Let's Live Magazine, January, 1965

HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . .
Its Relations to Calcium

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part 2

During its movement in drainage waters from the prehistoric lands to the seas, magnesium was precipitated along with calcium as limestones. These substances were not always deposited in a fixed ratio, consequently, we have limestone either as nearly pure calcium carbonate, or with added magnesium carbonate, in amounts varying from none to the equal molecular ratio occurring in dolomite. This mineral contains one element of calcium and one of magnesium in ratios, by weight, of 21.73% and 13.8% respectively. Their carbonate compounds are in ratios of 54.26%) calcium to 45.74% magnesium. In the dolomite deposits which are less pure, or contaminated more by clay inwash to the seas, these percentage figures are smaller. The impurities of the original limestone, such as the silicates or clays, are left to develop into soil from the weathering of rocks.

Distribution

In the course of this natural process, the carbonate compounds are removed completely. But the calcium moves out into drainage and back to the sea more readily than the magnesium. Consequently, the resulting clay fraction is relatively richer in magnesium during weathering. Erosion of such clay from uplands, and its deposition in lowlands, has been a means of distributing magnesium more widely and favorably than we appreciate. It was very probably by such a natural process that much of the high-magnesium soil of the lowlands of southeastern Missouri was inwashed by the Ohio River from the weathered dolomitic limestones in its drainage basin, and not from the Mississippi River. Very probably these Missouri lowlands are not the work of the latter river, which brings its erosion load from soil areas suggesting more highly calcareous materials, including readily erodable strata of such substances in the soil profile.

Thus, soils developed highly from limestones under higher rainfalls would be mainly the impurities left from the original rocks. Since these impurities had survived a cycle of weathering from rock to more insoluble residues in the depths of the sea, they would not suggest their rapid weathering into available plant nutrients from their uplifted limestones and from their repeat of such a traverse. This is a natural fact contradicting the oft-heard remark that "soils from limestones are usually productive soils." That idea must consider the degree to which the limestone soils have been developed in the particular setting.

Calcium readily removed

In the development of soils from rocks containing sodium and potassium as well as calcium and magnesium in their original silicates, the first two are broken out and removed more readily than the second pair. Thus, the semi-humid soils may be rich in calcium and also in magnesium. With the higher degree of development of the soil from more rainfall, the calcium for crop nutrition becomes deficient before magnesium does. For these reasons soils of our mid-continent have not shown impending deficiencies of magnesium in crops so widely. Also, when calcium is deficient and limestones are applied to the soil, they usually carry magnesium and unwittingly cover the magnesium needs amply. No attention is paid to the fact that the limestones so used as fertilizers add both calcium and magnesium, the foremost plant nutrients, in balanced amounts.

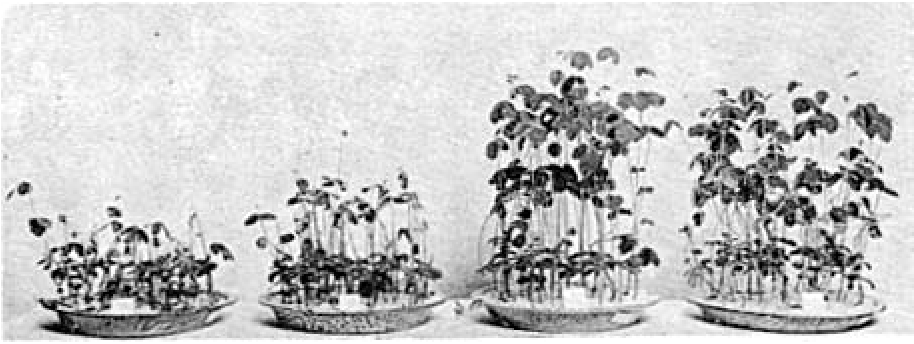
Moderately.weathered virgin soils usually were found relatively well stocked with calcium in available forms adsorbed on the clay and humus. But where no dolomitic limestones contributed to soil development, the magnesium was not ample for extended years of soil exploitation. These are facts now coming more clearly into focus when, in the springtime, animals turned out to start grazing the lush early growth suddenly die of what is called "grass tetany."

Results of studies

In the early 30's, research at the Missouri Experiment Station, using standardized colloidal clays, suggested that, as the minimum for the heavier agricultural soils, at least half of their adsorption, or exchange capacity, should be taken up by calcium. Later studies of magnesium suggested that this companion divalent element, in favorable balance with the calcium, should be adsorbed on the clay in amounts of about one-seventh to one-tenth of the calcium equivalents.

Thus, when for many legumes calcium at 65% of adsorptive capacity was found more nearly optimum, the corresponding requisite for magnesium was 10%. Variation in the soil's active organic matter is a significant factor buffering these percentages when differing from these values.

Calcium and magnesium represent 75% of the soils' available essential cations. This places these two elements at the top of the list of soil fertility elements and in rather specific ratios in the plant diets offered by the soils. Yet these are not listed on the fertilizer bag in connection with legal inspections of this product of extensive and vital commerce. When potassium on the clay-humus colloid of soils is ample at 2% or, at most, 5% of the soils' capacity, the situation just suggested is even more grotesque.



SOYBEANS DO BETTER WITH CALCIUM . . . First plant on the left received Potassium Chloride in early growth; the second, Magnesium Chloride; third, Calcium Chloride; and the fourth received Calcium Acetate.

Comparison of values

Considering the ratios of calcium to magnesium--less than 2 to 1 in dolomite and 7-10 to 1 as available nutrients in the soil--it is surprising that in the chemical composition of plants, in general, the ratios between calcium and magnesium are so much narrower at values of 1.6 to 1.0; while in warmblooded bodies they are so much wider at values of 32.0 to 1.0.

All this seems to emphasize the importance of magnesium when its deficiencies range from what would seem but a minor amount in the warmblooded body to a major amount in vegetable matter. Yet so little is said about magnesium itself, much less about its balance with other nutrient elements.

Let's Live Magazine, February, 1965

HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . .
Its Relation to Calcium in Plants

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part 3

That the quality shortages in food and feed bring on failing nutritional support as serious as functional degeneration--and its self-announcement--is a new concept. This is especially significant when the shortage of one single element of soil fertility, such as the alkaline earth, magnesium, in the food should provoke in man the same disorder which has long been known as "grass tetany" in ruminant animals. This same ailment, due to a magnesium deficiency with its consequent degeneration in nerve function, can now be listed simply as "tetany," and is by no means limited to cases where grass is the main food.

We now know, also, that this is a degeneration in humans which is not transmitted to them by animals, or vice versa.[1] There is a common cause for the separate cases of the same ailment or degeneration, viz: the shortage of an essential inorganic element which must come from the soil via quality food and feed. It is the failure of nutrition to be fully supported by the requisite fertility of the soil expected to grow nutritious foods and feeds.

Baffling disease

The baffling nature of "tetany" has kept hidden the real cause of the sudden death of apparently healthy cattle or sheep when they are shifted from dry feed under housing to luscious growth of young herbage. Post-mortems reveal no recognizable anatomical pathology. The preceding convulsions suggest nervous irregularities and point to disturbed magnesium-calcium interrelationships, when these two soil-borne elements can exercise either contrary or similar effects on neuromuscular transmissions.

When "deficiency of the magnesium ions and excess of calcium ions increases the release of acetylcholine[2] which excites the muscle," and when "deficiency of either will prolong the effect of acetylcholine" one can understand why the diagnoses have not been able to pinpoint one particular factor of only these two as the cause.

The interrelations of such small amounts as may bring nerve excitation are still too intricate for us to separate even two factors like the amounts of calcium and magnesium in the fluid which bathes the nerves. "The increase in acetylcholine and the extended prolongation of its effects can give rise to neuromuscular upsets."[3]

It is essential to note that Dr. Voisin, of France, speaks of the "ions" of the inorganic magnesium and calcium. "Ions" are the most active forms of these minerals when their salts are in water. He is not speaking of the chelations with, or combinations into, the larger organic molecules whereby they are not so highly active, do not pass so readily through membranes, nor modify the physicochemical condition of their medium, transmit electricity so freely, disturb water relations in tissues, etc. So combined into the larger organic molecules, they behave in plant tissues in what we call "a buffered state."

Not readily changed

This means that their physicochemical characteristics are not readily shifted or quickly changed. Should these be modified a bit, they move back readily to their former state.

Their elemental inclusion into much larger organic molecules makes this steady chemical state which characterizes the several living substances. It is part of their "power to survive." It is the "shock-absorbing capacity" of healthy living tissues.

These living substances do not have a high salt, or ionic, content, save as any salt may be separated from even the cell's protein by confinement within the cell's vacuole; by extracellular restriction; or by movement within the excretory system enroute to elimination. Living tissues and processes are highly "buffered" because they are highly organo-molecular and not "salty" or "ionic." It is by the "ionic" states of magnesium and calcium that the troubles, called "tetany," are brought about.

