alone reduced the concentration some below that of no treatment; sulfate of potash also reduced it but less than the preceding two treatments. It brought little change in the yields. That fact tells us that the potassium was available from the natural pulverized rock supply in the soil. It was not the factor limiting the yields. But when all three, *viz.*: nitrogen, phosphorus and potassium, were added to the soil, the yields, the concentration of potassium in the crop and the amount of it taken from the soil were highest. This tells us that some other fertility or soil factors needed to be corrected to gain still higher yields.

Less costly

Research is repeating just such studies today, when it would be less costly to search out of the literature just such knowledge established nearly a half century ago. Little attention is now going to the natural delivery to the crop of potash from the tremendous supply in the natural minerals of most any soil. Little recognition is given to the unbalancing effects on plant composition by adding--for example--soluble nitrogen, of which but a low portion is taken by the crop.

Even as early as 1914, the addition of the three elements, nitrogen, phosphorus and potassium, suggested that other fertility elements not in the commercial fertilizer bag need to be considered, for higher yields and possibly uniform quality, as animal nutrition. At that early date the owners of livery stables observed that Chile saltpeter on their hay ground made their horses unable to stand up under the road work expected of them.

Buried evidence

Buried in the unopened publications there is the evidence which tells us that the manuring of the hay meadows was mobilizing the natural mineral potash from the soil into the crops; that mobilization was high enough to give larger total amounts in good yields; and it resulted in wide variation of the concentration of the potassium in the forage when separate elements such as salts were applied to the soil. At that early date the animal health responded according to the soil growing the feed under commercial fertilizer treatment. Mere contradiction of the facts in these buried and unopened reports isn't a refutation of their truth about nature's behaviors. To say "I don't believe it," is not necessarily a negation of the report. It may be merely a confession of a lack of knowledge of it.

Let's Live Magazine, July, 1961

HIDDEN IDEAS IN UNOPENED BOOKS

Nitrates . . . Possible Poison Grown Into Foods

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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The conversion of organic nitrogen of the soil into the highly oxidized form of nitrate (saltpeter) is a natural microbial activity in any fertile soil. This soluble kind of nitrogen is taken readily from the soil for normal plant nourishment. But under disturbed conditions for the plant and for the soil microbes, like drought and its disruptions, these may cause the nitrates to accumulate within the plant rather than to function normally for their synthesis into plant proteins.

Excessive nitrates in forages and foods have brought disturbing publicity in the last few years. That was a sequel to the shortages of soil moisture in the mid-continent for the highly-fertilized corn crop in particular. (1) The damaging effects of the high temperature on the plant's physiology have not been discussed. Emphasis has gone to the dangers from nitrogen applied as a fertilizer. There have been animal deaths on some soils not given fertilizers and such even before the wider use of them, as soil treatments.

Proof is difficult

It is extremely difficult to prove any substance poisonous in feed or food, especially when it comes from a fertilizer--by way of the soil and the crop plants--to animals and man. For such proof in court, it seems almost necessary to exhibit the corpse, or some morbidly clinical case. A sub-clinical one is not sufficient. Animals killed by nitrate poisoning have been periodic exhibitions. They represented terrific losses to individual, but scattered, farmers over many years. They have been reported in the publications of the Experiment Stations in certain climatic sections of the United States and with careful diagnoses as far back as 1895. (2)

Potassium nitrate (saltpeter) was found crystallized out on drought-stricken corn stalks which had poisoned cattle eating it with the fodder. The burning of the dried vegetable matter gave a sparkling effect of miniature explosions of gun-powder. That phenomenon was considered a simple test for nitrates as poisonous feed.

Precautions taken

The pioneers, who used nitrates in the salt mixture for tanning pelts and hides, made certain they were kept away from livestock, which were inclined to lick or chew the salty skins with lethal results. In the first decade of this century studies were under way at the University of Illinois which used humans in so-called "poison squads" to test the effects of saltpeter "cure" of pork on men consuming such in contrast to those taking similar meat cured without nitrates.

Nitrates in different vegetables have also been under study. They, like the forages for animals, proved that the soil, modified by the variation in the weather during the growing season or by certain soil treatments, could be a disturbing factor responsible for wide variation of the concentration of nitrate nitrogen in the vegetative mass. Naturally, the concentrations were low in the seed parts of the plants.

Professor J. K. Wilson, a distinguished (deceased) microbiologist of the Cornell Experiment Station, who was interested in the biochemical transformations of soil organic matter, reported many determinations of nitrates in plant juices, extracts and dry matter as early as 1942. [(3)] His observations deserve attention anew, buried as they are now in unopened volumes.

Revelations made

Wilson's report revived interest in an earlier publication of the Kansas Station. In that, [(2)] N. S. Mayo reported on cattle killed by eating drought-stricken corn fodder in 1895. That grain crop was then just going west, in its move from the humid to the semi-humid area. C. S. Gilbert, et al., of Wyoming, reported nitrate poisoning for cattle by weeds under drought effects in 1946. [(4)] Two years later, the Easter Sunday Edition of the Kansas City *Star* had the headline, "Win in Dash for Life", on March 28, 1949, reporting the recovery of a baby from nitrite poisoning via shallow well water used in its formula, after a dash to a Kansas City hospital.

