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Let's Live Magazine, January, 1957

Rhododendrons . . . a problem of soil fertility, not acidity

by William A. Albrecht, A.B., B.S., M.S., Ph.D.
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Rhododendrons, azaleas and other shrubs belonging to that same family, are considered "hard to grow" on soils containing much lime or calcium. It is commonly said, "They require an acid soil." So far as earlier publications report, it was not known whether poor growth on calcareous soils by these plants is due to the soil alkalinity--that is, the high pH; or whether it is due to injurious effects by the calcium itself; or by some other factor induced by the soil's surplus of this element.

This same confusion prevailed--and still persists--in connection with legumes of which the opposite is said, "They require a calcareous or non-acid soil." Legumes have been shown to fail on acid soils, not because there is present so much of the element hydrogen--which gives them a low pH or makes them acid in chemical reaction--but because from a soil naturally developed so highly that much hydrogen has come in, there has gone out the calcium, magnesium, potassium, and other nutrient elements, displaced by the hydrogen or acidity, to starve these protein-producing forages. It is not the chemical soil condition which we call "an acid reaction" that is injurious. Instead it is the absence of what gives complete nutrition for the plants. Legumes grow well on an "acid" soil if they can be properly nourished there.

Rhododendrons

The confusion about the growth of rhododendrons and its requirement of acid soils, or its failure to grow on alkaline or neutral soils, has recently been shown to be another case where it is not the soil reaction but the failing nutrition of this flowering shrub that is the disturbing factor.

It has long been known that rhododendrons showing a yellowing of foliage and failing to grow when transplanted to high-lime soils are restored to normal growth by soil treatments in some cases using magnesium sulfate, and in some by aluminium sulfate. This suggests that these plants cannot tolerate much calcium in their fertility diet from the soil, but will tolerate the magnesium.

Using this observation as his postulate, Dr. Tod of the Edinburgh and East of Scotland College of Agriculture reported (*Misc. Pub. No.* 164) his separation of the effects by soil alkalinity from those by excess of soil calcium. He used an acid soil, growing rhododendrons normally, and made additional pots of it increasingly alkaline in reaction by adding two increments of magnesium carbonate in place of calcium carbonate, or ordinary limestone. This left the soil low in calcium (0.25 to 0.38 milligrams equivalents per 100 grams soil), but gave initial pH values of 4.7, 6.8, and 8.4 in his several three-pot series. The phosphorus in the soil was "very low," while the supply of potassium was "medium."

Slow growth

The seedling growth was slow and the color of the foliage was a normal green, with no signs of the well-known yellowing on neutral or alkaline soils of high pH. There was little difference between the plants grown on these different treatments. They flowered for the first time after five years, with the earliest date of that shown by the soil treatment with the highest magnesium.

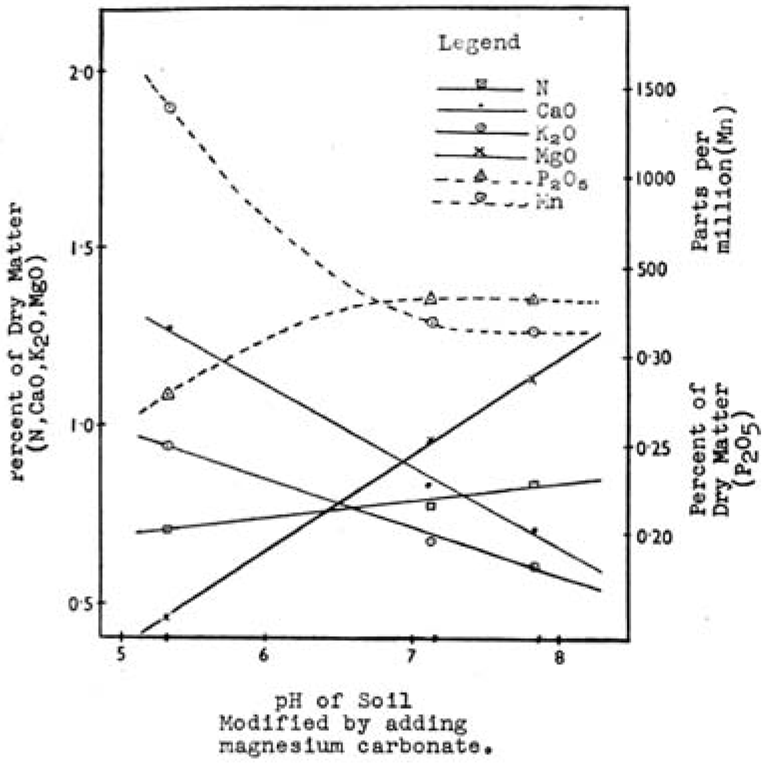

FIGURE I ... Varied chemical composition of Rhododendron plants growing well on three soils of pH 5.3, 6.8, and 7.8 because the soil calcium was low.

Chemical analyses of the plants (See Figure 1) showed that the concentrations of the inorganic, or mineral, elements were what are probably within normal limits. Phosphate in the plants was high. The manganese there was low, but evidently not of deficiency level since no evidence was ever shown previously by leaf symptoms. The magnesium in the plants was pushed up decidedly by this soil treatment. But, while along with this there were increased concentrations of the plant's nitrogen and phosphorus also, it reduced the concentrations of manganese, potassium, and calcium in the plants. These results give suggestions as to what the highly developed soil for rhododendrons representing plant nutrition must offer as natural diet rather than a certain pH or degree of acidity as a soil "condition" in terms of chemical reaction.

An index

We need to see "soil acidity" as an index of the degree of natural development of the soil in going from rock to the sea. Thereby we can get nature's suggestion as to what is left of the rock making soil in terms of plant nutrition. Plants are not sensitive to degrees of acidity. But they are very sensitive to deficiencies in the required diet of soil fertility.

Let's Live Magazine, February, 1957

Is Soil Fertility via Food Quality Reported in Your Varied Pulse Rate?

by William A. Albrecht, A.B., B.S., M.S., Ph.D.
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Note--This is a review of a book which has just come off the press lately, and suggests that each one of us can measure his disturbing reactions of the body when the items going from the digestive tract into the bloodstream are disturbing because the blood chemistry is not equipped to handle those compounds without disturbance. It is similar to what we call anaphylactic shock when the hypodermic needle puts into the bloodstream some substance to which the body cannot accommodate itself.

The discovery by Dr. Coca that the pulse rate is accelerated by the substances we eat, and to which we are allergic, makes it worth trying to learn whether the soil differences will not also be similarly registered via the vegetables grown thereon and tested against the pulse rate.--William A. Albrecht.

"The Pulse Test" by Arthur F. Coca, M.D. University Books by arrangement with Lyle Stuart, 225 Lafayette, New York City 12. Price $3.75.

When are you allergic?" has been about as debatable a question as "when are you drunk?" Refined chemical tests of the blood have recently come into the legal domain, to distinguish differing degrees of the latter disturbing condition of your body in relation to what you drink. Now the simple counting of your heart beats, in relation to what you eat, has been cataloged to detect how seriously you are allergic. Even alcoholism and allergies may have some closer connections and similarities, as the studies and reports of Dr. Coca in his recent book point out.

This publication of 189 pages by an M.D. deals with prevention, and thereby your own cure, of allergies. To him these do not mean only hay fever, hives, and asthma. They include epileptic seizures, high blood pressure, stomach ulcers, diabetes, eczema, colds, migraine headache, hypertension, and a host of other commonly tormenting ailments which do not submit to medication.