Significant fact

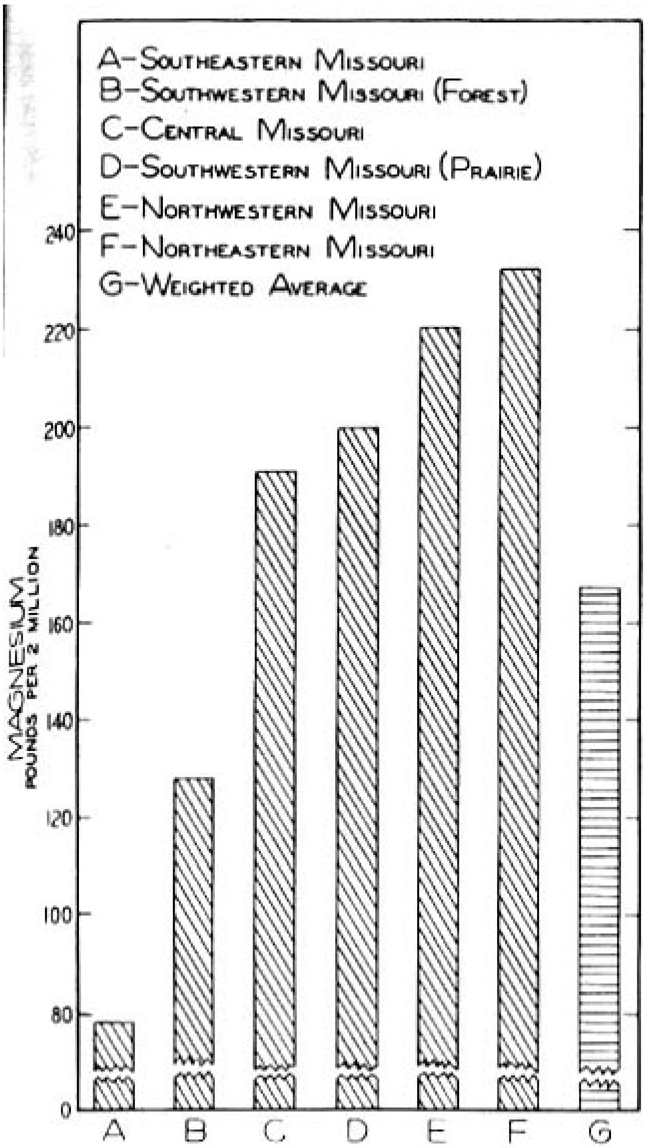
It is a very significant material fact that calcium and magnesium are a part of the cell walls of plants, among the several larger organic molecules of cellulose, hemicellulose and others. Composing the cell walls, "the microfibrils are embedded in a matrix of substances containing a preponderance of sugars other than glucose--which are amorphous or, more probably, paracrystalline. Among these, linear or branched polymers of xylose, mannose, and other sugars are known as hemicelluloses. . . .

"The other major group of substances in the matrix is the polyuronides; one such is pectic acid, which occurs in the form of methylated derivatives and often as the calcium and magnesium salt. The molecular chains of pectic acid are said to be linked both to the hemicelluloses and to the cellulose through calcium and magnesium bridges and through phosphate groups." [4]

Cells of root hairs as membranous tissue constructed of cellulosic fibers tied together by calcium (and magnesium), should suggest our thinking of the danger of a disturbance in the strucure of that membrane from loosing these two inorganic cations to the coloidal clay of the soil in contact with them, when the latter has a low degree of calcium saturation with its reciprocally high degrees of hydrogen saturation, or of soil acidity.

Result of studies

Studies at the Missouri Experiment Station have shown such troubles in the root membranes unless they are in contact with clays of saturation by calcium above 50% of capacity. The root membranes with their necessary calcium determine whether nutrients move from the soil into the root in proper amount and balance to bring about plant composition which is nutritious as animal foods; or whether even the seed-given nutrients may not flow in reverse from plant to soil to give vegetative bulk of less nutrient content (nitrogen, phosphorus, potassium) than those originally present in the planted seeds.



SOIL TEST SURVEYS . . . Chart shows "available" magnesium as pounds per acre for six areas of Missouri in 1943.

As parts of the construction material, no more extensive than the cellulosic walls of plant cells, calcium and its relation to magnesium point to their role in moving--or failing to move (see accompanying graph)---not only themselves but also other nutrient elements from the soil into forages to determine the nutritional services in fitness or failure for animals and man.

1. Warren C. Walker, M.D., and Bert L. Vallee, M.D., "Magnesium Deficiency Tetany Syndrome in Man," *Borden's Review of Research,* 22: 51-71, No 4, Oct -Dec., 1961.
2. Acetylcholine is the messenger material between the end of the nerve and the muscle that responds by reaction to the nerve stimuli. Ernest Borek, *The Atoms Within Us,* p. 222, Columbia University Press, 1961.
3. Andre Voisin, "Magnesium and Neuro-Muscular Transmission," pp. 99-105, *Grass Tetany,* Chap. 19, Crosby Lockwood and Son, Ltd., London, 1963.
4. R. D. Preston, "Structural Plant Polysaccharides," *Endeavor,* XXIII: 153-160, No. 90, Sept., 1964.

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HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . .
Its Relation to Calcium in Body Tissues

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Part 4

In a previous discussion (LET'S LIVE, Vol. 33, No. 2), we considered the disturbed interrelations of magnesium and calcium in the fluid around the nerves as a causal agent in the nerve breakdown called "tetany." This deduction seems to be a logical one when membranes, or cell walls, of plant roots undergo changes disrupting the plant's nutrition because their contact with the soil's moist clay is exchanging to them erratic amounts of calcium and magnesium. This is a plant's deviation from its normal physiology. It duplicates what is considered a parallel case of the nerve disturbance (tetany) in a warm-blooded body.

Experiments with varied degrees of saturation by magnesium and calcium on the clay have shown corresponding variations in nutrition and healthy functions of legume plants. The intake of cations gave normal, protein-rich growth, and generous nitrogen-fixation. The absence of the latter produced an erratic, mainly carbonaceous plant-growth, during which there was a reverse movement of the inorganic nutrients from the plant to the soil.

Indicates disruption

This latter indicates clearly a serious disruption in the structural properties and physicochemical functions of the root's cell walls, not only of the root hairs, but also of the successive cell layers from these hairs to the root interior. It suggests a breakdown in the unique function of the layers of root cells when, as normal, interface membranes--in contact and exchange with adsorbed nutrient elements on the clay--they "control" the intake and outgo of essentials for the healthy growth of plants.

Apparently the aforesaid breakdown occurs because of either insufficient calcium or excess of magnesium and other cations replacing the calcium in the cell walls where their microfibrillar structure of cellulose is cross-tied by calcium. [1] The clay as a colloid, matched against the root colloid, has been shown an able competitor for holding cations against the latter's taking or removing them, and vice versa. [2] Hence, we might expect the disturbance of the calcium in the cell wall to be causally related to the latter's control when we say "the 'semipermeable' membrane of the root determines the exchanges through it."

Like nerve disturbances

Irregularities in the plant because of irregularities in exchanges of calcium and magnesium with the clay colloid seem very similar to the upsets of nerves due to similar deficiencies and imbalances of those cations in the fluids bathing these bits of impulse-transmitting body tissue.

Since the degeneration of health can be traced to the disruption of the physicochemical functions in the walls and other parts of cells, and since performances of these minute body portions are biochemically so similar, regardless of whether they be cells of plants or of warmblooded bodies, it will be of interest here to give attention to calcium and magnesium in relation to at least one membrane of the human body.

Intestinal changes

For theoretical consideration, there are the suggested modifications in the intestinal wall--closely similar to those in the walls of the plant root--when magnesium sulfate is used as a purgative. Shall we not envision this excessive magnesium as displacing the calcium in the cellular wall structure of the intestines to disrupt their power of controlling intake and outgo? Should we not expect, then, their allowing the larger amounts of water and other liquids or substances from the blood stream to be the flushing agency? Then, should we not expect the duration of the purge to be no longer than the time required for the blood stream to absorb the magnesium from the cells of the intestinal wall and replace it with calcium to restore the normal physico-chemical control against excessive losses of liquids and other matters from the blood to the intestinal canal?

The sudden drain on the blood's low supply of calcium, which prevails in certain kinds of arthritis, may be so dangerous that one dare not consider Epsom salts as a purge in such cases. An extended purge by dripping magnesium salts, used for dehydration in preparation for brain surgery, may put excessive magnesium into the blood stream to threaten the patient with coma. In view of these facts it is evident that the intestinal wall must be undergoing a change in its membranous structure with consequent breakdown where calcium is replaced by magnesium, and then vice versa for recovery.

Appreciation lagging

We are slow in coming to appreciate the significance of "deficiencies" and imbalances" in the soil-borne inorganic elements which may cause irregularities in our bodies, as they do in the soil, in its microbes, and in the plants. All these struggle to be healthy and to maintain self-protection; but their biochemistry can manage only what is possible within the limits their environment provides. Numerous degenerations of body functions suggest similarity in cellular principles which are common not only to man and his animals, but also to life strata still lower, namely, plants and microbes.

Using the soil as in a mining operation, rather than managing it as nutrition for microbes and plants dependent on organic matter as well as minerals for their foods will finally bring us to recognize degenerations based on the failing creative capacity, that is the fertility, of our soils.

1. R. D. Preston, "Structural Plant Polysaccharides," *Endeavor,* XXIII, 153-159 (No. 90), Sept., 1964.
2. William A. Albrecht. "Some Soil Factors in Nitrogen Fixation by Legumes," *Trans. Third Com. Internat'1 Soc. Soil Science,* Vol. A, 71-84, U.S.A., 1939.

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HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . .
Its Relation to Potassium

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Part 5

It may sound like silly arithmetic to tell the beginning student of biological sciences that the cells of living tissues multiply by dividing. But we must also tell him that each part of the equal division of the cell must enlarge by growth of itself before it can divide again in the continuing growth process. This kind of multiplication by cell division holds true whether it be in the simplest, lower life strata (microbes or plants), in the cold-blooded, intermediate forms (insects and reptiles) or in the warm-blooded, most complex bodies at the apex of the biotic pyramid (animals and man).