In the Kansas situation, a very dry autumn and early winter were followed by an accumulation of later winter snows. Those were melted by the early spring rains to move the soil nitrates into the wells of mid-Kansas, where only the third one of the reported babies so poisoned was saved from death. It was those buried ideas in the older reports that prompted Professor Wilson's extensive testing of leafy vegetables, frozen foods, baby foods, and other possible nitrate carriers among foods to learn whether they may contribute to *hemoglobinemia,* or other toxic, if not lethal, conditions for adults. Some of his data for vegetables are given in the accompanying Tables I, II, and III.

TABLE I
Nitrates in Green Vegetables Collected August-September 1942 (As KNO^3, parts per million in Expressed juices)

Beets	1,333
Broccoli	785
Cabbage	2,222
Celery	1,212
Cauliflower	2,000
Carrots	442
Cucumber Vine	4,170
Cucumber Fruit from Above	121
Lettuce (head)	1,250
Lettuce (Curly)	870
Lettuce	666
Water Melon Vine	10,000
Water Fruit from above	500
Water Vine	1,000
Water Fruit from above	1,000
Tomato Fruit	0

TABLE II
Nitrates in juices of green vegetables on Market May 1948 (KNO^3 equivalent ppm)

Asparagus	50
Cabbage	1,200
Cabbage	186
Carrots	325
Celery	1,240
Celery (pascal)	3,232
Lettuce (curly)	1,818
Lettuce (head)	400
Potatoes (new)	63
Spinach Plant 1	2,353
Spinach Plant 2	1,600
Spinach Plant 3	2,000
Spinach (Quick frozen)	3,636

TABLE III
Nitrates in Some Baby Foods on the Market (KNO^3 equivalent in ppm)

Green Beans	37

Beets	333, 750
Carrots	3, 0
Peas	0
Spinach	616, 833, 0, 0
Tomatoes	0
Vegetable Soup	37

Chemical reactions

Those earlier reports tell us that, "When the nitrate is ingested, it passes into an environment where oxygen is in demand; the nitrate is reduced to nitrite; and the latter is toxic. This nitrite, once in the blood stream, combines with the blood. It produces a *methemoglobin* to prevent the blood from supplying oxygen to the tissues, and thus the body suffocates. . . . The disease was reported similar to poisoning by *hydrocyanic* acid."

Wilson cited the report that 1.5% of potassium nitrate in the dry matter of feeds was known to be lethal to livestock, or to cause abortion. Missouri more recently cites that amount as deadly; reproduction difficulties at 1.0-1.5%; symptoms suggesting vitamin A deficiency at 0.6-1.0%; and no trouble with less nitrates if a normal ration is fed. For the concentration of nitrate nitrogen in water for babies, J. G. Heart suggested the maximum safety limit of 10 ppm. [5]

We are a bit slow to learn that the soil is a biochemical matter about which we should be concerned, lest we upset nature as we try to manage her efforts more for our economic advantages in labor and monetary outlay. Hidden ideas in the past can help us see more of the natural in the garden and the field, if we will but open to some of these basic facts in the recorded experiences escaping us because the books remain unopened.

(1) George B. Garner, "Learn, to Live with Nitrates". Mo. Agr. Expt. Sta. Bul. 708, June, 1958.

(2) Mayo, N. S., "Cattle Poisoning by Nitrate of Potash". Kansas Agr. Sta. Bul. 49, 1895.

(3) Wilson, J. K., "Nitrate in Plants: Its relation to fertilizer injury, changes during silage-making and indirect toxicity to animals". Jour. Amer. Soc. Agr., 35:379-290, 1943.

(4) Gilbert, C. S. et al, "Nitrate Accumulations in Cultivated Plants and Weeds". Wyo. Agr. Exp. Sta. Bul. 277:1-37, 1946.

(5) J. G. Heart, "New 'Blue Baby' Diseases". Science News Letter 53: No. 18, 275-276, 1948.

Let's Live Magazine, August, 1961

HIDDEN IDEAS IN UNOPENED BOOKS

To Keep the Soil A "Living" One

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Some studies of the effects of incorporating organic matter regularly into the soil were undertaken by the Missouri Agricultural Experiment Station as far back as 1917. (*Missouri Agr. Expt. Sta. Res. Bul. 249. 1936. Methods of Incorporating Organic Matter with the Soil in Relation to Nitrogen Accumulations.*) These told us how much organic matter needs to go into a cultivated soil annually, if that soil is to maintain "the standard of its living" which it exhibited when broken out of its early sod. This record of the "living" soil has too long remained hidden.