Particular premise

Dr. Coca is the conceiver of the particular premise and its establisher as a basis of health--namely, "your pulse rate is accelerated by the foods and substances to which you are allergic." He pioneered the simple, safe, and harmless pulse test by which one can discover his allergenic foods. Then, by the avoidance of them, one can eliminate his own ailments. These are usually in numbers far greater than on the commonly considered list of allergies.

The test

This pulse test suggests itself as a new but simple technique by which one's own eating, in relation to the subsequent changes in rate of heart beat, can measure and report the quality of his food, even as the soil where it was grown determines it.

It suggests that a gardener and his family can play guinea pigs and run regular bio-assays of his soil management and treatments for their own better health. By giving only a part of the garden a particular soil treatment, and by planting the rows of vegetables across both this and the untreated soil area| with seed from the same source, the eating of the vegetables from each treatment separately--followed by the pulse counts and the data therefrom--can] give the possible allergic effects coming via the soil in the food differences.

Bio-assay

Here is a simple means of bio-assay by the human body itself, rather than by guinea pigs or rabbits, of the nutritional quality of the vegetables according to the fertility of the soils growing them. One need not be a chemist, nor a doctor of medicine. You need only to adopt the practice of counting pulse beats in the morning before rising, then before and after eating the vegetables, to appreciate fully the meaning of the old adage which tells us that, "The proof of the pudding is in the eating thereof."

Dr. Coca

Dr. Coca is also an immunologist, a bacteriologist, a chemist, a clinical professor of medicine, a former medical director of the Lederle Laboratories for nearly a score of years; he is a teacher, a member of many learned societies, author of several scientific publications in the field of allergies, and a contributor to medical journals in many parts of the world. His book, *The Pulse Rate,* is written in plain and simple layman's language reporting a significant discovery of health via foods.

It gives the details of the method of putting it into practice by anyone who cares to observe and study the reactions of his body to the foods, etc., he eats--as they hinder or help his health. It bids fair to make each of us more nearly the captain of our own well-being through buoyant health.

Let's Live Magazine, March, 1957

Breeding Out Plant Proteins--Bringing In Diseases

by William A. Albrecht, A.B., B.S., MS., Ph.D.
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Much of what is apt to be considered plant breeding is mainly plant selection and then propagation of what we have selected. Such selections are usually made according to the criteria of taste, color, fruit-size, crop yield, and others. But these are not characters contributing to the plant's better survival, should it be growing in the wild and in the absence of the cultural ministrations like manuring, fertilizing, spraying and other helps for survival.

In the cross-breeding of one kind of plant with another, we select one for a certain set of characteristics and observable qualities. We select a second for another set. Then we cross these two, usually reciprocally; that is, using the first as the male on the second as the female and then vice versa in the hope for the desired combination of characteristics and qualities.

Experiment

As an illustration of this procedure, a plant breeder some years ago observed that broom corn has many nodes but short internodes in its stalks, while sweet sorghum cane has long internodes but few of them. He postulated that if by crossing these two he could combine the long internodes of the sweet sorghum cane with the many of them of the broom corn, he might get a much taller stalk of sweet cane and thus increase bountifully the yield of sweet sorghum syrup per acre. The crossbred plants resulted in long internodes and large numbers of them to give a very tall stalk. But to his sorrow, the stalk was too weak to stand up without supports as high as those common for hops. To his still greater sorrow, the stalks delivered no sugar and no sweet syrup. Cross-breeding does not necessarily combine the characteristics or properties just as we might hope.

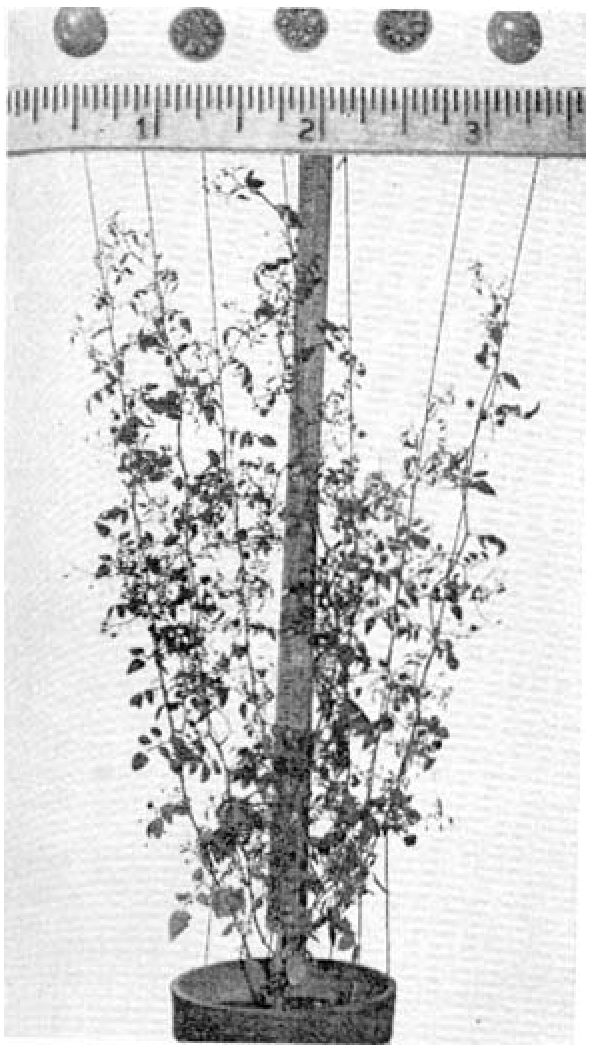
Tomato trouble

In similar hopes much effort has gone to the cross-breeding of tomatoes to make them less susceptible, or more resistant, to the fungus attacks resulting in the wilting of the plants. This trouble is all too common in the tomato varieties giving highly desirable fruits. The wild tomato, Lycopersicon pimpinellafolium, often called the "currant tomato," is not susceptible to the wilts and diseases plaguing the cultivated; kinds. It is a viney, small plant producing many small fruits of about currant size stuffed with seeds but little else to invite our eating it. One might hope, then, that by cross-breeding this immune, wild tomato on the choice, cultivated kinds that the resulting cross-bred plants would give the regular cultivated big plants, bearing our choice, delicious fruits and be immune to the wilt troubles.

Results not good

Under experimental cross-breeding tests, however, such was not the good luck. The wild tomato makes proteins and packs them into seeds in large numbers in each small fruit. Apparently it also produces ample other proteins of antibiotic services to protect the plants against invasion of the fungi causing wilt. The dilution of this protective

quality, by the lessening of it in the cultured variety, through the first resulting generation, did not bring on a loss of the resistance. The resulting tomato, though immune to wilt, was only a small seedy one, entirely undesirable as fruit.



THE WILD TOMATO . . . It fruits profusely and is immune to the "wilt" disease. But when cross-bred on the cultured larger tomato with little seed and more carbohydrate in it, the immunity is lost. In nature, protection from disease depends on some specific proteins which the plants produce, governed by fertility of the soil.

Better results

When this immune first-cross was diluted more in its protein potential by a second cross with the cultured choice variety, a larger fruit resulted. As this process was continued by more crossbreeding in the same direction to develop the larger, juicy, well-meated, less seedy fruits approaching those of the choice variety, there was the loss of the immunity to the wilt. Dilution of the protein as potential in the many seeds for survival as multiplication, and also as protection against disease, gave more sugar and less seedy fruits. But there was a corresponding dilution of protection against the wilt from fungi attacks.