Basic pattern

Growth through cell division follows a universal basic pattern, common to every life form, whether we view it in a single cell under the microscope or in the multicelled individuals of any species of larger bodies. This self-duplicating process is always carried on through nutrition according as the growth potential of the soil in its geoclimatic setting allows. There is self-duplication in function, as well as in form, to maintain similarity of offspring to parent in both these categories.

The biochemistry of the cells is also a duplication when growth from the start resides in the (presently considered two) nucleic acids, simpler units of proteins, so named because they are always found in the cell's nucleus, where duplication by division begins. These nucleic acids are the warp and weft, as it were, weaving the growth according to the characteristic pattern of the various species.

The expenditure of energy by which the body struggles to do the work required for its existence and growth is also similarly patterned in the biochemistry of the many species. The conversion of stored energy from carbohydrates in food follows the same pattern of chemical reactions, that is, it is a duplicated process within the cells of the many life forms. Nutrition, whether it is serving to give energy or to bring about growth of any body, calls for the specific diet of "go" foods and "grow" foods in quality and quantity commensurate with the degree of complexity of the life form.

Cause is within

When healthy living units are so highly similar in the processes of growth and of provision of their required energy at the levels as basic as the very cells themselves; and when the activity of every living unit as a whole is the summation of the activity of the separate cells, must we not view the decadence of health as resulting from deficiencies in nutrition which bring degeneration--or weakening form and function--from within, rather than from some overpowering external agencies?

The preceding concepts are under-girded in their logic, now that health irregularities in man and animals are exhibiting more and more similarities in symptoms. Under superficial knowledge only of the intricate body functions, we are apt to blame the animals for giving diseases to man (brucellosis), or vice versa.

Similar irregularities

With more basic knowledge from continuing research bringing us into fuller comprehension of the cellular biochemistry duplicated in both, the same health irregularity must be suspected as occurring in both from the same deficiency in the same physiological setting. This has now been illustrated for "The Magnesium Deficiency Tetany Syndrome in Man," [1] once considered to be grass tetany, [2] and limited to herbivorous feeders. It is significant that this deficiency is connected with the soil-borne element magnesium or its imbalances with other soil-borne essential inorganic nutrients given our attention in this present series of discussions.

Consideration of magnesium in its relations to potassium may suggest imbalances occurring more commonly when we remind ourselves that potassium is a monovalent, and magnesium a divalent, chemical element, and also that they are, respectively, an alkali in contrast to an alkaline earth. Accepted tests show that for healthier plant growth, the supply of exchangeable potassium of the soil needs he but 3%, while two or three times that amount of magnesium is required.

Rapid accumulation

It is also common knowledge that potassium is taken from soil and accumulated by plants much more rapidly and to a much greater degree than are bivalent ions, such as calcium and magnesium. This tells us what many studies have shown, namely, that the plant's content of potassium increases considerably and suddenly following the application of potassium, thus creating or accentuating various mineral imbalances.

This ready entrance of potassium into the plant lowers its content of sodium (another monovalent ion) until the sodium may be but one-third of the potassium in chemical equivalent. The ratio of potassium to calcium and magnesium combined may be nearly doubled, or approach the suggested upper limit (1.84) in forage, threatening dangerous disturbance to livestock. The potassium may be pushing the magnesium content of the forage so low that it brings down the magnesium in the blood serum of the animal consuming it, causing the animal to develop tetany and die.

Effect of nitrogen

Studies of potassium fertilization of forage in relation to the depression of magnesium levels in the blood serum have shown that these effects are much more prompt in bringing on tetany when nitrogenous fertilizers are used simultaneously. On the basis of such experiments, it has been suggested that the ranges of magnesium in the blood serum serve as limits by which tetany may be invoked or avoided.

Advance in our basic knowledge of biology as a whole shows that degeneration of our health--too often called disease"--is the result of deficiencies and imbalances of essential mineral nutrient elements coming into the nutrition of both man and his food animals via the soil.

AN ACT OF DESPERATION . . . The mineral nutrition has become badly out of balance when the animal is "down" and also eats the soil.

1. Warren C. Walker, M.D., and Bert L. Vallee, M.D., "Magnesium Deficiency Tetany Syndrome in Man," *Borden's Review of Research,* 22: 51-71, No 4, Oct -Dec., 1961.
2. Andre Voisin, *Grass Tetany,* D.V.M., 1963 Crosby Lockwood and Son, Ltd., 26 Old Brompton Road, London.

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HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . . Its Excess, According to Plant Species

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part 6

We know that the essential positively-charged nutrient elements, or cations--calcium, magnesium, potassium. sodium, manganese, zinc, copper and others--are taken out of solution and adsorbed by colloidal clays and humus of the soil, but are, nevertheless, exchangeable to plant roots offering the non-nutrient hydrogen in trade. We need to consider just what part of that adsorption-exchange capacity by each nutrient element will offer a balanced diet for the healthy growth and multiplication of each desired plant species.

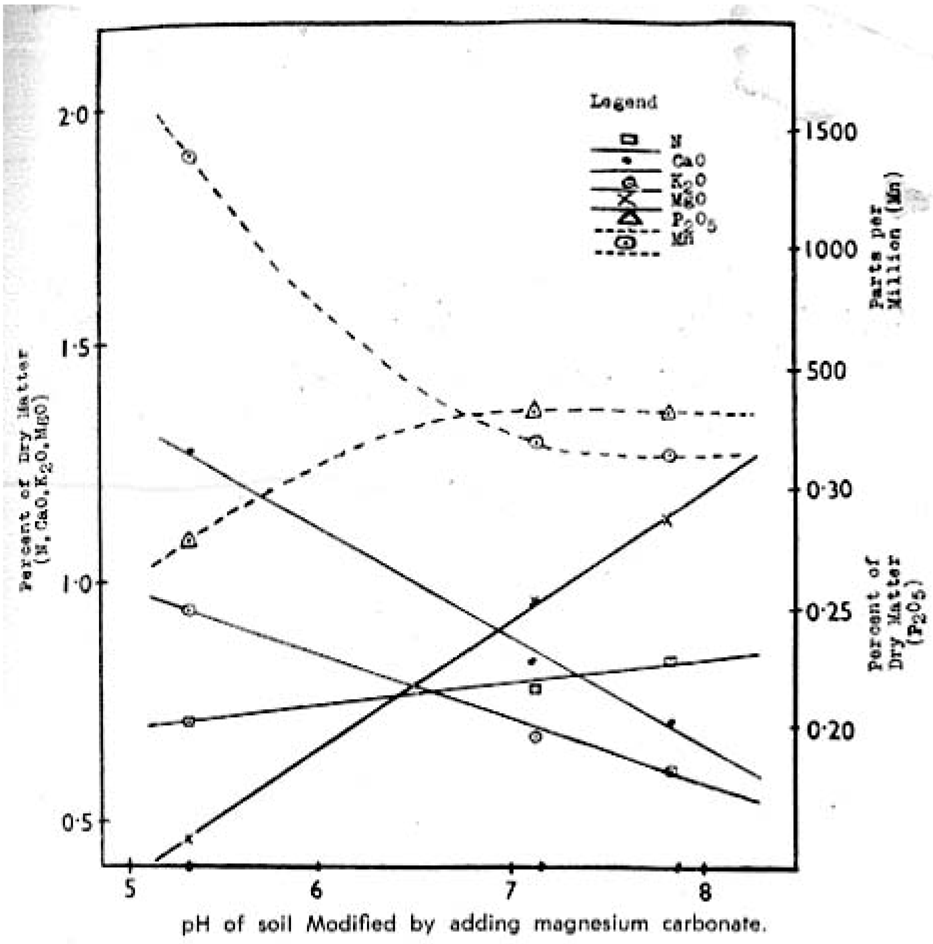
Contribution from Scotland

A contribution to the answer to this question was made in Scotland by a study of what increasing amounts of magnesium do to rhododendron plants. This species is erroneously believed to require acid soil; it really requires one of low calcium content. It does well on a high-magnesium soil, and consequently served well to study what, for most commonly cultivated crops, would be an excess of magnesium.

For testing the growth of the rhododendron, the researchers used a very acid soil (pH 5.0) in which three stages of acidity reduction (above pH 5.0, above 7.0 and near 8.0) were brought about by increments of magnesium carbonate. The reduction of the soil acidity from roughly pH 5.0 to 8.0 caused the plants to grow better. This fact tells us that this species does not grow well on soil with an acid or hydrogen-saturated clay-humus. Instead, it requires a soil with the exchange capacity of that fraction of the soil highly loaded with magnesium. The rhododendron is a *magnesiphile* and a *calciphobe;* that is, it is magnesium-loving and calcium-hating. In experiments, it grew best when magnesium carbonate (not calcium carbonate) had increased the pH roughly from 5.0 to near 8.0.

Graph shows effects

Just what this high degree of magnesium saturation did to the plant's chemical composition is shown most simply in the accompanying graph, in which the concentrations of nitrogen (N), calcium (CaO), potassium (K_2O) and magnesium (MgO) are shown on the scale on the left as percent of dry matter; the phosphorus (P_2O_5) is shown similarly by the scale at lower right; and the manganese is given as parts per million in the scale at the upper right.



DESCRIPTION . . . Decreasing the soil acidity (raising the pH) by using increasing amounts of calcium carbonate augmented the nitrogen (N), magnesium (MgO) and phosphorus (P_2O_5) in the rhododendron plants, but decreased the amount of calcium (CaO), potassium (K_2O) and manganese (Mn).

Significant results

The significant results show: (1) the adverse effects of high magnesium in the soil on the movement of calcium, potassium and manganese into the plant; (2) the favorable effects on the movement of nitrogen and phosphorus into the plant as a result of saturating the soil with magnesium; and (3) the very large increase in the concentration of the magnesium in the plants when the magnesium in the soil was increased.