Know soil needs

Under natural climax crops all the produce of the soil is left on it. This decays in place and the return to the soil serves to build it up for its higher living, as measured by the accumulated nitrogen, the index of protein, or the living contents of cells. It is helpful to know just how much of the organic matter grown on a soil needs to go back annually to keep the living soil actively and healthily so. If the garden plot, or the field, is to be kept high in its organic matter content while its crops are hauled off, how much additional soil area must there be supplying the organic matter to keep it so? Then also, there is the question whether organic matter is the only addition to the soil needed to keep it living.

Experiments in treatment

Beginning with 1917, some plots of Putnam silt loam soil were kept free of crops and of erosion under screen covers. Each plot was tilled once annually to duplicate the plowing and preparing of a seed bed. One series of plots was given no other soil treatment; a second series turned some dry, chopped red clover hay into the soil at the rate of two and one-half tons, or the equivalent of 106 pounds of nitrogen, per acre; while the third series had the same additions, but these were applied after the tillage to leave the organic matter on the surface of the soil for its remains to be turned under by the tillage of the next year. Chemical measurements of the total nitrogen of the soil were made annually at tillage dates from 1918 to 1932 inclusive, or for a period of 15 years, in order to determine the changes in the soil's supply of organic matter during that period.

For this study it was necessary to import the clover as a growth from some other soil if we were to study the addition of the organic matter as an effect separated from that of the growth of the crop on the same soil. This allowed the microbial activities within the living soil to be measured in the absence of effects from the growth and organic additions of the roots of a crop. It aimed to determine the effects of added plant tops when the soil made no expenditures in plant production. Its only expenditure was in growing a microbiological crop, the one living within, and at the expense of, the organic matter of the soil.

Basic facts

The following are some of the basic facts that exhibit themselves via this soils study:

1. The increases obtained in the soil's nitrogen content when given the annual additions of clover differed by only the small figure of 3%, according as the clover was left on the surface or was mixed into the soil during simultaneous applications and tillage. Since this advantage of 3% was in favor of the organic matter left on the surface, we are told thereby that the surface application did not volatize or leach any more than the incorporation into the soil.

Measured by the soil's increased store of nitrogen coming from the atmosphere via legumes, the surface application of organic matter, according to nature's plan, was more effective than man's practice of mechanically incorporating it into the soil.

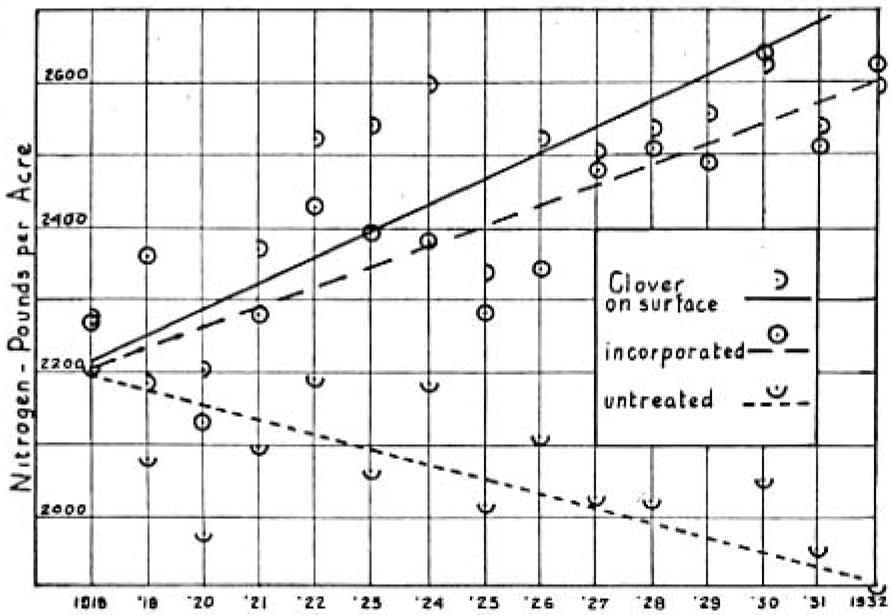
Clover improved soil

2. Even with these heavy applications of nitrogen in leguminous organic matter, the soil's store of nitrogen was increased by no more than 20% (one-fifth) of the annually applied nitrogen. However, when this increase is corrected for the annual decline of the soil's store of nitrogen under tillage and under no additions of organic matter, the effects of adding the clover, for keeping the living soil actively so, approach an improvement by 33% (one-third) of the nitrogen applied annually.

3. For the untreated soils there was an annual loss or a decline in the store of nitrogen. This was equivalent to the upbuilding effect from one-half ton of clover, as demonstrated on the treated plots. Hence, this soil, living under fallow, requires one-half ton of clover (dry weight) annually merely as a "maintenance ration".

Nitrogen studies

4. There were neither losses nor gains of nitrogen in the subsurface layer of the soils given no additions of organic matter. But, below the surface soil where the clover was incorporated, the subsurface gained more nitrogen than the corresponding lower layer under the area where the clover was left on the surface.



