Let's Live Magazine, January, 1959

Soil Organic Matter--

Possible Poisons Naturally

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

The organic matter in the soil represents the death-end processes of the *organic* remains of previous crops. They are giving up the *inorganic* parts which initially come from the soil. Those parts were the original mineral starters and directors of the chemical synthesis by the plants of their combustible selves.

We commonly assume that organic matter in our crops, grown naturally, is always good nourishment for warmblooded bodies, and always beneficial manure for microbes and plants when plowed under. Whether that is true depends on (a) climate, in general; (b) season, occasionally; (c) the plant species, in particular; and even (d) the soil. These factors may disturb the natural processes in the cycle of growth, death, and decay enough to give poisons from organic substances in the soil. The processes may also be perverted from their normal by man's management to give poisons of our own making.

Dangerous

Poisonous organic matter may occur in the soil because we use highly poisonous organic chemicals as crop protection. We forget that putting them in the soil or on the crop, to protect against insects, fungi, bacteria and weeds, is also an application of them to the soil for possible poisons to the microbes and to the crops we grow, supposedly to be nourished, not poisoned, via the soil. Poisons put into the plant's living system may be a case of dangerously poisonous herbage and of turning under poisonous organic matter for the microbes or even for the following crop.

The more powerful we make the poisons, especially those recently designed in terms of the complex carbon-ring structures with their additions, the more resistant, in general, those chemicals are to decomposition via natural chemical and biochemical processes in the soil and in the bodies and cells of the various living forms. It was this ring-carbon structure, like carbolic acid, from coal tar distillates that was one of our first antiseptics. It serves well in killing bacteria. It is concentrated in the bark of trees. In passing from these to be recovered in coal, it suggests that it is chemically more stable, or permanent, than we appreciate.

Side reactions

While "more and better chemicals" are apt to breed confidence in better protective chemical services to crops, we need to be reminded that organic reactions are not completely predictable. What we call "better poisons" for plants, insects and microbes may bring on unknown side-reactions deceptively harmful to animals and man.

Poisons

The crops are poisonous sometimes because the plants take up too extensively some poisonous elements from the soil in certain climatic settings. This is more common in areas of low rainfall, because the rocks and minerals have not been significantly weathered into soil. The two elements, molybdenum and selenium, will serve to illustrate the case of their concentrations in the herbage to be poisons to animals and man consuming the herbage and the seeds.

Molybdenum in higher concentrations in the forage brings on excessive cathartic effects with emaciation and then death of the animal as the final result. Yet this is an essential element, especially if legumes are to grow root nodules and use nitrogen from the atmosphere in building their higher protein concentrations. Only fractions of an ounce of molybdenum per acre are the difference between success and failure of the legume crop. Likewise, only ounces in excess spell poison. Unfortunately, no soil tests commonly used give warning of such danger. Selenium, not considered a fertility element, is also taken excessively by crops in areas of lower annual rainfall. It accumulates to high concentrations in the plant tissue and in the seeds of some species. Certain geological conditions in the soil's origin contribute to the danger. Animals may discriminate against plants growing where the fertility is imbalanced, but their self-protection is not so discriminatory in case of selenium as an inorganic poison within the organic matter eaten.

Mushrooms

That a plant species which grows on ordinary organic matter may have some varieties which grow food, while others grow poisons, is well illustrated by the mushroom. The distinguishing characteristics are not common knowledge.

The crop is one of the fastest growing ones we raise. That speed is possible because the mushroom builds itself more from the only partially-decayed organic matter synthesized by other crops. It suggests that all crops might be users of organic compounds more extensively than we realize, and susceptible to taking up poisonous organics as well as beneficial ones.

The early drug business was built up on herbs, extracts of plants and other organic materials grown naturally for their drug value. The pioneer studied his plant-medicines. Even wild animals know theirs. Medicines and poisons from plants give their names to the labeled jars on the drug shelf too numerous to recount here.