The "antagonistic" effect by the magnesium on the calcium is an almost directly inverse one. The graph shows that the line for the concentrations of calcium goes downward at an angle about equal to that of the line showing rising concentrations of magnesium. This has been a well-known fact for many years. Similarly, there is the antagonistic reduction of potassium in the plant by the increased magnesium in the plant due to that in the soil, when, at the same time, its carbonate reduced the degree of soil acidity. Also, there was a very significant reduction in the concentration of the manganese in the plant. Relatively speaking, this latter was one of the largest reductions in the elements for which analysis was made.

Increased phosphorus

Perhaps the most surprising result was the increase in the amount of phosphorus taken into the plants when magnesium in the soil was increased. In the quantitative determination of phosphorus in the laboratory, it is common practice to precipitate it as magnesium phosphate, a most insoluble compound. Yet, contrariwise, putting more magnesium into the soil mobilized more of the soil's phosphorus into the rhododendron plants. This tells us that chemical analysis of the soil gives by no means the same values we get when the values are determined by the biochemistry by root contact in the soil.

Increase in the nitrogen of the plants was as expected, since it is the constituent of protein, the chemical compound carrying life, and its increase goes with increase of growth and the factors bringing it about.

Clarifies interrelationships

All this clarifies the interrelations (all too poorly comprehended) between the nutrient elements in the soil and the different crops created by these elements' quantitatively different roles. It explains the variations in the chemical compositions of any single crop as the result of its diet varying according to the exchange capacity of the colloidal clay and the soil organic matter.

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HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . .
Indirect Modifications via Mixed Flora

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part 7

From observing the general pattern of distribution of plants on the earth, that is, according to the science of ecology, we are coming to realize that the fertility of the soil is a prominent factor in control of it. Accordingly, the nutrient mineral balances of the soil influence these balances in the growth of the plant. This fact has been established by extensive works of soil science and of plant physiology.

The soil studies point first to the three inorganic nutrient elements, calcium, magnesium and potassium, which occupy, respectively, 60%-70%, 10%-20% and 2%-5% of the adsorptive-exchange capacity of the clay-humus colloid. Then some 5% is given to essential trace elements and approximately 10% to the non-nutrient cation (*positively charged ion*), hydrogen, or acidity. Secondly, these studies point to three, also inorganic, but anionic (*characterized by surface active negatively charged ions*) elements associated with the soil's organic matter, namely, nitrogen, sulfur and phosphorus. The phosphorus may well be so categorized, since it is commonly in the oxidized, or phosphate, form just as are nitrogen in nitrates and sulfur in sulfates, all connected with organic matter.

Recent knowledge

Knowledge of the association of phosphorus with energy changes in the metabolism of organic compounds within the cell is comparatively recent. It was very recently that Melvin Calvin, in his Nobel Prize paper, connected phosphorus with photosynthesis. He reported that, in its first stage, this process yields a compound of three carbons and one phosphorous, of which two unite, via the dropout of the phosphorus, to give the six-carbon sugar, glucose.

In these current discussions of magnesium along with calcium and potassium, the other major adsorbed cations on the clay-humus complex, we have concerned ourselves with variations in their amounts and the resultant balance and imbalance in vegetation. We have discussed how these imbalances represent similar situations in nutrition of animals in relation to the ailment called tetany, connected more specifically with the irregularities in the nervous systems of both animals and man.

For legume growth

Studies using colloidal clay titrated to differing degrees of saturation by the nutrient cations, calcium, magnesium and potassium, as well as by trace elements and the non-nutrient cation of hydrogen, have suggested that for good growth of legume crops and their significant fixation of atmospheric nitrogen into their proteins, the percentage saturations cited previously for the soil colloid represent balanced availabilities of those cations.

Mathematically, then, with so little of the highly active monovalent (*capable of binding one complement only*), potassium, we can consider its ratio to calcium and magnesium combined, more plentiful and less active divalent (*capable of combining with two complements*) cations, in the fractional arrangement,

$$\frac{\text{potassium}}{\text{calcium} + \text{magnesium}}$$

each as percentage parts of the total exchange capacity and in milligram equivalents per 100 grams of soil. Accordingly, the numerator varies over but small number values when doubling or trebling. But the much larger number values for the denominator--calcium and magnesium--need much wider additions as numbers before they disturb the ratio significantly. Discussions so far have considered direct relations as chemical elements. It is aimed to point out some indirect relations mitigating the dangers of magnesium deficiencies.

EXAMPLE OF POTASH DEFICIENCY . . .
Two plots show scant growth of clover. Legume crop grew abundantly on strip between the plots--the area where man is standing.

Means of control

Modifying the flora of the grazing animal is an indirect means of controlling the nutrient balance of cations when the balance in the soil may not be modified. The introduction of white clover into a combination of grasses is a case in point. While extra potassium favors the development of white clover (see illustration), this is a legume crop with liberal concentrations in itself of calcium and magnesium. Thus, it works against magnesium deficiencies related to high potassium in the grass-legume diet which the animal consumes. Without changing the fertility on the soil colloid, the threateningly high potassium gives more white clover in the mixed flora diet and encourages the animal to choose, by protein values, the legume providing more magnesium as protection against tetany.

Commercial nitrogen fertilizers contradict and offset, indirectly, the above beneficial effects via magnesium uplift in the flora, since nitrogen depresses the white clover, which, in turn, reduces the animal intake of magnesium as protection against the shortages of magnesium in the grasses, thus inviting the danger of tetany.

Balance important

The two monovalents, potassium and ammonium, considered in their play against the divalents calcium and magnesium, serve well, both directly and indirectly, to emphasize the importance of so-called "balance" and "imbalance" even if concerned only with the nutrients held on the clay-humus complex and commonly measured by soil tests. This balance becomes all the more important in relation to other matters of indirect relations via soil organic matter, varieties of crops and other factors. When plant nutrition from the soil is not so simple, certainly the animal nutrition from the forages becomes no more simple, relative to balanced diets for healthy growth by plants, animals and man.

Let's Live Magazine, July, 1965

HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . .
Imbalances Among Companion Elements

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part 8

Hidden in a 20-page pamphlet is evidence that man suffers "The Magnesium Deficiency Syndrome" [1] which has been a baffling and disastrous ailment among livestock for many years. It has been called "grass tetany" because it occurs in the spring when animals are put out to graze after a winter on dry feed.

During recent years veterinarians have connected grass tetany with a deficiency of magnesium in the soil, resulting in disturbed nerve transmissions and irregularities associated with the characteristic convulsions and sudden death. No advance warning of the impending disaster is given.

Compiled facts

Andre Voison, [2] a capable physiologist as well as a veterinarian, in his translation of *Grass Tetany* from the French, has brought together the essential facts reported in some 340 research references. He pictures this ailment, common to both livestock and man, as a reflection of deficiency not in the parts of a compound ration for the animals, but in the vegetation as the soil grows it. The pasture is often the scene of the disaster.

The significant factor is not always the specific minimum amount of magnesium alone, nor is it one to be revealed by soil test. It is not a case of such specificity. Rather, it concerns itself with improper nutrition of the plant, possibly due to a whole set of imbalances in the quantities of the four cationic (positively charged) elements, namely, calcium, magnesium, potassium and sodium, in terms of which a deficient concentration of magnesium results in herbage and health troubles.

Divergent behavior

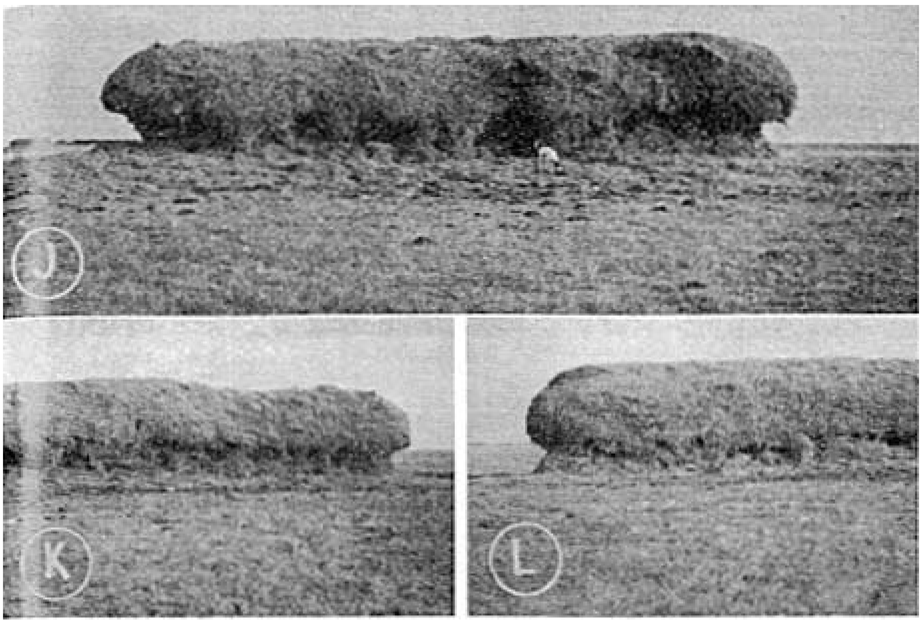
Calcium and magnesium are less soluble alkaline earths, each carrying two electrical charges. Potassium and sodium are highly soluble alkalis, each with one electrical charge, and of widely differing behavior in the soil. For example, through the ages, sodium has been readily carried to the sea, making the water more salty. But potassium, although equally soluble, has been held back much more by the clay in the soil and provides a higher ash constituency of plants. Calcium and magnesium also differ widely as essentials in living matter. Calcium is the foremost ash element in warmblooded life forms, where magnesium is almost a trace element. (The percentages are 1.5 and 0.05, respectively.)