ANNUAL NITROGEN CONTENTS . . . The annual nitrogen contents of the surface soils given annual applications of red clover--either on the surface or incorporated--increased steadily for 15 years to retain about one-third of the applied nitrogen. Given no organic matter, the annual loss of nitrogen was the equivalent of that in a half ton of red clover.

This tells us that its incorporation mobilized the nitrogen more rapidly into the subsurface soil. It suggests that applying organic matter as a surface mulch may be a more efficient use of its nitrogen as fertilizer for crops, so far as keeping a larger active store of nitrogen in the soil's surface layer is concerned.

Mineral fertilizer

5. These facts were obtained from a soil to which mineral dust was added naturally from the atmosphere by the prevailing winds, which brought it out of the Southwest at the rate of 1000 pounds per acre annually. This figure was obtained from the dust collectors for the study of the loessial deposits, such as the river bluffs, which came from the drier areas in the Missouri River's flood plain.

The dusts consist of naturally pulverized but unweathered rock minerals, according to examinations under special microscopes. These minerals have doubtless been a factor in the upbringing of nitrogen by organic matter on these shallow soils, underlain as they are by a plastic, hydrogen-saturated clay subsoil in which a slight increase in nitrogen resulted under addition of clover to the surface soil. What the nitrogen increase would have been in the absence of the additions of this natural rock fertilizer--so common in the loessial soil area, like the Corn Belt--must remain a conjecture so far as this study went.

These studies of nearly five decades ago served to measure for us the two natural forces in "soil construction", namely (a) the regular offering within the soil of unweathered, mixed, rock minerals; and (b) the annual additions of the leguminous or highly nitrogenous organic matter. The microbial digestion of the organic matter serves to weather the rock minerals more rapidly and to release their insoluble nutrient elements of microbial combination with organic compounds as more favorable plant nutrition in ways we do not yet fully comprehend.

Soil destruction

These studies measured also the forces of "soil destruction" in the same soil under man's failure to return organic matter to it. By balancing these two accounts of construction and destruction against each other, we have the clear picture of the difference between man's management of the soil and nature's, when she builds climax crops of plants, animals and man for their healthy survival. It is the weathering of the natural minerals by the maintenance of a generous supply of organic matter that keeps the "living" soil actively so, as these studies have so clearly demonstrated.

Let's Live Magazine, September, 1961

HIDDEN IDEAS IN UNOPENED BOOKS

Soil's Resurrection In Three Years

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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During the first 10 or 20 years of the present century, the scientists studying soils and plant nutrition emphasized two main factors. They were concerned about mineral breakdown within the soil as the source of the inorganic nutrients for plants. And they were even more concerned about the return to the soil of barnyard and green manures which were considered the agency by which the living soil maintained its productivity. That is the soil's source of internal energy.

One of the pioneers among the scholars of soil science and plant composition at that time was Dr. Cyril G. Hopkins of the University of Illinois. His plans for maintaining "soil fertility and permanent agriculture" [(1)] called for close cooperation with nature. His research aimed to comprehend the underlying mechanisms by which the essential elements within the inorganic rock particles of the soil are broken out; how they are present as a reserve in the soil, yet can be available in sufficient quantities for plants during the growing season; and how the organic matter returned to the soil functions to increase availabilities of the inorganic nutrients and to contribute organic nutrition to crops. He envisioned Nature "making bread from stones". [(2)]

Strong acid treatment

As early as 1909, Dr. Hopkins pointed to soils deficient in decaying organic matter as those on which chemical fertilizers demonstrated their interactions. He was confident that decaying organic matter released inorganic elements from the mineral particles. He undertook research with his staff, aiming to learn what amounts of potassium in the soil could be made usable for crops by starting with the "insoluble residue" of a productive soil. That residue had been produced after treating the soil by strong hydrochloric acid at 212° F for a long period and then washing it free of solubles by distilled water. That was the treatment employed in the laboratory for removing anything that might become soluble for plant use.

In one of his early experiments [(3)] enough of such "insoluble residue" was prepared to fill three pots. Then, with two similar pots of normal soil for comparison, the following treatments of the "insoluble residues" were set up. To one pot (No. 2) there were added calcium carbonate, calcium phosphate, calcium sulfate, magnesium sulfate and iron chloride. Then another similar pot (No. 3) was given that same list of treatments, but with ammonium nitrate in addition. Then a fourth pot (No. 4), which duplicated the second and its treatments, was given also sodium ammonium phosphate and sodium ammonium acid phosphate to supply soluble nitrogen and phosphorus.

Rocks weathered in one year

Those soils were seeded to inoculated red clover and rape in 1910. The clover failed, but small rape plants started and were soon turned under as the first addition of organic matter. Pot No. 2, as the first of the "insoluble residue" series, was given 0.2 gm. of potassium sulfate, some ammonium phosphate and ammonium nitrate. Then also, since these three "residue" pots were in a bad physical condition, each was divided into equal parts to which acid-treated and washed quartz sand was added to give duplicate pots of half sand and half "insoluble residues". These six pots, along with the normal soils, were planted to red and alsike clovers.