Rebuild soil

Here is a suggestion; our emphasis on the plant's production of carbohydrates, usually resulting in larger yields or more sugars as sweets, plus our neglect of the proteins, is inviting more plant disease because we are pushing out the element that is the plant's own protection. This protection is the proteins, or the antibiotics as compounds similar to them. The growth, the self-protection and the reproduction of plants in the wild are associated with proteins. In our selection and propagation for sweetness, larger yields, rapidly grown bulk and other desirable properties, we are pushing out the proteins and thereby opening the plant to more disease.

Fertile soil

If this is caused by chemical changes in the plant resulting from the exhaustion of our soil fertility, should we not expect the loss of our plant's resistance to disease unless we rebuild the fertility of our soil with healthy crops in mind? Less fungi, and even fewer insects on plants grown on soils nourishing crops for more protein in them have already given an affirmative answer to that question.

Let's Live Magazine, April, 1957

Cycles of Soil Changes in White Clover Years

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

Note--This is the first half of a report on white clover in cycles of soil change. It was written by Dr. Albrecht for Better Crops; Plant Food, of Washington, D.C. The second half will appear in LET'S LIVE for May.

Why we don't have a good crop of white clover and the fine honey from it every year, or why this kind of clover comes seemingly in cycles of about the biblical seven years, are not new queries. The beliefs they imply have been more than just fancy in the minds of older observers of the volunteer white clover coming into the bluegrass pastures and lawns in periodic years. The inquirers have connected the intermittent appearance of white clover with certain kinds of soils. They have emphasized this cycle of dominance by this kind of clover especially on the glaciated, the windblown, and on the other more fertile soils where the growths of the bluegrass are also good. Some have believed that the "white clover year" is the "normal" after a year or two of drought.

Cycles

That we may expect white clover prominence in cycles of years is the suggestion from some soils studies in Missouri. Those studies suggest that this crop's periodic prevalence is related to the increasing degree of the soil's saturation by exchangeable calcium which favors the nutrition, and thereby the appearance and growth, of such a legume. So theoretically then, we may well look to cycles of increase and depletion of exchangeable calcium as possibly the cause of the white clover cycles. We may well expect this where the soil contains a reserve of weatherable calcium-bearing minerals in the surface or subsoil, as the glacier, for example, might have left it. Also, it would seem reasonable where unweathered floodplain deposits of silt, brought in from the arid West by the Missouri river. Then, too, when the clay of the soil, resulting from the weathering of the original minerals, is a partially reversible colloid which absorbs the active fertility elements while moist (but may not take them up again when wetted after it lost them through severe drying), the very prominent white clover of the 1956 spring makes us give consideration to the suggestive data from some soil studies under continuous bluegrass sod.

Soil samples

Apropos of the belief that the "white clover year" is a sequel to one of drought, the studies included soil samples collected annually from 1931 to 1938 inclusive, the last of which was considered a "white clover year." The plots went out of cultivation and into the blue grass sod in 1930.

While the 50-year average of the annual rainfall was 34.44 inches at Bethany, Missouri, the site of the Soil Conservation Research Station where the soils were studied, it was but 24.43 and 21.80 inches for the two years, 1936 and 1937 respectively, preceding the clover prominence. The former of these is well remembered for its disastrous heat and drought during June, July, and August. Also in 1934, there had been an almost equally serious drought. During the first half of the year 1938, the total rainfall was 16.06 inches with the amounts of 2.50, 4.39, and 3.07 inches for the months of April, May, and June respectively, to invite the while clover in what would seem nearly normal precipitation.

Particular study

Starting with 1931, the soil samples were taken annually in a series of plots. But particular study was made of the changes in the soil under continuous bluegrass sod. This was given no soil treatment. It had no crops removed and was showing no more erosion than what would amount to carrying the surface seven inches of soil away in 4,545 years. The soil changes suggest themselves as theoretical reasons for the cycles of periodic prominence of white clover in continuous bluegrass. They suggest corresponding cycles of fluctuating growths in the sod crop too. These would go unnoticed since they do not call themselves to our attention by such flashes of color as does the white clover.

Soil examined

The soil under sod was examined carefully by one-inch layers in order to measure the changes with time more accurately. This plot served as the basis for measuring the changes in the other plots undergoing fertility treatments, and surface soil losses. It was the check for the rates at which the other plot profiles were being truncated or whittled off at their tops. The seed plot was "the standard" in the study.

(Continued in May)

Let's Live Magazine, May, 1957

Cycles of Soil Changes in White Clover Years

by William A. Albrecht, A.B., B.S., M.S., Ph.D.
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This is the second and concluding part of the article on white clover and soil which Dr. Albrecht began in the April issue of LET'S LIVE Magazine.

Soil samples for the alternate years 1931, 1933, 1935, and 1937 were considered sufficient numbers to show the changes in the soil fertility. Since legumes like white clover require calcium (and magnesium) generously, it is significant to note the increase in the exchangeable calcium during those seven years before the one of white clover prominence.

For these four odd-numbered years the percentages saturation by calcium of the soil's exchange capacity stepped up in the following order, 56.96, 55.09, 69.70, and 70.96, respectively. Since for better crops of legumes, like alfalfa, the experiences with soil tests correlated with the crops suggested that the calcium saturation should be brought up to 75%, it seems highly probable that this increase in the soil saturation by this dibasic nutrient might be enough to invite white clover when at the lower figure the deficient calcium was prohibiting it.

Values fluctuate

When the saturations of the soil by calcium combined with magnesium were considered, the values fluctuated between a low of 75.45% and a high of 90.85% during those years. The high value represents a soil well stocked with these two essentials for protein-producing crops like white clover and other legumes in general. Thus, we might expect the white clover to come back because the fertility improved so much in respect to calcium. Since none was applied, the incidence of the white clover suggests that either the reserve soil minerals or those recently blown in were weathered enough during the absence of the clover to bring the active fertility up again to meet the needs of the clover in this respect. The total exchange of the soil remained constant during those years. The figures for the four samplings within the seven-year period were 19.98, 19.06, 19.20, and 19.35 milligram equivalents,) respectively.

Of particular interest was the increase in the organic matter of the soil as a result of growing the bluegrass. As per cent of the dry soil, the figures for the four years cited were 3.53, 3.71, 4.07, and 4.29, respectively. The total nitrogen also increased according to the following per cents of the dry soil, 0.173, 0.185, 0.190, and 0.205 respectively.

Results shown

One might have expected this increase in nitrogen to give it more activity in growing more bluegrass. But while this more stable organic matter of the soil was increasing, it was not becoming any the less woody or less carbonaceous to increase its rate of liberating its nitrogen, phosphorus, potassium, calcium, or any other of its nutrients. This was shown by the nearly constant carbon-nitrogen ratios of it. Those values during the four sampled years cited for the seven-year period were respectively 11.85, 11.63, 12.41, and 12.15. The organic matter seemed relatively too stable for any shift to speedy decomposition without tillage. Thus the bluegrass sod was building up the more permanent organic matter. It. was increasing the percentages saturation of the soil with those inorganic essentials by which the white clover would be encouraged, since as a legume it needed little nitrogen from the soil and could build its own protein-rich organic matter from atmospheric nitrogen. This organic matter, dropped back to the soil on the death of the white clover, would provide extra and active nitrogen. It would invite subsequent lush growth of the bluegrass.