These four elements, when weathered out of the rock minerals, occupy most of the exchange capacity of the clay of our soils, save for some hydrogen held there also, but as a nonnutrient for plants.

The behavior of magnesium as it moves into the plant is not simply a matter of the exchangeable amount on the clay. Its movement into the plant depends on the amount necessary to balance the concentrations of potassium, sodium and calcium and on the withdrawals made by the species of herbage. These withdrawals vary with the plant's synthesis of carbohydrates or proteins.

Result of analyses

Extensive literature dealing with tetany has resulted in a consideration of the balance of the four nutrient elements in herbage for livestock. Certain minimum percentages of these elements in the dry feed have been suggested as inviting tetany. Similarly, percentages of the elements required for prevention of the disease have been suggested. The work by Naumann [3] affords an excellent review of the mineral imbalances occurring in herbage of tetany pastures as revealed by a large number of chemical analyses of soils and pasture grasses in the area of the Lower Rhine River. where the incidence of grass tetany is high.



LIVESTOCK ARE SELECTIVE . . . Hay in stack J, cut from an area which eight years previously had been treated with a combination of calcium, phosphorus and nitrogen, was chosen by cattle in preference to hay in stacks K and L, cut from untreated parts of the same meadow. Cattle passed by stacks K and L daily to reach stack J.

Percentages listed

He cites the characteristics of tetanigenic herbage by listing its percentage of six essential nutrient elements in relation to animal requirements. Of the two soluble alkalis, sodium and potassium, the latter was high (3.88%) in the dry matter; the former was very low (0.13%). The magnesium was low (0.17%), relatively three-quarters of the requirement. Consequently, the potassium was far out of balance in relation to the magnesium and the sodium.

The magnesium content at a mean of 99 ppm was more than sufficient, while copper was 8.3 ppm, which is approximately the lower limit of safety, or about 70% of the requirement. The concentration of the phosphorus element in the dry matter was 0.41%, barely covering the requirement. According to these results, tetany may be anticipated when the single element magnesium is low in the feed and food, but its amount as related to imbalances with respect to other elements seems to be the baffling aspect of the ailment. Consequently, the intercationic balance of the nutrient elements adsorbed on the clay becomes the basic matter of concern.

Since tetany is a human problem, also, perhaps the balanced nutrition of the plant via the soil will become significant in human nutrition as well as in feeds for animals.

1. Warren E. C. Wacker, M.D. and Bert L. Vallee, M.D., "The Magnesium Deficiency Syndrome in Man," *Borden's Review of Nutrition Research,* 22:51-71, Oct.-Dec., 1961.
2. Andre Voison, *Grass Tetany,* 1963, Crosby Lockwood and Son, Ltd., 26 Old Brompton Road, London SW 7.
3. K. Naumann, *Report of Activities for 1959 of the Bonn Services of Agronomic Studies and Research* (translated title), Landwirtschafts Kammer, Rhineland, 1960.

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HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . . Biochemically, So Little Is So Important

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part 9

Now that untimely degenerations of the parts and processes of the human body have led to the collection of voluntary contributions for research studies, and we have learned more details of physiology with its underlying biochemistry, we are discovering that more and more of the basic functions of human and other warm-blooded bodies show close similarities in the behaviors maintaining health. In spite of these facts, we are slow to believe that experimental studies of details in animal bodies allow us to envision applicable suggestions for requisites of health in the human body.

Individual study necessary

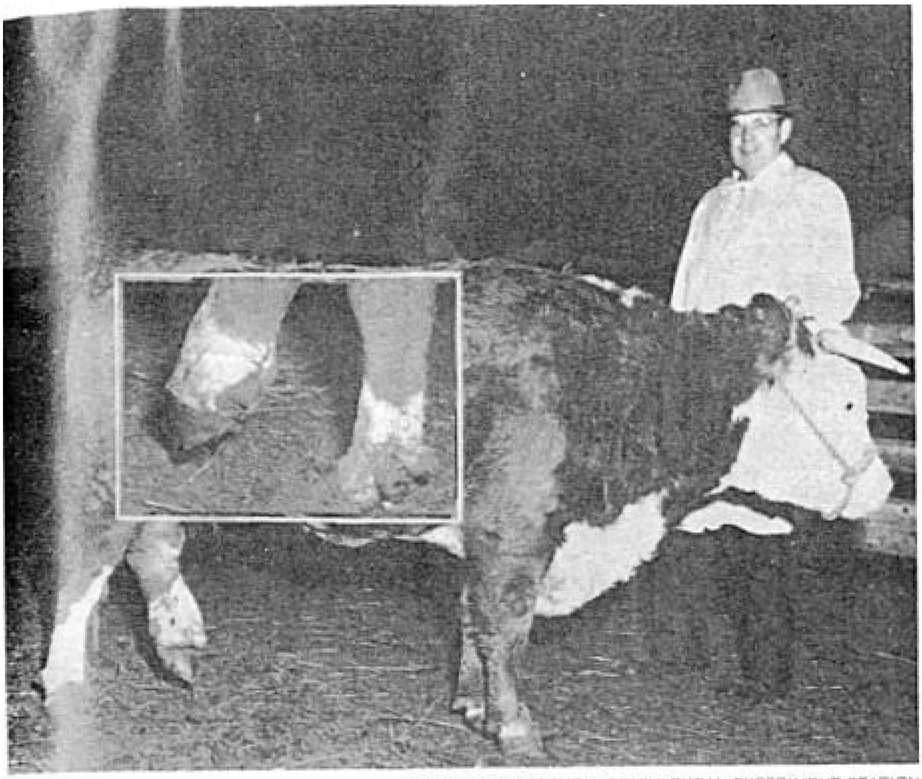
We have long known that cattle have tuberculosis with the secondary symptoms of infection by the same tubercle bacillus found in human tuberculosis. Since this disease indicates that deficiencies in essential nutrient chemical elements and compounds invite microbial invasion, and since proper nutrition and reduced activity will arrest this degeneration, we should move speedily to the practice of prevention of degenerations of many kinds by individual study of the requisites for maintaining health. While relief of the afflicted is a worthy humanitarian practice, it is far more rewarding for each individual to guard his own abstinences and practices, and thereby arrive at a national health, rather than to hope for that result to come via taxation and direction from federal officials.

Deficiency disease

In a 20-page publication, Doctors Wacker and Vallee [1] reported on "The Magnesium Deficiency Tetany Syndrome in Man." Tetany is another example of the same affliction affecting both man and beast. But it is not a microbial infection. Rather, it is due to the deficiency of magnesium, an inorganic or mineral nutrient element in the soil growing feed and food. Acceptance of the fact that man suffers this same affliction in common with cattle seems to meet bold resistance even by bureaucratic appointees who are supposedly concerned with human health. We do not seem ready to view disease in the negative, that is, a deficiency within the body. We view mainly in the positive, and search for an agency attacking from without.

"Magnesium," Doctors Wacker and Vallee tell us in their documented report, "is an essential nutrient for animals and plants, suggesting that a dietary inadequacy of this might readily result in a deficiency disease. Indeed, such deficiency states have been induced in animals. Tetany and convulsions subsequent to experimental magnesium deficiency, were first shown to occur in rats in 1932, and later in other animal species. Spontaneous magnesium deficiency tetany has been observed a well characterized in cattle . . . . The varieties of neuromuscular aberrations credited to magnesium deficiency are so numerous that they do not add specificity to knowledge of the metabolic functions of this element."

"This is a problem which has been overcome recently by the development of the flame photometer. Almost as a direct consequence of these circumstances, a new specific clinical entity, human magnesium deficiency tetany, has been described. The syndrome is virtually identical to that of hypocalcemic tetany, from which it can be differentiated only by chemical meal Its manifestations correspond almost exactly to those seen in magnesium-deficient animals. In each of the patients in whom the disease has been observed, the parenteral administration of magnesium sulfate promptly and completely reversed the symptoms, signs and chemical changes of the syndrome. An appreciation of the clinical consequences of magnesium deficiency resulting in tetany requires an understanding of the *biochemical* and *physiological* actions of this [nutrient] ion." [2]



COURTESY MISSOURI AGRICULTURAL EXPERIMENT STATION

MANY ABNORMALITIES are caused by forage crops lacking in magnesium. A typical case of "fescue foot" indicates impending sacrifice of this animal. The disease takes the name of the forage crop bringing it about--a tufted perennial grass with panicled spikelets. The formation of the animal's left hind foot is characteristic of nearly every case.

Reason for bafflement

"The biochemical fact that only lately has magnesium been found in laboratory tests to be an activator of many enzymes explains why the cause of tetany as a deficiency of an inorganic, soil-borne nutrient element has been so baffling so long. We need to remind ourselves that the photosynthesis of sugars in every green leaf depends on magnesium as the inorganic core of chlorophyll. There it is the 24 parts (as the final ash portion of a large organic molecule and not as an ion) in a total of either 900 or 925 parts of which all the rest is organic substance.

"A host of enzymes has been found to be activated by magnesium. Unfortunately it has not been possible to translate these in vitro [laboratory] effects, with absolute certainty, directly to physiologic events in the living animals. Most of the studies have been performed on isolated enzyme systems where magnesium ions were simply added to a given enzyme under observation, and the . . . resulting increase in activity was measured. . . . Thus it has not been possible to prove an absolute requirement for magnesium. On this basis, a definite physiologic role for magnesium in these systems cannot be assigned."