During that first year as much as 6½ grams of dry matter from one pot resulted. It contained 22.5 mgs. of potassium, when the total potassium applied was about 1.4 mgs. before leaching. The lowest crop yield was 0.5 gm. dry matter, containing twice as much potassium as was initially added. The crop residues were returned to the soil.

Rate of weathering increased

The crop grown in 1911, the second year, was better than that of 1910. It was harvested on August 9, and again on December 21. The crops per pot of "residues" soils ranged from 11.33 to 30.33 gms. dry matter. The organic matter was returned to the soil.

Crops take over

The crop of clovers in 1912 was still better. The tops harvested separately ranged in weights of dry matter per pot of "residue" soils from 25.25 to 41.07 gms.; and the weights of roots from those ranged from 10.47 to 26.80 gms. The potassium contained in the tops ranged from 90 to 157 mgs. per pot. That in the roots ranged from 21 to 25 mgs.

Since not over six milligrams of potassium had been added to the pots 3, 3a, 4 and 4a from 1910 to 1912, it is significant to note that the total potassium in the crop of 1912 alone from those four pots was 529.2 mgs. of which 523.2 mgs., or nearly 99% must have come from what was considered "insoluble residues" of the soil.

Dead soil restored

As a consequence of these experimental results, Dr. Hopkins told us the following as facts. "The results indicate that after two years of green manuring, sufficient potassium was liberated from the "insoluble residue" to enable the clover to be benefited by the lime and phosphate fertilizers so as to outyield the crops on the normal soil to which no such fertilizer had been applied.

"Potassium can be liberated from the inexhaustible supply naturally contained in the normal soils of Illinois."

Dr. Hopkins contributed much research work to support his belief in the importance of green manuring and all other means of maintaining a high level of active organic matter in the soil to further decomposition of the soil's minerals as sources of plant nutrients. His ideas about soil fertility and permanent agriculture are well worth reconsidering as hidden ideas among unopened books.

(1) Cyril C. Hopkins. Soil Fertility and Permanent Agriculture. Ginn and Co., Chicago, 1910.

(2) Cyril G. Hopkins, Bread from Stones. Ill. Agr. Expt. Sta. Cir. 168, 1913.

(3) Cyril G. Hopkins and J. P. Aumer. Potassium From the Soil. Ill. Agr. Expt. Sta. Bul. 182, 1915.

Let's Live Magazine, October, 1961

HIDDEN IDEAS IN UNOPENED BOOKS

Schedule of Soil Fertility Delivery And Crop Growth

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
Prof. Emeritus of Soils, College of Agriculture, University of Missouri, Columbia, Mo.

I. Crop Yields

Just how much inorganic nourishment a crop takes from the soil (per week, month, or season), and to what extent that contribution of mineral breakdown from the soil's reserve will result in different parts of the plant was very clearly presented for the mineral-rich, high-protein crop of alfalfa as early as 1897. Professor John A. Widtsoe reported a rare assembly of facts about the soil fertility required, and about the differences in chemical composition of the plant as potential nutrition for animals, in *Bulletin No. 48* of the Utah Agricultural Experiment Station.

Prof. Widtsoe's data deserve recollection and repetition for emphasis. They show the pronounced variations in the plants as crop yields and as nutritional values, according to the age of the plant. Reading his report at this date will be enlightening. A critical study of his data will help one appreciate the spring season as the naturally favorable birthdate of the young of grazing animals.

Dr. Widtsoe's report lends itself to review by discussion in two parts, namely, (a) soil fertility taken during periods of growth of the crop (alfalfa) and (b) soil fertility and crop quality by seasonal periods. We shall consider the subject accordingly.

Growth periods (alfalfa)

Since alfalfa is a perennial forage crop, and permits of several cuttings during a single year, it is significant to note that each period of plant growth taken as a cutting for hay is a cycle of development and physiological changes from youth of the plant to its maturity, as it were, for each cutting.

Let us examine, first, the yields of the crop as growth (increase in dry weight) per week and month in terms of the whole plant; then, also in terms of the separate plant parts, as leaves, stalks and flowers (see chart). For the first 12 of the 16 weeks (May 4 to August 4) there is a steady increase in the dry weight of the whole plant. Then for the next four weeks (the last one-fourth of its growth period) there is a decrease.

The weight of the stalks takes the same graphic pattern of increase for the respective dates; but for the last quarter of the growth time, the weights are constant rather than on the decrease.