Would compete

This non-legume would compete with the next crop of clover for other fertility elements liberated because the added nitrogen would hasten the decomposition of the more carbonaceous soil organic matter to set them free or make them active again.

Thus we can visualize the bluegrass exhausting the soil's supply of active nitrogen and of other active fertility, and building these into more stable organic matter even with an increase in total nitrogen. This was happening while the decomposition of the reserve minerals was releasing extra calcium to saturate the soil's exchange capacity more highly with this active, essential cation. This would favor the advent and the growth of a legume crop, like white clover, which fixes atmospheric nitrogen. But this clover growth would reduce the calcium saturation to the hindrance of its own future growth. It would put extra and active nitrogen into the soil. So while eliminating itself by exhaustion of the active calcium, it would favor the bluegrass by providing the active nitrogen.

The time period required for building up the sufficiently increased calcium saturation needed for the white clover suggests itself as the time interval between the "white clover years." That interval may well include "drought" years for whatever changes in the soil or cycle they bring about.

Let's Live Magazine, June, 1957

Fertilizing With Nitrogen: The Cow Makes Her Suggestions

by William A. Albrecht, A.B., B.S., MS., Ph.D.
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Among the garden crops, the peas, beans, lentils and other legumes are mainstays because, as nitrogen-fixers, they have long been known to be higher in the proteins and all else which such plants must take from the soil as essential elements and compounds to be legumes. These are the crops which can take the gaseous nitrogen from the air and combine it into the highly valuable food constituent, namely, the proteins. In feeding animals, the legumes are the feeds for "growing." They supplement the corn, for example, as feed for fattening the animals--usually castrated males carrying no load of reproduction or of growing foetal young.

To measure nitrogen

Because proteins contain the element nitrogen in a particular chemical structure which we call "amino" nitrogen, and some other forms of it, to the extent of about 16 per cent of these compounds, we have been measuring the nitrogen by "ashing" our foods and feeds in sulfuric acid. Then we multiply the measured value of this element by 6.25 and call the result the "crude" protein of the food or feed. The cereal chemist multiplies it by 5.73 for the proteins in the grains. Thus, the nitrogen has become synonomous for the proteins, but not without danger of serious confusion.

That confusion is becoming more dangerous, now that we are applying nitrogen to the soil generously as fertilizer, and such in highly active chemical forms. The plant may take up these; it may fail to convert them into the proteins; and yet our chemical analysis will credit the plant with high protein when much of that may even be poisonous. There is also the increasing inference that non-legume crops, fertilized generously with nitrogen and consequently brought to contain a high percentage of nitrogen in their dry matter, must therefore, be rich in proteins. If that figure for percentage of nitrogen duplicates the one for legumes, the erroneous conclusion is apt to be drawn that our use of plenty of fertilizer nitrogen on grasses and other non-legume crops will grow proteins in quantity and quality in those as well as when we use the regular legumes.

Elements must balance

That such is not necessarily the case follows from the fact that soils must be well stocked with calcium, magnesium, potassium, boron, manganese, copper, zinc, and many other essentials in the list of the major and the minor or "trace" amounts before legumes will grow. Only after legumes have a balanced soil fertility in terms of all the essential elements except nitrogen, and those in good supply first, will those plants add the nitrogen of the atmosphere to that stock and cany out this process of nitrogen fixation by which they grow, protect themselves, and reproduce. The nitrogen is not taken up in that natural process by legumes except as it moves via the protein forms of it.

EXCELLENT ILLUSTRATION . . . Spots of tall, dark-green grass in the pasture of humid areas tell us that even the cow applies too much nitrogen, when she refuses to eat the results of her own soil treatments. She allows the tall grass to grow taller while she eats the short grass shorter.

That the corn plant, as one of the grasses, can deceive us and take up large quantities of nitrogen from the soil without converting this essential element into protein, was demonstrated by the drought when the so-called "silo-fillers disease" gave us not only a newly coined term but also some new concepts about the dangerous biochemistry of silage making. The chopped fodder gave of enough nitrous oxide fumes over night to kill one on entering the partially closed silo the following morning. The chemical analysis of the corn stalks suggested that, because the heat of the drought had destroyed the enzymes which were normally converting the nitrates coming into the plant from the soil into other plant compounds, the nitrate nitrogen or even this in the nitrite combination had accumulated excessively in the corn stalks.

Deadly compounds

Nitrates and nitrites are deadly compounds for animals and man when taken in even very small dosages. Some analyses of corn stalks, reporting one percent of total nitrogen, showed as much as 0.65 per cent of this element in the nitrate form. Thus, we might have believed that the dry matter of the corn fodder had 6.25 per cent protein. But instead it had 4.06 per cent so-called protein--equivalent of the 0.65 per cent nitrogen--which was poison, as the deaths of the cows had sadly reported.

The cow has, perhaps, been the oldest producer and distributor of nitrogenous fertilizers, putting out some of it in the organic and some in the soluble salt form, viz. urea. She demonstrates her activities in that industry every time she voids her droppings of either feces or urine on the grassy swards. There we see the markedly green growth of grass encircling the feces and the much taller and probably greener growth of it encouraged by the urine.

But if we observe closely and consider farther, we will be forced to conclude that such is an excess of nitrogen fertilization in the humid soil areas, and is not producing a nutritious forage feed, regardless of how demonstrative in yield and how attractive to the eye. Testimony to that is given by the cow herself when she refuses to eat that green growth, but lets it grow taller while she eats the surrounding grass shorter and shorter. Even she tells us that one must be cautious to balance the nitrogen salts with all other fertility in using them as fertilizers.

Nutritional value

The cow is not classifying forage crops by variety name, nor by tonnage yield per acre, nor by luscious green growth. Instead, she is classifying forage according to its nutritional value in terms of complete protein and all else coming with it, according as the fertility of the soil determines. As a biochemist or an assayer, she is not satisfied with the value of the nitrogen in the ash multiplied by 6.25 and labelled "crude protein."

When we fertilize with nitrogen salts, we dare not always say we are thereby necessarily making crops more concentrated in protein because they look greener and more luscious. The growing of plants is a problem in plant nutrition no less complicated than any other problems of trying to feed some life form properly. So when using nitrogen-carrying fertilizers, one dares not operate under the belief that "if a little is good, more will be better," even though nature seems to follow that philosophy when she fertilizes with nitrogen in the form of organic matter which she may pile up abundantly.

Let's Live Magazine, July, 1957

Fertilizing With Nitrogen: Rabbits Testify by Experiments

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

When we observe crops either in the garden or in the field, they are anatomically very similar. They all have roots, stems, branches, and leaves. They are of a luscious green color. They look alike, and--so far as we can see--we might expect one to do what the other does when we fertilize the soil under them with extra chemical nitrogen. We are usually delighted when both the garden and the field crops improve in their production of more vegetation and a greener color. We measure their contents of nitrogen and find that the concentration of this in the dry matter was increased decidedly by the fertilization. We believe we have thereby made them richer in protein as food.

Widely different

We do not appreciate the fact that, in terms of their physiology, the plants may be as widely different as the talents of folks when some can and some cannot. Two plants looking alike are not necessarily of equal feed value. The cow confirms this when she may choose one plant in her grazing and disregard the other. In the form of hays separated in the feed-rack, she may consume one entirely before even touching the other. Under most delicate testing by using weanling rabbits in feeding experiments, the fertilizing of a grass like timothy with nitrogen increased the "crude" protein decidedly. But even then, this was not necessarily good nutrition. This suggests that the physiology of the non-legume, timothy, in its use of fertilizer nitrogen, does not necessarily give us the nutritional values for rabbits in the crude protein or even in the amino acids which are equal to those in a legume like the red clover.