Because the soil-borne element, magnesium, is so small a part of so many enzymes, which are doing so much in spite of their being present in such small amounts, and since they are absent in the resulting products which they catalyze, it has been difficult to ascribe sudden disasters such as convulsions and death to a deficiency of magnesium in the soil, especially since it operates in no closer chemical contact than in the liquid bathing the nerves. Nevertheless, it makes the part of the soil in nutrition more significant, in giving ecological order for man as well as animals, to tell us that "we are what we are, because of where we are" in relation to the degree of development of soil from the rock according to the climatic forces.

1. Wacker, Warren E. C., M..D. and Vallee, Bert., M.D., "The Magnesium Deficiency Tetany Syndrome in Man, *Borden's Review of Nutrition Research* 22: 51-71, Oct.-Dec., 1961.
2. Italics ours.

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HIDDEN IDEAS IN UNOPENED BOOKS

Magnesium . . .
Relation of Soil Test to Crop Analyses

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Part 10

Improved technical aids in the laboratory have helped increase our knowledge of the soil's supply of nutrient elements and its relation to the plant's content of these factors. This has given us a clearer vision of what we can consider a balanced diet as measured by soil tests.

Some experimental studies made in Scotland since 1949 have concentrated attention on magnesium in soils and crops. [1] The effects of magnesian and calcic limestones on the magnesium contents of herbage and other crops were measured. Whether crops grown on soils relatively low in readily soluble (available) magnesium respond to its application was considered. Attention went to the effectiveness of the use of different materials which contain this element on the growth of the crop and on its chemical composition.

The relation of potassium to magnesium was also studied, since potassium can modify the assimilation of magnesium by the plant. In addition, the plan allowed measurement of the relations of different rates of applied nitrogen and phosphorus on successive cuttings of grass during the growing season.

Chief reasons

There were two main reasons for these experiments. First was the increased incidence of animal disorders (*tetany*) associated with deficiencies of magnesium. Second, there was the possibility of a deficiency restricting crop yields, especially with the application of large amounts of fertilizers with no magnesium.

Investigators used freely-drained soils from glacial drift of varying origins, with pH range 5.2 to 6.5; ignition losses, 2% to 13% as indices of organic matter; and clay contents of 8% to 19%, save two soils with but 4% to 5%. The contents of magnesium, soluble in acetic acid and ammonium acetate, ranged from 1.5 mg. to 18.4 mg. per 100 gm. of soil and 1.3 mg. to 21.5 mg. per 100 gm. of soil. All but three soils contained less than six milligrams-percent of magnesium.

This last soil-test value is a suggestive one, since in a significant area of northern Scotland about half of the agricultural land seems to contain less than 6.1 mg. per 100 gm. of soil; and nearly one-fifth has less than 3.1 mg.

Ten magnesium materials were used to add this element to soils. These were mainly natural minerals, or those burnt and supplying magnesium, calcium at sulfur.

Emphasis on herbage

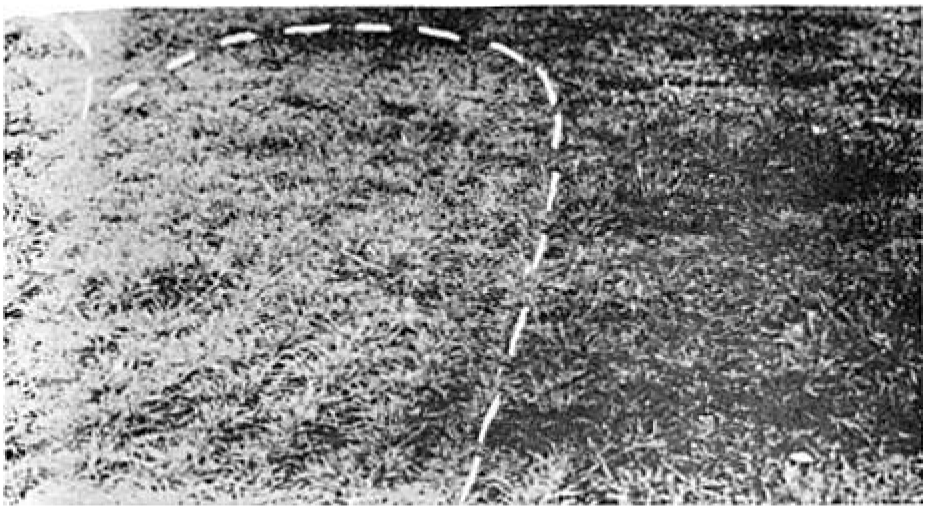
Since the emphasis in the study was on herbage for grazing as related to the threat of tetany, a danger from magnesium deficiencies in pastures, the mixed grasses and clover were the major crops used. There were also oats, barley, yellow turnips (swedes) and potatoes.

The differences in the uptake of magnesium by the various crops stand out decidedly. The differing physiology of crops largely determines their ability to obtain inorganic nutrient elements from the soil in order to prevent deficiencies in the ration or diet. Or course, if the soil is too low in supply, no plant can deliver the element in question.

The experimental results for potatoes and swedes on soils with magnesium no higher than 6 mg. per 100 gm.--120 pounds per 2,000,000 of soil, or per acre plowed seven inches deep--but given increments of calcined magnesium sulfate and of kieserite, a slightly soluble hydrous magnesium sulfate, tell us that the treatments had no effect on the yield. But they did increase the percentages of magnesium in both crops. Without applied magnesium, the mean percentages in the fresh tubers and roots were 0.0156% and 0.0087% magnesium, respectively; while the corresponding values with the 36-pound magnesium treatment were 0.0164% and 0.0102%. These represent increases by 5% and 17%, respectively.

No constant effect

When the soils for these two food crops were liberally treated with nitrogen, phosphorus and potassium, "the nitrogen and phosphorus had no large or constant effect on the magnesium contents of the tubers and roots; the mean percentages of magnesium for 10 experiments on potatoes and 16 on swedes being 0.0173% and 0.0089% respectively. The potassium had no influence on the magnesium content of swede roots, but tended to increase the percentage in potato tubers. Healthy crops grown in the northern half of Scotland have contained as little as 0.008% and. 0.006% of magnesium in tubers and roots, respectively. Differences between crops are much greater than the variations produced by normal dressings on NPK fertilizers." [1]



NOT APPARENT TO ANIMALS . . . Cattle's first selection was small area where fertilizer drill doubled treatment (indicated by dotted line). However, cattle seem unable to detect magnesium deficiency in spring pasture grass, even when lack is sufficient to cause death from tetany.

This report tells us that applied magnesium is not much of a direct factor in modifying crop yields, thus explaining why so little attention has gone to it as commercial fertilizer. The report does not refute the possibility of indirect effects of magnesium on other elements via enzymatic activities, or others, as has been suggested.[2] It tells us that crops measure the magnesium of the soils biochemically in greater detail than we measure it chemically to categorize it according to the nutritional quality of the crops it produces.

Test treatments

In the grass crop, the uplift of magnesium content of the hay and the herbage was accomplished by mixing clover--a legume crop--with the grasses. The effect stands out prominently. Magnesium treatments, coupled with different amounts of applied potassium, were tested by analyses of the mixed herbage, and of the rye grass, the orchard grass and the clover, the last three separated from the mixture. There were three cuttings per year.

"The magnesium treatment applied in March did not increase the yield, and had practically no effect on the amount of herbage. . . . The percentage of magnesium in the clover was only slightly greater at the second and third cutting than at the first. These results illustrate the well-known fact that clovers generally contain more magnesium than do the grasses."[1] The average magnesium concentrations for magnesian soil treatments, coupled with the highest treatment by potassium, were as follows: rye grass--0.15%; orchard grass--0.23%; mixed herbage--0.24%; and clover--0.46%.

Results significant

These results demonstrate that the roots of legumes have a greater ability than non-legumes to take exchangeable cationic nutrients from the soil.[3] Also, it shows that the uplift effect as soil-born elements in mixed herbages and hays results because a higher concentration of the soil's several cationic elements in legumes supports their creation of more protein-rich forages.

In these experiments the added clover made the difference in higher magnesium concentration as possible prevention of tetany. But the amount of magnesium in clover is only about one-tenth of its calcium content. The quantitative ratios among these basic elements in the plant are reflected in similar ratios of supplies adsorbed on the clay of the soil growing the legumes.

But legumes, like these clovers, cannot grow successfully unless the soils are relatively well supplied with the basic, or cationic, nutrient elements: namely, calcium, magnesium and potassium. Even then, in a more specifically balanced lot. or diet, the needs of specific plants and crops have not yet been fully established. Chemical contents of the soils are slowly being precisely measured and related to their value as nutrition to the crops produced. This knowledge serves to emphasize the connection between "the handful of dust" and the creations therefrom.

1. J. W. S. Keith, "The Magnesium Contents of Soils and Crops." *Jour. of Science, Food and Agriculture* (No. 6) 14:417-426, 1963.
2. Wm. A. Albrecht. "Some Factors in Nitrogen Fixation by Legumes." *Trans. III Com. Int. Soc. Soil Sci.,* New Brunswick, N.J., U.S.A., Vol. A: 71-84, 1939.
3. Herbert A. Hampton and Wm. A. Albrecht, "Nodulation Modifies Nutrient Intake From Colloidal Clay by Soybeans," S*oil Sci. Soc. Amer. Proceedings,* 8:234-237. 1944.

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HIDDEN IDEAS IN UNOPENED BOOKS

Balanced Soil Fertility
Requisite for Nutritional Quality of Crops

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Research here in soil and nutrition has placed major emphasis on the balance (as a plant diet) of the positively-charged nutrient elements (cations) exchangeable from the soil's clay-humus colloid to the plant roots. The criterion for establishing that balance among calcium, magnesium, potassium, sodium and the non-nutrient hydrogen (as so far considered) has been the effective symbiotic relations between the legume plants and their specific nitrogen-fixing bacteria. Through these the legumes supplement their soil-nitrogen supply with that from the atmosphere to become protein-rich, mineral-rich feeds and foods. These several nutrient cations can be supplied from soil reserves of pulverized rock particles of sizes commonly carried by water and wind.