Leaf increases

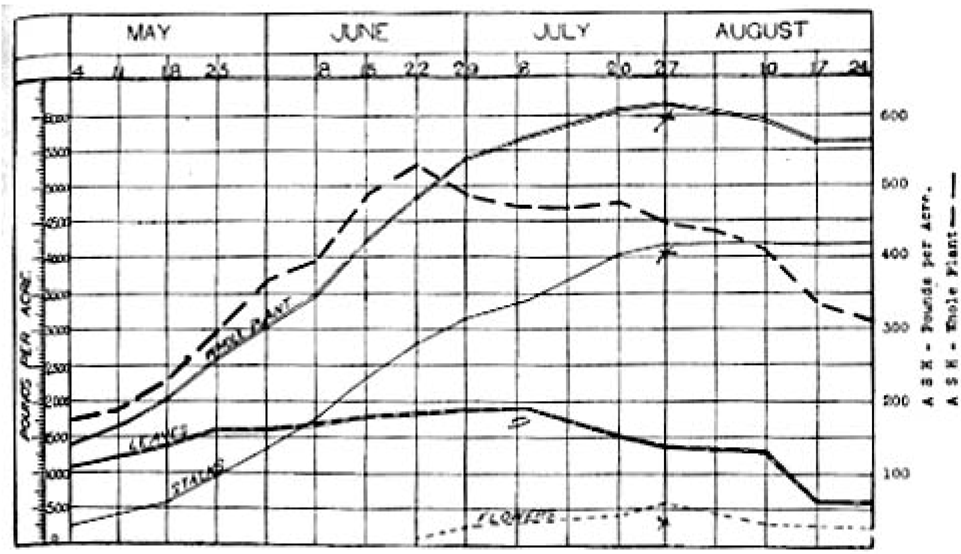
The weights of the leaves do not give such a rapidly rising curve as the one for weights of the stalks, or of the whole plant. The leaf increase in weight ceases three weeks before the cessation of growth as bulk by the stalks and the whole plant. These facts point to the late increase in bulk of the whole plant as being due mainly to that of the stalks. The latter represent storage of carbohydrates, and reflect the photosynthetic activities of converting water from the soil and carbon dioxide from the atmosphere into sugars, starches, cellulosic and other fuel substances. Those are the aspects that contribute tonnage per acre only, so commonly the economic interest in crop growth.

Leaf growth depends on the biosynthesis of proteins by the leaf itself while simultaneously carrying on photosynthesis of carbohydrates. It is the increase in proteins that grows more leaf surface to catch more sunshine. It is important to note in the illustration that the increase in mass of leaves continued for but nine of the 16 weeks. Cessation of leaf growth, though, came but two weeks after the start of flower production, or after the beginning stage of reproduction.

Role in propagation

The weights of the flowers reached their maximum at the same date as the stalks and as the entire plants. One can see this shift in the weights of leaves connected with the biosynthesis of proteins for growth of the flowers, their fertilization and their activities in providing the seeds as means of reproducing the plants and preserving the species. Here we see the shift in physiology from one of vegetative increase in bulk to one emphasizing proteins for reproduction. This shift registers in the decreased mass of the whole plant. Likewise, the threat of it is shown two or three weeks (flower start) before the leaf weight drops.

This physiological shift becomes a shock, as it were, to vegetative increase. It is triggered when the pollen (male cell) is dropped from the anther to be caught on the stigma, grown down into the ovary, and fertilizes the egg for production of the seed. This conception releases many new hormones and other catalytic agencies to terminate the vegetative physiology and give activity and emphasis to reproduction. This brings about the termination of more yield or tonnage output.



THE SCHEDULE OF WEIGHT INCREASE of the first crop of alfalfa, according to different parts of the plant, and according to the soil's delivery of fertility (ash, pounds per acre) during the periods of crop's growth. (Data from Bulletin 48, Utah Agr. Expt. Sta., 1897.)

Even though plants are monoecious organisms, they are shocked decidedly when the separate female part demonstrates the act of conception. Some distinct physiological changes occur. The plant, initiating reproduction, experiences some changes in body biochemistry, as does the bride taken suddenly by some strange symptoms and a disturbing surprise.

Growth and fertility

We need to remind ourselves--with emphasis--that the soil's contribution of fertility, or plant nourishment, must precede the growth of the crop. The germinating seed sends its root down into the soil first, and then, later, the plant top up into the air. Hence, when the total amount of ash elements going into the alfalfa crop are measured by time periods, it should be expectable (though possibly surprising) that the total ash in the crop reaches its maximum by the seventh week in a plant's life history lasting about 16 weeks. The maximum of its fertility must have been mobilized from the soil into the young crop of alfalfa (see chart) before its season of growth, or its life, is half spent. The ash data are reported graphically only for the crop as a whole for comparison with the amounts of the crop's yields as bulk of the different plant parts.

The additional fertility data by Prof. Widtsoe (not shown in the chart) emphasizes the facts also that (1) the maximum ash content of the leaves was reached by the sixth week, one week earlier than for the plant as a whole; (2) that declined to a total of almost a third by the end of the season; (3) the maximum ash of the stalks occurred at the seventh week, determining that for the plant as a whole; (4) the ash content of the stalks declined but little from that date to maturity; (5) the maximum ash in the flowers was not reached until the 12th week, the date of maximum crop bulk.

One needs but glance at the graphic report by Prof. Widtsoe to realize the simple fact that the soil must already be a dynamic force at the time the crop is started. The soil must have made its major nutritional contribution before the first half of the crop life is gone. The leaves, as the photosynthetic and biosynthetic power, must have their store of fertility in stock and in action by the time three-eighths of the crop life is gone.