We need to remind ourselves that drug plants are naturally more numerous on the highly weathered soils of the wet tropics. Some narcotics will illustrate by listing, for example, quinine, opium, caffein, morphine, codiene, atrophine, digitalis, etc., all coming from plants, including larger plant groups among which some farm crops and weeds may be varieties. Organic poisons and drugs are common but our emphasis on those from the chemist's laboratory have made us forget those from plants.

Drugs and poisons

Farm crops carry drugs and poisons too. They develop these in some cases, because of their disturbed growth. Sweet clover is an excellent legume for green manure effects in supplying corn with nitrogen. But corn grain grown after green sweet clover is turned under will not be taken by hogs if they choose corn grown where sweet clover grew to maturity and only the dead crop residues were turned under. Green sweet clover so used produces the drug dicumoral, an anticoagulant of blood. Other legumes, the crotalaria, grown in the South have varieties with poisonous effects. Cows offered these in cafeteria style will discriminate amongst them.

Some of the farm grasses and grains may grow poisons because of seasonal irregularities or even partial crop harvest by cutting . The rye will grow the ergot in place of a grain. Bluegrass does likewise. This is a fungus giving the powerful drug, *ergotamine.* Animals fed on grains or bays carrying the ergot become stiff, lose their hooves and eventually die. The common sorghums, also grasses, if cut and allowed to regrow produce a poisonous alkaloid acting via hydrocyanic acid.

Slow realization

In these cases most of the poisons contain a complex carbon structure with nitrogen linked into it. However, this kind of nitrogen is not the "amino" form, characterizing the proteins for which every life form is struggling. Yet in measuring the "crude" protein contents of these crops we merely digest them in sulfuric acid, collect all the nitrogen, multiply it by 6.25 and call all of it protein. We are only coming around to realize that what organic matter we offer as nourishment to all the life forms, from the lowest to the highest, may possibly be poisons, even naturally.

(Next month: Possible Poisons of Our Own Make)

Let's Live Magazine, February, 1959

Soil Organic Matter--

Possible Poisons of Our Own Make

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

We take it for granted that a growing plant, like corn in the field or in the garden, will be feed or food. We certainly do not expect it to be poison. Nor would we imagine that the nitrogen in the decaying organic matter, making its cycle of going from the dead plant remains to the living plant tissue, might be the dangerous element. We would not anticipate decaying organic matter to put poisonous nitrogen into the water we drink from our wells.

The biodynamics of the living soil are also assumed to behave regularly. We forget that the climatic forces, the inorganic and the organic parts of the soil, and the particular growing crop, all operate under carefully integrated conditions to give what we know as "normal" crop growth of high food value. We can scarcely imagine that decaying organic matter, setting free its nitrogen in the soil to feed microbes, plants, animals and man, might be thrown out of integration to turn that nitrogen into poison for the entire upper part of that biotic pyramid. We may be growing crops in which the nitrogen is not a part of the protein but is poison of our own make.

Costly teachers

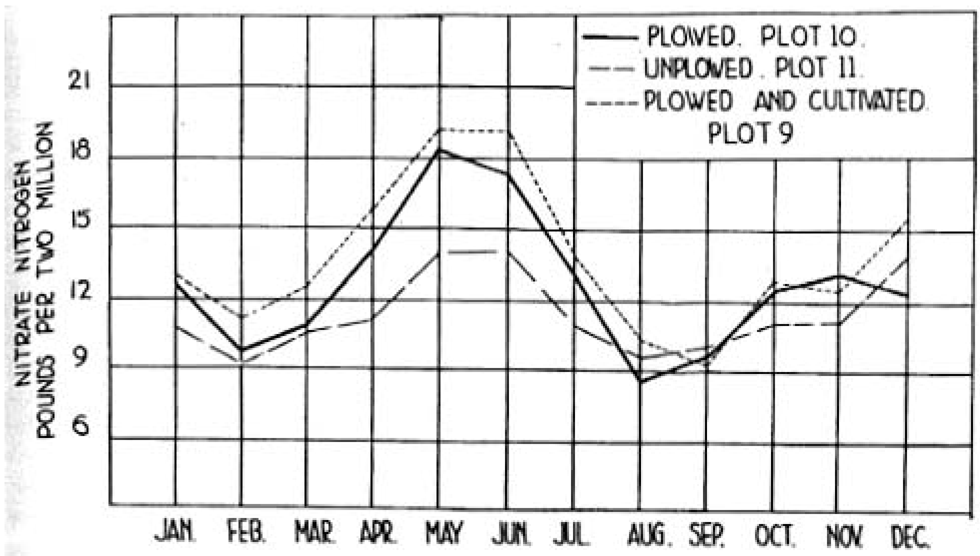
Only slowly are we learning enough about the soil to appreciate how seriously some small changes in the growing conditions can affect the physiology of the crop. We may appreciate the complex physiology of our bodies, but we do not imagine that the physiology of the plant is very near the equal in complexity and delicate operations of its many required processes for healthy plants.