Foundation of pyramid

Under such criteria of matching the managed fertility support of the soil against the crop's needs for cationic nutrients, the study of soils and their microbes demonstrated that these are the two foundation strata of the entire biotic pyramid. They have been the biochemical support of all the other life strata. Natural grinding and mixing of rock-minerals from the earth's surface by climatic forces has built soils matched to crop needs--under the above criteria.

But while the ratios between the nearly half-dozen cationic nutrient elements on the soil's clay-humus colloid have been established, we have not yet worked out a balance of the soil's negatively charged elements. These include the anions, nitrogen, phosphorus, sulfur, and some of the trace elements. Among the latter are some which can function as either positively or negatively charged. These are said to be "amphoteric."

These anions are held in the soil and are more available to microbes and plants through the soil's active organic matter which connects them with the higher energy reserve-supplies of carbon for microbial action. They are active and available to plants in the "living" soil. Of these elements, phosphorus has too long been considered only in the group of inorganics, or rock minerals. But since this anionic nutrient has been recognized as so important in biochemical energy changes--even in the first step of photosynthesis of sugars and possibly of lignin compounds--we need to connect phosphorus closely with the soil organic matter in plant nutrition.

Much is unknown

Theoretical consideration may well be given to such a one of the anionic nutrients aiding the effectiveness with which mycorrhizal symbiosis of fungi and non-legume plant roots increases plant nutritional values. This would be similar to the case of legume-bacterial symbiosis where the cationic element, calcium, is such an essential. Unfortunately, the anionic sector of the group of requisite fertility elements, as well as the many organic nutrient compounds, is still much unknown in plant functions through which soil management can give uplift to the nutritional quality of food crops.

Natural consequence

Our early separation of the functions of nutrient cations in plants from those of the anions in the soil seems to be a natural consequence of educational sequence. First, we become familiar with inorganic chemistry before any interest in the organic arises. Second, for geological studies in mineral decomposition and soil formation, the cationic activities and losses to the sea exceed those of the anionic. The former consists of many elements with which we become familiar early in the study of chemistry. The latter is mainly the colloidal silica of clays, pushed aside in early chemistry to await the day later in the educational program when newer technologies elucidate colloidal chemistry, mineral structures and reactions of the residue of rocks weathered into soils.

Then also, the comprehension of the intricate roles played in plant nutrition by the anions, nitrogen, sulfur and phosphorus, is delayed still more when within the plants they are combined into large organic molecules as reduced elements. But they are readily oxidized into forms of increased solubility and release considerable energy to the responsible microbes. Combination of anions with carbon in organic matter magnifies this dynamic energy aspect. It marks nitrogen release from its combination with carbon.

In the role of soil fertility in plant nutrition, the complicated molecular biochemical connections of the anions are not clear; nor is the union of either inorganic cations or anions with larger organic molecules by what is called "chelation."

Function of microorganisms

That soil microbes, acting as wrecking crews and salvaging agents of plant residues, should conserve and mobilize many large organic molecules in close root contact for uptake as nutrition is still an embryonic concept. That their action affects the flavor and quality of vegetables still awaits scientific cataloging, though it is widely proclaimed by empiricism.

The fact that organic matter in the soil is essential for growing quality foods is emphasized when one of the larger producers of frozen vegetables uses the practice of "fertilizing the fertilizing green manure crop" and grows its vegetables only in the second year, after heavier fertilizer and green manure treatments of the soil. Organic matter and the microbes struggling for energy therefrom give crops the ability to survive and grow in spite of soil doctors.

Ideas still hidden

Now that the limited knowledge of balancing the fertility cations absorbed on the soil's colloidal complex has shown itself as such a prominent control factor of crop quality, we are forcefully reminded that (1) we have not yet given "balance" to the fertility anions in the soil under like criteria, (2) nor has the "balance" of soil organic matter per se, or against cations and anions, been divided into specific ratios or relations as manageable matters. Our ignorance of soil management for growing quality crops exceeds our knowledge of the subject. This fact is emphasized in fertilizer sales literature reporting research. Many ideas are still hidden in nature's unopened books.

Let's Live Magazine, November, 1965

HIDDEN IDEAS IN UNOPENED BOOKS

Quality Becomes More Quantitative

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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Food quality is the essence that develops a noble, health-guarding taste. One can observe this fact demonstrated when livestock break through the fence to get to preferred grass, or when the animals choose to graze the portion of a field given a certain soil treatment, or to avoid grazing where some other soil treatment was applied. We are but slowly coming to see nutritional quality in feed and food as the result of the plant's nutrition via carefully balanced fertility of the soil which insures healthy, self-protecting crops.

The quality of crops for, or from, the market can not be judged by taste. That criterion can be exercised only after the purchase transaction has been closed.

Concerned with quality

Werner Schuphan, Ph.D., Geisenheim, Germany, has concerned himself with food quality, in terms of nutritional values grown into it, ever since World War I. He founded a research station for the study, and refined quantitative measures of quality differences in our food crops according to the many modifying factors. But it was only this year that his assembled reports appeared in the English translation. These comprise the 280-page book, *Nutritional Values in Crops and Plants (Problems for Producers and Consumers),* published by Faber and Faber, 24 Russell Square, London, W.C.I.

According to the author himself, "The book defines a position with regard to worldwide problems of the quality of agricultural and horticultural food-plants. It attempts to integrate concepts of all those interested in the problems of quality in order to find a common denominator."

Interests differ

"The demand for quality--this must be emphasized--is not confined to the consumer," he continues. "Both producer and merchant are interested for similar reasons. This does not mean they have the same reasons regarding what is meant by the term 'quality'. Moreover, the interests of those concerned in the quality problem are different. Producer, manufacturer and retailer often attend to their own economic interests too one-sidedly. To direct these largely to the legitimate desires of the consumers for an unobjectionable, wholesome diet is a far-sighted policy which is also an advantage to others who are interested in plant production.

"On the other hand, the consumer must not make unrealizable demands on our field and garden products; efficiency in production in agriculture--as in industry--is the main thing. Our modern methods of cultivation are subservient to this necessity. With the daily increase in the world's population, rational production is the only way to provide quantities of food."

Criticism appropriate

"However, bulk production of attractive crops is not always synonymous with high nutritional quality," Dr. Schuphan explains. "Therefore, constructive criticism of the methods employed by the producer, the manufacturer or the retailer is appropriate where loss of quality touches the interests of the consumer.

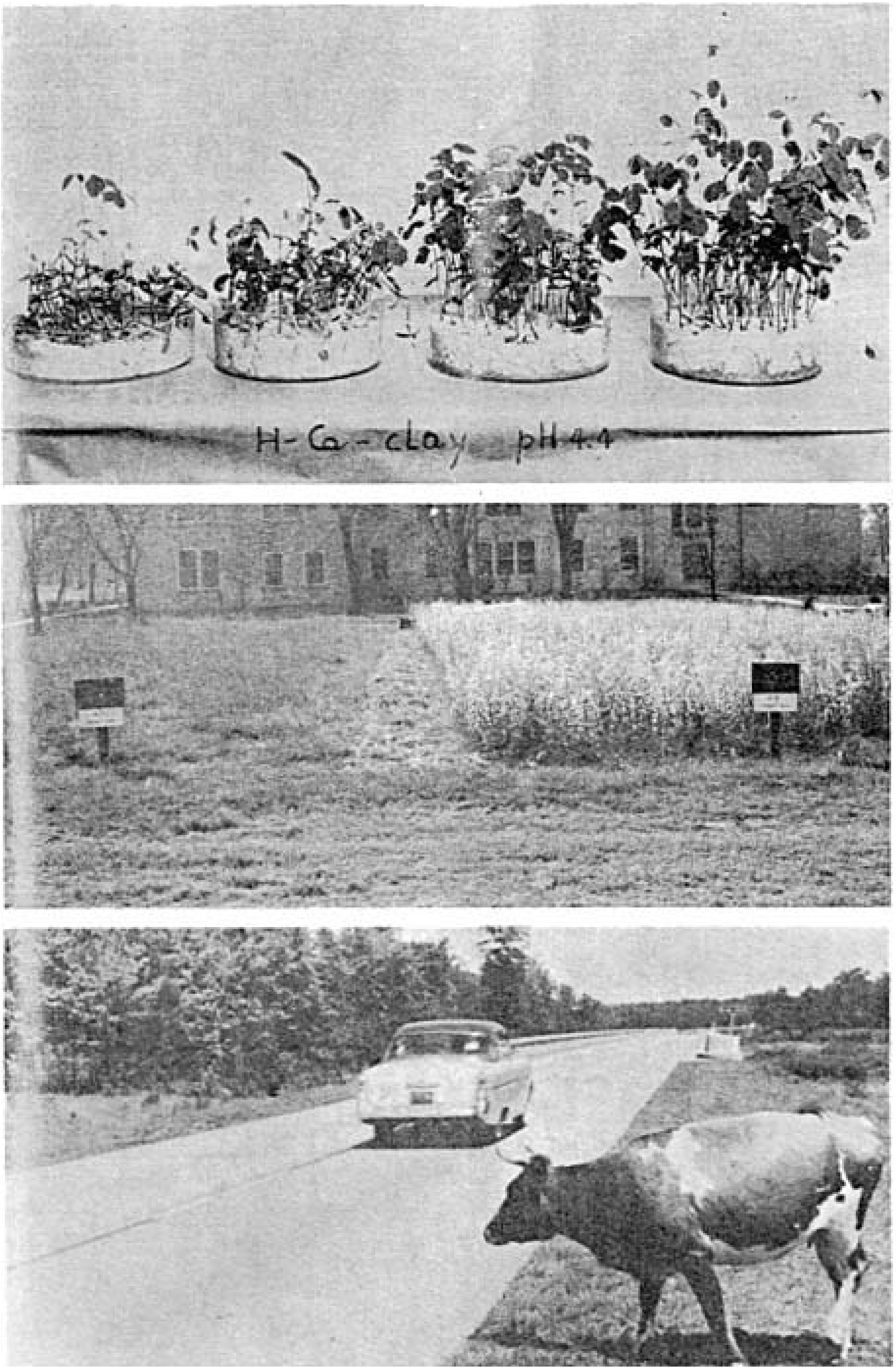
"These questions deserve to be given particularly careful attention by those responsible for the nutrition of infants, of children and of the sick."