Timothy hay fertilized with both nitrogen and trace elements was fed experimentally to weanling rabbits during the summer heat wave of 1954. But with every severe rise in temperature the heat killed some of the rabbits until 70% were dead. Then, since the experiment had gone its planned time and the rabbits added from the stock supply at fortnightly intervals had maintained the number, dried skim milk powder was added as a protein supplement to improve the quality of the ration in that respect. From that date forward no more fatalities occurred, even though the heat waves continued.

No more deaths

Then the original experiment was repeated. There resulted again the repetition of the deaths by the heat waves, which were accepted as part of the test, until 30% of the experimental rabbits were killed. Then the timothy hay was replaced by some red clover hay grown in a field where the clover has been in rotation systems since 1888. From the date of this substitution, and with the heat waves holding on, no more rabbits died while feeding on the red clover hay.

It is interesting to note that the timothy and the red clover hay, under chemical analyses for total nitrogen and under microbial bioassay for the essential amino acids, would not tell us all the reasons why the clover saved the rabbits from death by the heat but the timothy did not. It is interesting, nevertheless, to note the differences between the two hays so far as the chemical analyses for these essentials could give suggestions. They are given in the accompanying table.

Total nitrogen and essential amino acids in timothy and red clover hays
(Mgm. per gm. dry matter)

	Timothy Hay	Red Clover Hay
Total nitrogen	13.1	17.4
Methionine	0.61	1.31
Tryptophane	3.11	*
Lysine	1.66	5.26
Threoine	2.97	4.51
Valine	3.49	5.70
Leucine	14.0	6.07
Isoleucine	7.12	4.43
Histidine	0.81	1.37
Arginine	3.64	9.59
Phenylalanine	2.79	4.86
*Not measured.		

Differences

From such data one cannot see differences wide enough to make a guess as to the particular amino acid deficiency which killed or the particular sufficiency which saved. It is significant to note how similar the two hays were in totals of the 10 and the nine amino acids respectively, but yet were more widely different in the total nitrogen. In this latter respect the red clover was almost a third higher than the timothy.

As an additional experiment, the red clover hay grown on 11 plots with that many different soil treatments and history, were each made up into diets for test rabbits so that each of the series contained 1.31% total nitrogen, or 8.18% crude proteins supplied by the clover from the particular plot. All else, as dietary factors, were also brought to a constant as nearly as possible. Then this set of supposedly uniform diets was again fed to carefully selected weanling rabbits and their gains in weights taken as the index of the diets' efficiencies, even when all were the same in "crude" protein.

It was startling to find that the gains per rabbit by lots per four weeks varied from a low of 34 grams to a high of 241 grams. The gains as grams per milligram of the nine essential amino acids consumed, varied from a low of 10.6 grams to a high of 77.9 grams. Then, finally, on examination of the livers of the rabbits, it was found that they varied widely in weights and ranged in color from almost black to the usually expected normal liver color.

Evidence

Here then, was evidence to tell us that timothy hay fertilized with ample chemical nitrogen and also given trace elements, failed to keep the rabbits alive under heat waves, while red clover with a variety of soil treatments ranging from none upward saved them from death under similar heat conditions. We are not able as yet to catalog all of what the soil gives to the crops by which one kills, and the other keeps alive, the animals feeding on them. Nor can we fertilize the soil with nitrogen and say much for the quality of the protein the plant makes, even if we are pleased when it gives more "crude" protein. Fertilizing for more feed values is not necessarily also fertilizing for better nutritional value when we use the highly active salts.

Note--Dr. Albrecht's third article on Fertilizing With Nitrogen will appear in the August number of LET'S LIVE Magazine.

Let's Live Magazine, August, 1957

Fertilizing With Nitrogen: We May Use Too Much Salt

by William A. Albrecht, A.B., B.S., M.S., Ph.D.
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Animal manures were the first soil treatments to give improved growth of the crops. The accumulated manures of sea birds collected and imported from the arid Pacific Coast of northern South America were some of the first commercial fertilizers. They were sold to our cotton farmers under the trade name of "guano." From near that same source and representing, probably, the evaporated leachings from the guano, there came later the nitrate of soda or the Chile saltpeter.

A shift

Thus, history gave us a gradual shift from the fertilizer nitrogen in the organic manures to that in the form of the inorganic chemical salts. But this shift was not accepted without serious protests by the Southern farmers. They contended that guano gave better results on their crops than the saltpeter. Perhaps, even they recognized some fertilizing helps from the organic compounds in the guano which were not given by the simpler, purer, more concentrated chemical salts. Many are still contending that organic manures are better fertilizers than pure chemical salts.

Another form

Not too long after the sodium nitrate became the common nitrogen fertilizer, the ammonium form of nitrogen combined as the sulfate came into the fertilizer trade. This was collected, along with coal-tar wastes, as a by-product of the destructive distillation of coal to give coke for the reduction of iron ores. This was a form of nitrogen different from nitrate. Chemically, it was a positively charged ion. Consequently it is held in the soil against rapid loss to the rain water going through it. It undergoes a slow, microbial conversion there into the nitrate form which has the negative charge and when united with a positive ion like calcium, for example, is not so firmly held by the soil. It is then a highly active salt and may be readily washed out. It is taking other ions of nutrient value and of opposite charge, as well as calcium, out off the soil. While this all happens, the nitrogen shifts itself from the positively charged ammonium form, held by the soil, into the negatively charged nitrate form not held. If it is applied as a sulfate, this latter, as a negative ion, also carries calcium or other positively charged ions out. The ammonium ion; as a positive one tastes hot. The nitrate, as a negative one, tastes cold. They are opposites in more ways than one.

Damage worse

When these various salts of nitrogen were combined with superphosphate as mixed fertilizers, it was soon discovered that while one could make heavy applications of phosphates with the seeding of grains, the nitrogen fertilizers could not be so used without injury to the germinating seed and serious reduction in the stand of the crop. Then when a potassium salt, like the muriate, was also included in the fertilizer salt mixture to give the so-called "complete" fertilizer, the damage was still worse.

On Sanborn Field one plot started as early as 1888 with heavy applications of commercial fertilizer salts of nitrogen, phosphorus and potassium, enough to represent those three elements taken off by the grain and straw in a 40-bushel. crop of wheat. Beginning with the virgin soil, that much of chemical salts drilled with the wheat seeding, where this crop was grown annually, was not damaging to either the germination or the final stand until after nearly 20 years. But during that period with all the straw and grain removed and with no organic matter returned the soil had lost much of its humus and organic matter, which represents its capacity to "buffer" the shock of so much chemical salts. Ever after that period and even today, the total fertilizers can be applied safely only as a divided application, one part with the autumn seeding while the other parts must be applied in the spring or later.

BEFORE AND AFTER . . . The larger applications of nitrogen for corn on heavier soils are still demonstrative in their effects on wheat in the following year (left) when compared with the same crop on soil given no nitrogen (right).

A problem

In practice, in general, most fertilizers are now applied on soils unable to handle these more concentrated forms and heavier salt treatments, unless by special placement of them at some distance from the seeds. We are faced with the mechanical problem of proper placement of those chemical salts to escape their early damage. That was no problem with nitrogen in guano or in its organic combination.