During the high temperatures of 1954, in Missouri from late June to mid-September, unusual heat and drought operated through the soil organic matter to give disasters because we grew poisonous corn crops. The heat stunted the corn plants to make them represent death, not feed, for the animals. Man too, was the victim in a few cases. But that dry season with its disasters brought our studies to explain why and how those resulted. Animal deaths from ensilage had been reported a few decades ago as "forage poisoning." "Corn stalk disease" of horses and cattle was the label for autumn and winter troubles 40 years ago. The theory of the causes remained to suggest explanation at this late date.

Corn did not fit

Temperatures reached their maximum of 113° F. in the early part of July. That high heat was sufficient to change the green color of the leaf to white in that end portion where the deficiency of nitrogen is regularly outlined when the corn is said to be "fired by the drought." The absence of soil moisture, allowing the soil as well as the atmospheric temperatures to mount so high, was changed but briefly by a two-inch rain in early August. That set the rewetted soils into increased microbial activities in decaying the organic matter. That stepped up the conversion of nitrogen into the highly oxidized saltpeter, or the nitrate form. This salt naturally moved up into the plants. But since the activities by the enzymes in the leaves had been disrupted as the result of that living protein's "pasteurization," the unaltered nitrates accumulated in the stalks.

Chemical analyses of the internodal sections of them showed that there were increasing concentrations of nitrate nitrogen in going from the top sections toward the lower ones of the stalk. Even in the dry stalks in the field in January, dangerously high concentrations of nitrate (and nitrite) nitrogen were still present according to the chemical tests.



NITRATE-NITROGEN CHART . . . Seasonal curves of the accumulation of nitrate-nitrogen in the soil under corn. After June the crop takes up this nitrogen rapidly to suggest how much accumulates in the plants if they do not transform it into protein.

Those disrupted soil-plant activities concerned with the nitrogen coming from the soil's organic matter prompted the intense study because of the sudden deaths of cattle grazing the corn fields in September, and of men making ensilage, in due season, from the heat-stunted corn. When cattle had grazed the injured corn plants in July or even in early August without deaths, it was most disturbing that the damaged plants should threaten with an epidemic of "silo-filler disease" caused by dangerous nitrous-nitric oxide fumes in silos after a day's operation of ensiling such corn fodder in September.

At that time the California research by Dr. Went (now of Shaw's Botanical Gardens of Missouri) had not yet reported that high temperatures for tomato plants cause abnormally high nitrate concentrations in the plant tissues to disrupt fruiting. Nor had any one ever seen yellow fumes roll out on the opened silo to flow to the ground to kill the vegetation to the leeward. We had not thought much about the freshly ensiled plant matter carrying on its anaerobic respiration in place of the normal aerobic one to give the reduction of the nitrates to nitrous oxide. We need the shocking experiences of the death of animals and man to bring the dynamics of soil organic matter to our attention.