All of this was emphasized before the close of the 18th Century, yet we are slow to appreciate the simple fact that the soil is the power of creation of all living substances and must be highly dynamic when we make the planting.

(Continued in November)

Let's Live Magazine, November, 1961

HIDDEN IDEAS IN UNOPENED BOOKS

Schedule of Soil Fertility Delivery And Crop Growth

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
Prof. Emeritus of Soils, College of Agriculture, University of Missouri, Columbia, Mo.

Part 2: Crop's Nutritional Value

It was reported in last month's article that a forage crop, like alfalfa, increases its yield of dry matter for three-fourths of its growth period, or season. It attains its maximum by the 12th of the total of 16 weeks. Such was the schedule when the weight of the entire crop as bulk was the measure. But when the weight of the leaves was considered, the maximum yield was attained three weeks earlier, or by the ninth week of growth.

Leaf grows first

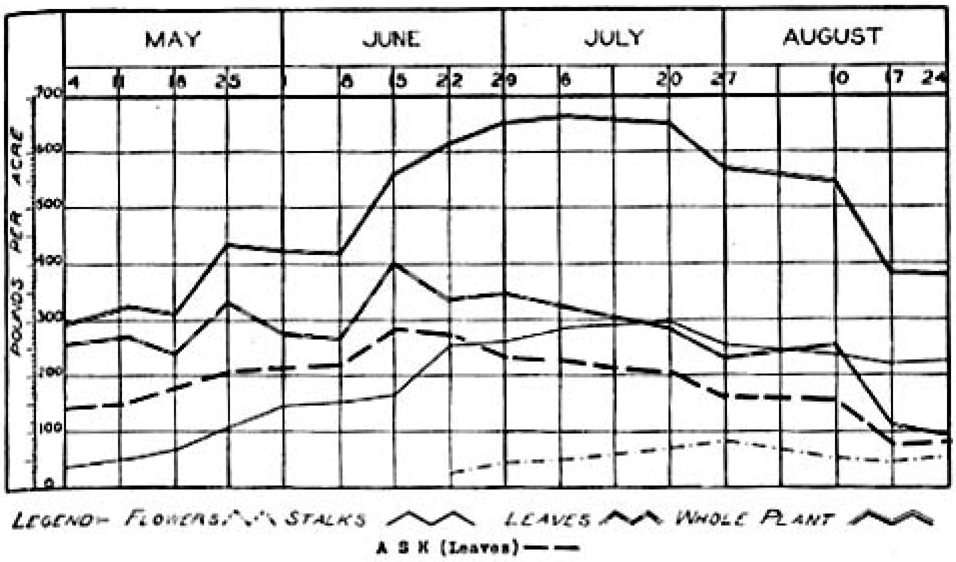
Since the leaves carry out both photosynthetic and biosynthetic activities, the photosynthetic activity makes the increase possible through extended leaf surface via photosynthesis of proteins as living substance. In the early portion of the plant's life, the extension of leaf surface, the increased photosynthesis and the enlarged bulk dominate. But in the later period, the activities of the leaves shift away from vegetative output to the reproductive one of seed formation, when the proper degree of maturity in the plant's schedule demands.

The reproductive action calls heavily on the proteins. They are not a direct result of photosynthesis. They are an output of the plant's life processes using carbohydrates, in part, for energy and also as starter compounds from which to synthesize the proteins. The elaboration of that living substance demands also extra and early fertility from the soil.

Although the continued increase in yield extended itself through three-fourths of the life period, it required that the highest supply of fertility be delivered to the plant before scarcely half of the growth had taken place. This demand comes through the life processes which are building the proteins, our life-supporting foods, much more than from the photosynthetic processes that pile up carbohydrates, which are only fuel foods.

Early fertility delivery

That the delivery of fertility by the soil is most closely connected with the output of quality nutrition in proteins for animals, by a crop like alfalfa, will be quite evident if we will notice the schedule of the concentrations of albuminoids (the flesh-formers, the important part of "crude" proteins) found in the alfalfa plants and its correlation with their fertility uptake from the soil. (See graph.)



THE SCHEDULE OF YIELD INCREASE of albuminoid protein in the first crop of alfalfa, in different parts of the plant, according to the delivery of fertility (ash, also pounds per acre) in the leaves during the growth periods of the crop. (*Data from Bulletin 48, Utah Agr. Expt. Sta., 1897.*)

We previously reported that the highest yield of leaves occurred in the ninth week of the 16-week session. But the high nutritional quality, the highest concentration and yield of the albuminoids in the leaves, occurred in the sixth week of this same length of growing season. The albuminoids at their maximum preceded the measurable amount of flowers. This fact emphasized the shift of that form of protein from vegetative increase to reproductive output. It is indicated by the drop in the graph for albuminoid content of leaves during the seventh week. Simultaneously, there is a decided rise in the graph for albuminoids in the stalks, which suggests they are enroute from leaf to flower and caught in the stalk of the plant.