Such facts are turning our thinking back to organic matter to consider the problem of handling nitrogen and potassium, or other salts, so highly active and thereby so readily damaging. We are taking to the suggestion that, perhaps, a kind of natural composting of the nitrogen fertilizers by the help of the microbes in our virgin soils of high organic matter contents was Nature's method that saved us when we first used it without damage from the excessive salts.

Use nitrogen

There comes, then the suggestion that nitrogen ought to be used along with crop residues, and with applied organic matter if the depleted soils are to be restored and the nitrogen held to the best advantage in the soil. Composting either within the soil, or in the special compost pile above it, seems to be the prevention against fertilizing with too much salt. This seems to be no small danger when the concentrations of the fertilizers are mounting and the larger applications commonly applied are both crowding under increased economic demands for higher yields per acre. It is these conditions which portend a compulsory reverse of history with its shift from the nitrogen salts back to more of these elements in the form of organic compounds.

Note--Dr. Albrecht's fourth and concluding article on Fertilizing with Nitrogen will appear in the September number of LET'S LIVE Magazine.

Let's Live Magazine, September, 1957

Fertilizing With Nitrogen: Fertility Imbalance and Insect Damage

by William A. Albrecht, A.B., B.S., M.S., Ph.D.
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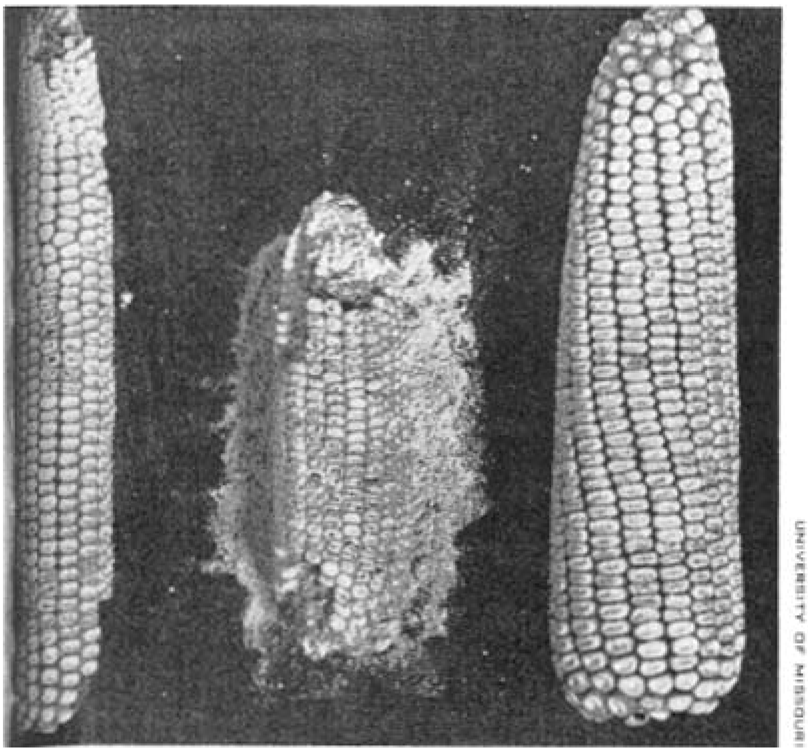
Just as wild animals seem to know how to protect themselves and to be healthy, so plants, in the wild, seem to grow their own protection even for the seed carried over the winter. That the soil fertility should help grow a protection into the seed against grain insects is scarcely surmised until we see it demonstrated. During the season of 1954 some trials with high nitrogen fertilizers on corn in South Dakota furnished the samples for some careful observations of the failing protection against the lesser grain borer when the corn was fertilized with nitrogen only.

Only slight deficiency

In the illustration given herewith, the small ear, the middle one of the three, represents the size of the ears and suggests the yield of the corn crop on the soil given nitrogenous fertilizer only. This was the treatment suggested by the soil test which indicated no serious fertility deficiency save that the nitrogen might be improved by soil treatment with this nutrient element as fertilizer. The nitrogen was applied with the corn planting in the spring of 1954. The grain was harvested in September.



EXAMPLES . . . Of the two hybrid ears on the left, the middle one, fertilized by nitrogen only, was badly infested by the lesser grain borer after storage of two years. The larger one on the left, grown on soil fertilized with nitrogen and phosphate, was attacked only at points of contact with the smaller ear. The open-pollinated corn on the right in contact for six months, has but one grain injured by the borer.

The ear on the left represents the yield of corn from the plot given, not only nitrogen at the rate used on the other plot, but also this combined with fertilization by phosphates, even though the soil test had not suggested that there was a deficiency in the phosphorus. Both of these grains were grown from hybrid seeds.

Better results

The samples from these two soil treatments had been stored for two years when the photograph was made in late September, 1956, to illustrate the wide difference in the damages to the seeds by the lesser corn borer. The ear grown on the soil fertilized with nitrogen only was almost completely riddled with accumulated, floury waste removed twice in advance of the last accumulations exhibited in the illustration. The ear on the left, grown on soil fertilized with phosphates as well as with nitrogen, had been in contact with the badly infested one but was damaged by the grain borer only at the point of contact with the smaller ear, and on the lower left side at a few points of contact, apparently, with the shelf. The ear on the right was grown on well fertilized, highly organic soil from open-pollinated seed and had been in contact with the badly damaged ear for six fall and winter months before all were photographed. It showed but one or two grains attacked by the borer.

Protect themselves

It has been previously demonstrated in experimental trials that young soybean plants protected themselves against a fungus attack (suggesting "damping off") as the increasing amount of clay in the soil supplied them with increasing amounts of exchangeable calcium while all other fertility supplies were constant. It has also been demonstrated that the attacks on the leaf eating thrips insects were prohibited when the nitrogen applied to the soil was in larger amounts, and when the lower amounts of that fertilizer allowed the insect attacks, even those were lessened by increasing amounts of calcium used as fertilizer. This demonstrated also that the fertilizer treatment of nitrogen was better protection against leaf eating insects according as the application was heavier and in combination with calcium. In the case of the stored grain, there was the better protection against the grain borer according as the nitrogen--synonymous with protein--was balanced by some phosphorus, but, was inviting destruction almost completely when it was used alone as the fertilizer.

Soils must be balanced

It is significant to remind ourselves that when forage crops use extra nitrogen from the air to build themselves richer in protein, which is the protection or immunity in most living forms, they do so only after all other essentials of fertility are present in the soil in generous amounts. In the humid area "legumes are hard to grow," or the soils must be well balanced in their fertility if these crops are to fix nitrogen and are to be free of diseases. We dare not rush in to apply nitrogen, then, on the non-legumes--if this reasoning by simile is sound--without anticipating the possible imbalance to be damaging rather than beneficial. If nature fertilizes with nitrogen via the plants' combination of it in the form of organic matter, perhaps the composting of fertilizer nitrogen will be wiser use than its direct application to a crop as salts. We may well ponder that question in relation to what nutritional and protective values the crop finds in the nitrogen treatments as generously applied salts.

Let's Live Magazine, October, 1957

Too Much Salt For The Soil

by William A. Albrecht, A.B., B.S., MS., Ph.D.
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Plant growth is disturbed by small concentrations of salts in a soil not only in alkaline or low rainfall areas. Similar disturbances are becoming more common in the humid, or higher rainfall, regions. We are putting the western deserts on the march eastward, as it were, by heavy applications of highly concentrated fertilizer salts.