Similar symptoms

As far back as 1918, there was some research by the Illinois Agricultural Experiment Station on animal deaths at certain seasons from feeding them ensilage. There had been deaths during some late winter seasons when the animals were feeding on the dry stalks in the fields. These reports, coupled with the experiences in 1954, are now pointing up the nitrate production in the soil from the oxidative decay of the soil organic matter (more lately from fertilizer nitrogen) particularly during drier seasons when the high temperatures disturbed the physiology of the plants. No such cases are on record for 1958 with its unusually favorable seasonal distribution (possibly excess) of rainfall in Missouri. Some animal deaths from their licking of nitrate fertilizers for salts through even a knothole have also contributed to the explanation. All the factors, viz: climate, soil, plants and animals need to be considered when such experiences are so disastrous.

Excessive nitrates naturally present in the soil in Kansas in March 1948, where no fertilizer nitrogen was used, were deadly to babies whose milk formulae had been made up with shallow well water carrying enough nitrates to be deadly. A dry autumn and early winter did not prohibit accumulation of nitrates in the soil. A heavy winter snow on which late March rains fell was rapid movement of ample water through the soils and into the wells to carry the dangerous nitrates from the soil into the wells with deaths for two babies. A third one was rushed to Kansas City where it was literally resurrected as the report of the newspaper had it on Easter Sunday.

Will man manage?

We have now learned to live with excess of nitrates so far as medical emergencies like these are concerned. We are now in position to be on guard when high temperatures may be reason for plants to accumulate them, or when droughts--and those broken by rainfall--may also move excessive nitrate nitrogen from the soil into the plants without their change of it to protein there. That condition may result even from the decay of natural soil organic matter. It should be more expectable if heavy applications of fertilizer nitrogen, as imbalance with other fertility elements, are used. We must know the nutrition of the plant as well as the fertility of the soil, since even the soil organic matter which is usually a safety factor in nature's nutrition of the crop, may prove to be poison under abnormalities in the crop's physiology as we manage the soil.

Let's Live Magazine, March, 1959

Soil Organic Matter--
And Man-Made Poisons

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

Experiments using varied fertility of the soil under crops have demonstrated that plants protect themselves against insect and fungus attacks according to the balance of that fertility for suggested protein production by the crops, (1). Yet it is still a prevailing practice and belief that we should expect insect pests and fight them with powerful poisons. We have given little thought to the simple fact that we can nourish the plants so they will build their own protection (thereby also better nutrition for us when we eat them) according as we manage the fertility of the soil growing them.

Since insect poisons, like DDT (in chemical name, l,l,l-Trichloro-2,2-bis (p-chlorophenyl) ethane) have been used now for over a decade in agriculture on orchard and annual crops, with the latter grown on both the untilled and the plowed soils, it is timely that the research stations are giving us data on what the living soils are doing to destroy the residues of these powerful organic poisons so widely used in sprays, and, conversely, what these deadly poisons intended for pests on the plants are doing to destroy the lowly life forms within the soil.

Poisons persist

The very chemical structures of the DDT, and of other chlorinated hydrocarbons or similar sulfonated aromatics representing most of the recent deadlier poisons, suggest that these might be expected to persist unchanged in the soil, or as residues on food and in contact with any kind of matter. Since carbolic acid, or phenol, of allied chemical structure with but a single benzene ring, was one of the first antiseptics, it has been under study for many years to learn if there are any microbes which destroy it, as well as that it should seemingly destroy most all microbes. Only in a few instances, and under rarer conditions, has it been reported that some microbes suggest their break-down of this carbon ring compound. If phenol is not broken down significantly in the soil, then we might well expect that these more powerful poisons, carrying combinations of several such rings with chlorine, sulfur and side-chains of carbon attached, would not be oxidized or changed much in the soil. That is the expectable, even though the surface layer of the soil is commonly considered a kind of universal crematory for most anything organic that we consign to it for destruction and disposal.