Dr. Schuphan's book outlines the problem and considers quality as the measure of value in terms of, first, the consumer's expectations under commercial grading in various countries; and, second, the mounting attention to utility and physiologically nutritional values. These emphasize what is called (a) "biological value" as an expression of quality, (b) protein supply, and (c) taste.

Nearly half the book is devoted to clearing up the confusion about how much and when the hereditary assets of the plant species can contribute to its nutritional quality; and, similarly, how the environment, natural or man-managed, can be a factor in that respect. It is here that the many tests carried out at the research station under the leadership of Dr. Schuphan are presented as quantitative measurements of nutritional values in their several phases as we now appreciate them.

Valuable reference

Differences in nutritional values because of species, varieties, "cultivars,"* form and shape, climate, soil, cultural practices, spacing, manuring, chemical protectives, time of harvest, transport, size, weight, storage, preparation for market, and other factors are presented by specific test data to make this volume an extensive--if not complete in all aspects--reference volume on quality of food as nutrition.



QUALITY IMPROVED . . . Soybeans (top) show increasing resistance to fungus disease paralleling increase in amounts of calcium in the soil (at constant degree of acidity). Weeds, broom sedge infest only the plot on Sanborn Field (center) where fertility was exhausted by continuous grass crop removal and no fertility return. (Bottom) Cow becomes trespasser on highway in order to graze strip of high-protein grass fertilized by calcium from concrete.

Food quality as a therapeutic factor is discussed also, particularly as a preventive for such degenerations as heart disease.

"In this book," says the author, "the interests of the producer are to be brought into harmony with the desires of the consumer. This involves confidence. Confidence presupposes knowledge of the problem. It is the object of this book to provide the knowledge."

* "A cultivar is a variant not known in the wild or not known to have an equivalent in sufficient numbers to justify Botanical recognition, as distinct from a variety, which is a wild variant demanding Botanical recognition," J.F.H.S., 77:161 (1952).

Let's Live Magazine, December, 1965

HIDDEN IDEAS IN UNOPENED BOOKS

Nutritional Quality of Vegetables Via Plant Species and Soil Fertility

by William A. Albrecht, B.A., B.S., M.S., Ph.D.
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When we speak of nutritional values of any of the vegetable crops, do we have a clear concept of what part of the plant represents those values, and how widely they may vary? They will vary naturally because of different plant species within a single use category (for example, "greens") and within the same species, because of where, when and how they are grown in your own garden. They will vary on the market, also, because of from where, when and how the crop was delivered. Also, they will vary between the time of purchase and time of consumption.

Vegetables grown under carefully controlled conditions and put under chemical and biochemical essays for such values (reported in Werner Schuphan's book [1]) serve to shock one's faith in the pedigree of a vegetable crop as any guarantee of its health-building value when eaten. The pedigree is merely a mark of the potential, or the possibility of values. Only the plant's nourishment from soil supporting the potential of high nutritional quality can assure this latter property.

The warp and weft

The biochemical understanding of the life processes has been carried back as far as the two bits of protein, namely, two nucleic acids, of the "gene" of the cell. One of these acids serves as the warp and the other as the weft in weaving the structural pattern. The infinitude of these two nucleic acids eliminates any extensive power for carrying very much control of growth from the parents to the single mated cell. The many growth stages, pushed along by many growth factors from conception to full development, offer numerous chances for deficiencies and disruptions of the potential in nutritional values of the plant products for higher life forms.

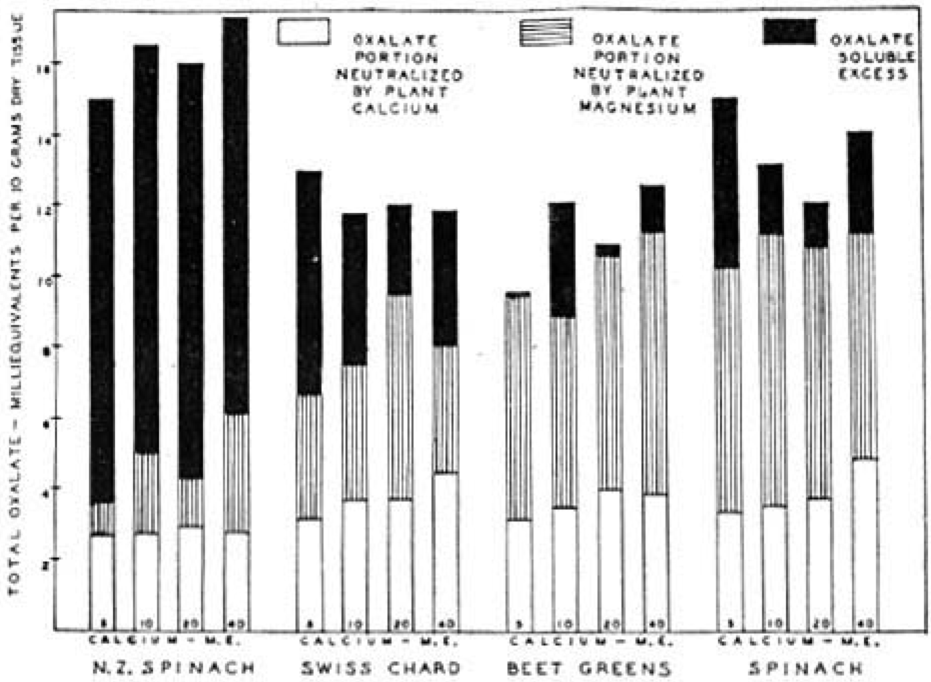
In the case of the vegetable "greens" for human consumption, a variety of different kinds of plants is included. Some of these contain considerable oxalic acid, a by-product of the plant's metabolism, while others do not. Oxalic acid reacts with the nutrient element calcium to form insoluble and indigestible fine needle crystals. These are irritating to the tongue and disturbing to the taste.

Differ in value

While green, leafy vegetables may appear to be a rich source of dietary calcium, according to analyses of ash contents some species would not classify as such under tests of digestion and nutrition, while others similarly listed as "greens" would. Savoy spinach, Swiss chard, beet greens and New Zealand spinach, all belonging to the goosefoot family (*Chenopodiaceae*), may be worthless as contributors of calcium and magnesium. In addition, if cooked with milk, their high oxalic acid content may bring about unavailability not only for their own calcium and magnesium, but also for a large percentage of these factors coming from the milk or other accompanying foods.

However, such is not the chemical composition, digestive behavior and nutritional quality for these mineral nutrients of the "greens" of the mustard family (*Cruciferae*), including kale, turnip greens, collards and mustard greens--to name four. All of the eight species of vegetable plants listed offer considerable calcium. But, considered nutritionally with respect to their contribution of calcium (the most necessary of the mineral essentials) the two families differ sufficiently to warrant more careful discrimination in their use (at least in children's diets) than is commonly exercised.

Studies at the Missouri Experiment Station[2] showed that the oxalic acid content of Savoy spinach, and its relatives, is seriously disturbing; but the "greens" in the mustard family are practically free of oxalic acid. Also, very often the latter are higher in vitamin content. Since the plants of the mustard family offer so much more mineral value than do those of the goosefoot family, it would be worthwhile to learn the nutritional values of the various "greens" so one can make an intelligent selection.



DIFFERENCES SHOWN . . . Graph indicates variations in oxalate contents of plants resulting from increases in calcium; amounts of the acid neutralized by calcium and by magnesium; and excess acid remaining.

The Missouri studies demonstrated not only differences in oxalic acid content according to plant species, but also showed these differences in relation to varied additions of nitrogen and calcium as soil fertilizer. (See accompanying graph.)

Chemical data for calcium, magnesium and oxalic acid showed enough of the latter to render both the calcium and magnesium insoluble; and in some cases showed nearly double the amount required to make both calcium and magnesium unavailable. The oxalic acid content was modified decidedly in relation to each of the fertilizing elements, calcium and nitrogen.

Convincing evidence

Here is clear evidence that the nutritional quality of vegetables may depend on the fertility of the soil. These studies show that variations in the plants' contents of the cations calcium and magnesium, as well as of the anions nitrogen and phosphorus, resulted in much greater variations in the production of oxalic acid when only two nutrient factors of soil fertility (nitrogen and calcium) were variables in the soil treatments.

Your health depends on the soil that nourishes it.

1. Werner Schuphan, *Nutritional Values in Crops and Plants,* Faber and Faber, 24 Russell Square, London.
2. S. H. Wittwer, Wm. A. Albrecht and H. R. Goff, *Vegetable Crops in Relation to Soil Fertility, III,* "Oxalate Content and Nitrogen Fertilization," *Food Research,* 11:51-60, 1946, No. 1.