Garden soils with their larger amounts of organic matter, and the increased microbial activity which that fosters, are not so susceptible to visible "salt-shocks," like the defective germination of seeds and the poor stands of the crops, as has been the increasing experience in heavily fertilized fields not regularly manured.

When nature demonstrates more abundant plant growth under rainfall high enough to leach salt solutions out of the soil, the remaining nutrients are held there by adsorption on the clay and humus colloids. Those essentials go to the plant mainly when the roots exchange hydrogen, or acidity, for them. From that illustration of natural crop growth, we may well respect the common warning of a farmer or a gardener when he says, "You can easily use too much of those chemical salts."

Note warning

That warning may come from some unfortunate experiences, possibly from putting the fertilizer salts in the row with the seeds and getting no stand. It may come from the disturbed flavors and tastes of the vegetables, like radishes, spinach, onions, and cabbage. It may come even from more plant diseases and more insect troubles.

The pioneer farmer was cautious about using salts, as illustrated by his reluctance to accept Chile saltpeter after he had used bird dung or guano from Chile. Even Dr. J. W. Sanborn, who laid out one of the oldest experiment fields of the country in 1888 in Missouri, had nearly half of the plots include barnyard manure as the soil treatment. He ventured only one plot of continuous wheat with significant applications of commercial fertilizer salts alone. He used those to put back the equivalent of the nitrogen, phosphorus and potassium taken from the soil in the grain and the straw of a 40-bushel crop.

Salt injury story

The history of the experiences with that plot under chemical salts now for 68 years tells us the salt injury story. The harmful dosing was not recognized as serious or as a disaster until after about 20 years of continual dosing. Then the drilling of that much salt with the seeding resulted in poor emergence of the seedlings and poor wheat stands. If one interprets the records carefully, it required a few years of seeding with such dire experiences to suspect the salts and not the seeds as the cause of crop failure. Subsequently the records report that the application of the fertilizer was reduced to but one-half the total amount drilled with the October seeding. The other half was applied as a top dressing in the spring. Later in the plot's history, when fertilizers became more concentrated, even that reduced amount became more dangerous to the stand of wheat and still lesser amounts of salts were drilled with the seeding.

Yield drops

The average yield of wheat on that plot fertilized heavily for now over 65 years has not been near the 40 bushels. It has been only slightly over half of that. Only nitrogen, phosphorus and potash, along with any contaminant or extra elements, were not maintaining the yields. Later when the more common trace elements and salts of some neglected others were added, the yields showed their improvement even though the organic matter in that plot is one of the lowest among the many on the field.

When the growth of plants in solutions of salts in the demonstrations by a botanical class, or in commercial hydroponics, calls for such very dilute salt solutions--and those renewed often and regularly--we ought to appreciate and respect, (a) the dangers from salts in the soil, and (b) the "shock-absorber services by the microbes along with the organic matter and the clay to take the ionic salts out of activity before they injure the seedlings of the plants. Also we might recognize all the commercial activity in designing new farm machinery for particular placement of fertilizers away from the seeds in the soil. This is testimony that (a) with more concentrated salts applied, and (b) with the organic matter content of the soil decreasing to reduce the microbial activity, there isn't enough "buffer capacity", or "shock-absorbing" ability left in the soil to remove the hazards from the "salt" effects.

Sick soils

Our soils are becoming sick and weak. Unlike the patient encouraged by the doctor who says, "You have a good constitution," we cannot say that for our soils, if we define that property as the ability of the soil to produce crops and maintain its naturally healthy condition in spite of the soil doctors rather than because of them.

The wise gardener or farmer will give his soil a "strong constitution" by using not only vegetable wastes--either composted or not--but also animal manures for the sake of their organic matter of direct plant origin and also for possibly some of the distinctly animal origin. If soils required additions as fertilizers to correct some of their nutrient deficiencies, the "salt effects" may be buffered by their use through a composting process either in the pile or plowed under as an application with much organic matter. We need to realize that we can use too much salt on the soil.

Let's Live Magazine, November, 1957

Blood Will Tell

by William A. Albrecht, A.B., B.S., MS., Ph.D.
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Our soils are no longer maintaining what for them might be called a "strong constitution." They are not growing a good supply of organic matter regularly within themselves. Our animals, feeding on what these soils have grown, do not exhibit a "strong constitution" either, if we mean the animal's ability to remain free from diseases. The increase in new and unnamed animal afflictions is supporting that statement. We are not ready to believe that "blood will tell," and will report health irregularity more delicately than it is recorded in commonly visible symptoms.

Transformation

When the cow takes the forages (also the soil and the microbes on them) into her paunch where this combination nourishes the microbes first, is it too great a stretch of the imagination to see her body's nutrition as a close connection with the fertility of the soil? She initiates her digestive processes by help of the microbial content in the fore part of her alimentary canal. The products of the transformations in the organic matter by the microbes, the digestive results of the cow's activities and the protein of the microbial cells so profusely multiplied, are all finally digested and absorbed into the blood stream for its reactions in summation. There is in it the reflection by a warm blooded animal of what the soil offers as fertility and as nutrition. Here then is the suggestion that the close chemical study of the cow's blood will tell not only the cow's condition as health, but may even point out the deficiencies in the soil's fertility responsible for the health deficiencies.

Health and soil

That the health of cows is so closely connected with the fertility of the soil might well have been the theory set up for test and demonstration in some epochal studies by Doctors J. Stewart (recently deceased) of Edinburgh and J. W. S. Reith of Aberdeen, Scotland. The experiments were made on a dairy farm plagued each early spring with attacks of "lactation" tetany or "grass" tetany. It was these studies of the increase, during the growing season, of the concentration of magnesium in the pasture herbage and the more common occurrence of tetany with generally disastrous results at the lower magnesium values, that brought the scientists to use a herd where tetany was common in the spring. They examined the cows' blood for concentrations of magnesium before treating the pasture soils with dolomitic limestones as magnesium fertilizers. Then for four years they followed the variations of this nutrient element in the herbages and in the blood, during and after the disappearance of the previously common afflictions of the cows with what was believed to be "grass" tetany.

Content varied

They found that the concentration of magnesium in the herbage is very low in April, May and June and increases from 60 to 100 percent by August, to remain nearly constant thereafter. The common type of tetany coincides with the part of the season when the concentration of magnesium in the pasture grasses is at its lowest. The scientists also found that "magnesium limestone dressing increased the magnesium content of mixed herbage throughout the growing season by at least 50 percent above that of herbage receiving no lime dressings or ordinary limestone dressings. Such an increase in the magnesium content of pastures in April and May will increase the magnesium intake of the animal grazing them by about 20 grams per day, assuming that a dairy cow will eat 30 pounds of dry matter per day and that the pastures' content of magnesium oxide has increased from 0.30 to 0.450 percent.

"This is comparable to the amount of magnesium each cow obtains when fed five ounces per day of a high-magnesium mineral mixture containing 16 percent magnesium as suggested by Blakemore and Stewart (1934) and shown by them to reduce the . . . risk of tetany in herds put to pasture in April or May."