Recent studies

Some recent studies on the persistence of DDT gave reports for soils in various conditions and for time periods of ten and more years. Some turf plots in Cleveland, Ohio, were treated with this poison for Japanese Beetle in 1945 at three different rates. The soils were sampled in 1955 for recovery of this applied poison. The results are given conveniently in the table below.

Recovery of DDT in the Upper 6" of Silty Clay Loam Turf Plots in 1945. Treated 10 years previously.

DDT Applied Lbs./Acre	PPM	DDT Recovered Lbs./Acre	DDT Recovered Percent of Amount Applied
12.5	0.77	1.36	10.9
25.0	2.04	3.52	14.1
25.0	2.04	3.52	14.1
37.5	3.89	6.72	17.9

It is significant to note in these data that, even after 10 years under the turf, as much as 10 percent of the original application was recoverable, and that was true for the lowest rate of the treatment. This tells us that this poisonous compound persists unchanged in the soil. It cannot be decomposed readily by the microbial life there. It renders, then, no food service to these lower life forms. It is significant to observe also from the data that the percentage recovery is higher as the application is heavier, i.e. a bigger share of the dose remains unaltered when that is heavier.

Heavy accumulations

Soil samples taken in some two dozen orchards in the same studies by E. P. Lichenstein (2) where the sprays were used in successive years for as long as 10 or more in the mid-continental states with soils of higher organic matter, there were pronounced accumulations of this powerful organic poison. After applications over periods from nine to 11 years the DDT was still present in the soil in amounts ranging from 93.5 to 106.0 ppm in Indiana; 38.6 ppm in Ohio; 36.6 ppm in Missouri and 1.5 to 38.3 ppm in Michigan. In a total of 14 orchards tested, the average recovery was *26.6 percent of the total amounts applied, and 237.0 percent of the average annual application.*

These data tell us that, rather than serving to destroy this poison, the soil is retaining it against removal by rainfall or leaching, and against microbial oxidation or other chemical reactions resulting in loss of its lethality, or deadliness. The annual destruction by the soil falls far short of the annual application. The soil, like the human body, suffers from an accumulation of DDT poisoning. This is an attendant danger not so apt to be appreciated when the poison is used to destroy insects on the vegetation and not within the soil.

Recovery high

Similar studies on the accumulation of this organic poison in cropped soils, also in the corn belt, growing various field and vegetable crops, showed serious amounts likewise. Of two dozen soils tested, the recovery from the surface layer of 6" amounted to *15.5 percent of the total applied, and to 61.2 percent of the average annual application.* The concentrations remaining in the soil ranged from 0.38 to 4.6 ppm.

Just what this accumulation means is not apt to be fully appreciated. But it emphasizes its danger when this poison is accumulating slowly, for example, also in the fatty tissues of the human body, and gives varied symptoms of its lethality when body stress calls on that reserve energy store to consume it but liberate its stored poison content into the system. Then, also we dare not forget that organic compounds of similar chemical structures, applied to seeds, are taken up by most any plants. They can be expected to be taken by plant roots from the soil for many years after application, due to their unchanged persistence there, according to these data. That they would not be altered much by life processes within the plant might well be expected when the many varied microbial processes of the soil do not transform them during periods as long as a decade. Shall we not expect such poisonous organics to be accumulating in the crop's organic matter?

Reasonably mature judgment in behalf of our own health would arouse skepticism about consuming vegetables grown on soil poisoned for plants in our aims to poison only insects, and poisoned still more by spraying the plants directly. Shall we take chances on fighting a few maurauding insects today at the possible price of our own lives at some later date through the delayed action of lethal accumulations in the soil, and in the plants as well as in our bodies?