Physiological changes

It is also in the seventh week that the albuminoids--in both the stalks and the plants as a whole--are not much below the maximum for the entire season. The growth period, from as early as the fifth to the seventh week, points out several marked physiological activities and changes. These include (a) the maximum supply of albuminoid protein in the leaves and its mobilization from them and (b) its services for the increase in the crop yield from 3500 pounds at the fifth week to more than 6000 pounds per acre by the 12th; and (c) the initiation and production of the flower crop, for the plant's reproduction and the survival of the species by the formation of seed. But most important for these dynamic aspects of crop growth is the delivery of the fertility which reaches its maximum in the synthesizing part of the plant (that is, the leaves) by the sixth week (with a sharp rise from the fifth week as shown in the graph), and reaching its maximum in the entire plant by the seventh week of its season of 16 weeks.

For many observers, crops are like Topsy, in the novel, Uncle Tom's Cabin, who said, "I wasn't born, I just growed." Little thought is given to the decided shifts and changes in the plants life processes during the growing season. Much less is it generally realized that the success of crop production depends on the activities of the living soil, through the dynamics of which the crop's nutritional quality is controlled. Yet as early as 1897, Professor Widtsoe reported the data by which these facts, and more, were clearly revealed. Much knowledge about nature remains hidden in unopened books.

Let's Live Magazine, December, 1961

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

"Balanced" Soil Fertility Requires High Phosphorous

Part VI

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The essential nutrient element, *phosphorus,* represented an unusually large part of the earlier kind of commercial fertilizers. They carried then, and still carry, nitrogen, phosphorus and potassium as their fertility contents for legal and labelling purposes under the common N-P-K symbols. There was originally a wide ratio between the phosphorus and each of the other two constituents of the fertilizers when the mixtures were labelled 2-10-2 and 2-12-2, with the three elements present in the 1-5-1 and 1-6-1 ratios respectively.

"Pushing up" dangerous?

Now that the nitrogen (N) and the potassium (K) have more recently been increased in the mixtures to give a 1-1-1 ratio like the 12-12-12, for example, which is emphasized for the economic advantages in handling the more concentrated material, this ratio may be nutritionally disturbing if not even detrimental to the growth of the plants. This "pushing up" of these companion elements of the phosphorus has been shown to lessen the amounts and concentrations of the phosphorus going into the vegetable matter grown for consumption as human and animal foods. This says nothing of the synthesizing processes within the crops which may be disturbed to give us less of the organic compounds the plants create for our nutritional benefits not yet cataloged.

More recently human food supplements, carrying organic phosphorus compounds of higher concentrations, have come into extensive use to the dismay and counter campaigns by some organized groups of folks. But since the consumers are recognizing the improvements in health resulting from the use of such supplements of organic phosphorus, it might be of broader health service if we should reconsider the phosphorus problem in the soil for crops.

"Hidden hungers"

We need to remind ourselves, first, that in cases of the humid soils, where the most abundant agriculture is located, those soils have always been low in their phosphorus supply. They have shown their responses to applied phosphorus by better crops most extensively through animal choice of forage and better nutrition of both animals and man. The legumes in both their forages and seeds have been the commercial supplements to home-grown feeds to the point of having become big business. Those legumes render better service as nutritional supplements in the humid region when grown on soils treated with both calcium and phosphorus.

All of these facts suggest that perhaps phosphorus deficiencies may be the cause of "hidden hungers" more often and more seriously than we realize and recognize only under clinical symptoms; and then not unless we find such manifestations of health troubles occurring repeatedly in the same body part. Animals indicate their phosphorus deficiencies by depraved appetites. Shall we not entertain the thought that extensive shortages of phosphorus in the soil for our protein-producing crops might mean deficiencies of organic phosphorus compounds for humans?

If then some food supplements, like organic phosphorus compounds are used with satisfaction to better health by a few individuals, it would seem well to consider health on a national scale or pattern, and to study the services by such supplements to human foods in their relation to the climatic pattern of soil development. Would it not be well to investigate whether phosphorus deficiencies in human nutrition are as extensive and serious as they are in plant nutrition in a given soil area? This would seem wise when phosphorus shortage in the soil has made phosphatic compounds big fertilizer business--for healthier crops and healthier animals.

Then when the nitrogen and potassium are pushed up in their fertilizer ratio to phosphorus, which as an imbalance in the plant's diet is apt to cut down the concentrations of the latter in the crops, may we not be undermining the health of plants, animals and man by bringing on phosphorus deficiencies as hidden hungers? It would seem wise to test that question by feeding ourselves organic phosphorus supplements to learn if better health does not result. If it does, such results would tell us that the food supplement would not be necessary if we would study the soil and provide "balanced" fertility in relation to the composition of the plants for their better nutritional values. Health from the ground up would be preferred by all to any health patched up by antidotes and hypodermic needles.

(Continued in January)