Revealing studies

The study of the blood of the cows showed that in place of the normal levels for magnesium at 2.5 to 3.0 mgs. per 100 ml. of serum, with 2.0 as the lower limit of normal range, the mean values in April, June, and July were 1.71, 2.38 and 2.56 mg. respectively, before the soils were treated on the farm where tetany had been common trouble. The following spring two long tons of dolomitic limestone containing 41.8 percent magnesium carbonate and 55.30 percent calcium carbonate were applied on one part of the pasture. Another part was left untreated. A third part was given the same rate of a nearly pure calcium carbonate limestone.

Their successive seasonal tests, for the years after the soil treatment, showed the magnesium in the herbage in April and May at the low mean values of 0.17 and 0.16 percent of the dry matter, respectively, for the no-treatment area; of 0.19 and 0.17 respectively for the area given calcium carbonate stone; and of 0.30 and 0.26 per cent, respectively, for the herbage of the area given the dolomitic limestone. On each of the plots, the concentration of the magnesium in the herbage went higher with the advancing season. By October and November, the figures were 0.26 and 0.26 percent respectively, for the plot without treatment; 0.27 and 0.28 percent, respectively for those months for the plot given calcium carbonate only; and 0.37 and 0.40 percent for the plot given the dolomitic limestone.

Other findings

Herbages on three other farms also suffering regularly from tetany were included in the study. The magnesium contents of their herbages in April, May and June were at the lows of 0.12, 0.13, and 0.17 percent, respectively, with the August, September and October values at 0.26, 0.34, and 0.30 percent. These were in close agreement with no-treatment or calcium carbonate treated values on the farm where the magnesium values of the blood of a dozen cows were studied for four years in order to follow the report by the cow's blood telling of the dolomitic soil treatment reflected by higher magnesium levels in this circulating form of body protein.

According to the report of blood samplings for two of the four years taken in February, April, May, and June, and for the other two years taken in March, April, May and July, the average blood level of magnesium of the cows dropped below the lower limit of 2.0 mg. per 100 ml. of serum in only April of the first year following the treatment of the soil with the dolomitic limestone. For the entire four years, the four months of samplings gave the mean blood levels of magnesium for the dozen cows as follows: February-March--2.63; April--2.06; May--2.48; and June-July--2.58; with the disappearance of the tetany which had formerly exhibited itself as a deficiency disease caused by magnesium deficiency in the forage because of magnesium as a deficiency in the soil fertility.

Concrete evidence

Here, then, is evidence that warm blooded animals suffer deficiency diseases connected with failing delivery of an essential element, magnesium, from the soil, to the vegetation, and to the animal consuming it. Still more significant is the fact that blood sample tests show that the blood will tell. Are we as vegetable-eating humans not also connected closely with the soil, either for deficiency diseases or freedom from them in buoyant health according as the soil fertility determines? Perhaps our blood also will tell.

Let's Live Magazine, December, 1957

What Texture of Soil is Preferred?

1. Sandy Soils Work Easily

by William A. Albrecht, A.B., B.S., M.S., Ph.D.
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To the question of which soil is preferred we usually get the reply, "Sandier garden soils are preferable. They are easily tilled without tearing up the tender seedlings. They are warm in the early spring. They are not hard and cloddy when dried out, and they do not pack down on tramping or under power tools going over them."

This illustrates our inclination to think first about how easily the tillage job can be done. Seldom does our thinking raise the question as to how well the soils produce in quality for our nutrition and health as well as for yields. Sandiness of the soil should quickly provoke that question.

Three viewpoints

Soil texture needs to be viewed in its variation; this includes (a) the sandy soils, (b) the silty soils and (c) the clay soils. This variation in physical properties causes diversity in the soil's potential productivity. In our preference for sandy soils, because of the ease with which they can be tilled, we fail to see the common deficiencies in *readily available fertility,* to say nothing of deficiencies in *fertility reserves.* We cannot buy our better vegetables of high nutritional values without significant labor as to tillage, and other labor phases of soil management.

When we speak of soil texture, we refer to the percentages of the coarse, the medium and the fine mineral particles composing the soil. We recognize and estimate amounts of these by the "feel" of the moist soil when it is rubbed between thumb and forefinger. The coarse, or the sand, particles are felt as individual grains. The medium, or the silt, particles feel smooth and velvety. They are too fine to register as single grains in contact with the skin, but between the teeth they are recognized with pronounced exaggeration of their size. The clay gives a non-grain but sticky feel, and dries into clods, this is much less the case for silty soils and seldom so for sandy ones.

Loam

Since most cultivated soils are commonly a mixture of these three, they are more often called loams. A loam is one which is not pronounced sandy, nor decidedly silty, nor very sticky in "feel." It requires more than half of the soil's body of sand to make it feel sandy; half of it as silt to make it silty; but from only one-fifth to less than one-third of clay to make it a "clayey" soil.

If the soil is to hold *available* nutrient elements like calcium, magnesium, potassium and others against loss from rain water percolating down through, then the sandy soils do not represent enough surface per units weight or volume to contain a significant supply of exchangeable nutrients for more nutritious plants. Their holding capacity can be increased only by the extra organic matter incorporated as a means of giving them additional adsorption and exchange capacities.

Sandy soil

Sandy soils are ready for tillage and plantings earlier in the spring because they do not stay water-logged very long. Consequently, they warm quickly, do not "puddle" when worked, and their organic matter undergoes active decay early and rapidly to give both inorganic and organic nutrition to the crop. Because sandy soils need organic matter, gardeners on such soils take readily to using compost because the effects of such reflect themselves quickly and decidedly in the improved growth of the crop.

Sandy soils of low organic matter, and thereby low in absorbing-exchange capacity, make one respect the possible damage to seeded crops from salt (commercial) fertilizers, especially if applied in contact with the seeding. In sandy soils those fertilizers remain longer as salt solutions instead of being made less active as salts by being adsorbed on the extensive surfaces of the ionic and finer colloidal minerals like the clay.

Plants do not use all the salt fertilizer at once, hence it must be held over for some period of time. In sandy soils this is but a short period, and much of the purchased plant foods is lost in the percolating rainwater unless the applications are repeatedly made as small dosages during the growing season.

Quartz

Sandy soils in the humid areas of higher rainfall do not represent much exchangeable fertility on the surfaces of the particles. Nor do they represent much as reserves in the undecomposed minerals. Particles as large as sand-size are made up of the mineral quartz. This is about the hardest and most insoluble of all the minerals. For this reason it remains as the larger left-over sizes from a natural original mixture of many minerals after all the others have weathered away. For this reason sandy soils in regions of ample rainfall, generally, are soils with much "site" value but less sustaining or productive power, unless they are built up in organic matter for the favorable action of which the sand is mainly the retaining framework or skeleton. Quartz, made up of silicon and oxygen--the former a non-nutrient so far as we know and the latter not used from that source--offers nothing as plant nutrition.

Mineral fertility

However, sandy soils in the arid areas of lower rainfall may be pulverized, well-mixed, unweathered rocks of widely varying mineral contents and much potential productivity when given water to decompose them and to make their products of that breakdown ionically active. Sandy soils have a favorable physical condition for easy tillage, but whether they are productive depends--like with any soil--on the mineral fertility reserves they have, giving--by decomposition--the necessary adsorbed--exchangeable elements, held on the finer particles of either or both the clay and the organic matter for service in nourishing the roots of plants. Soils, like any body of life, need a good anatomy, which sand can give; but with that there must go the complete physiology by which that body functions or performs in growing crops worthy of their classification as food or feed of high value.

("The Nutritional Blessing of the Winds," dealing with silt loams, will appear in the January issue)