(Continued in April)

(1) *Albrecht, Wm. A. Balanced Soil Fertility, Less Plant Pests and Diseases. Better Crops with Plant Food. Magazine XLII :18--22.*

(2) *E. P. Lichtenstein. DDT Accumulation in Mid-Western Orchard and Crop Soils Treated Since 1945, Jour. Econ. Entom. 50 : 545-547, 1957.*

Let's Live Magazine, April, 1959

Soil Organic Matter--

Man-Made Poisons

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

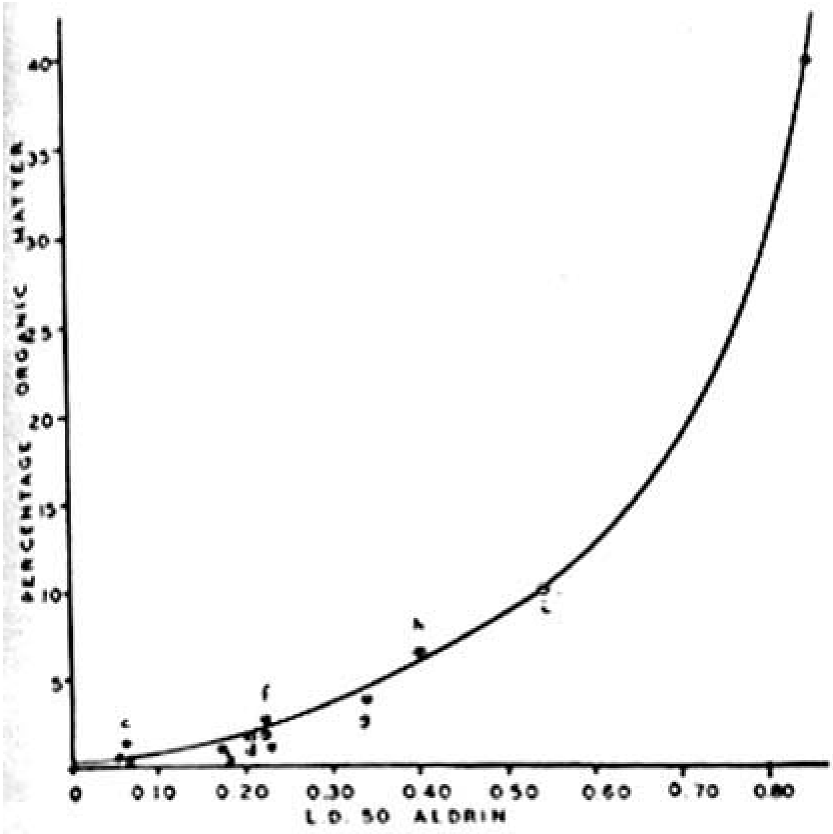
(Continued from March)

Natural organic matter in the soil is considerable protection against the deadliness of man-made organic poisons in an extensive chemical family including such names as aldrin, dieldrin, chlordane, lindane, toxaphene, methoxychlor, benzene, hexachloride and others. The soil organic matter absorbs them, so that they are less destructive to insects in contact with the soil, according to the report by the Wisconsin Experiment Station testing the poisoned soil with banana flies. (References: C. A. Edwards et al. Bioassay of Aldrin and Lindane in soil. Jour. Econ. Entom. 50: 622-626, 1957). The clay of the soil exercises a similar but less pronounced absorptive effect. The silt and sand as separates exercise much less of such action on them.

More protection

Accordingly, then, nature offers more protection for the insects against our attempts to poison them according as the soils are richer in organic matter, or are more fertile in this commonly neglected soil property. But conversely, the poisons will be more effective as we deplete our soils more of their natural organic matter. Also, but much worse on soils lower in natural organic matter, these man-made organic poisons neglected as residues within the soil will be more "available" to the plant roots and absorbed more readily into the plant tissues to make them more dangerous, or lethal as foods and feeds.

Highly organic soils, like the mucks, required more than 25 times as much lindane and aldrin, for example, as were required by sandy soils, to be lethal under tests with banana flies. As the natural organic matter of the tested soils was higher, more of each of these poisons was required for lethality. Unfortunately, the reduction of effectiveness of the poison by the soil organic matter was due to only a physical effect, since the poisons were recovered by chemical extraction. Again, the emphasis for safety goes to the soil's content of natural organic matter as its "constitution," or as the prominent factor in ameliorating the damaging effects of these powerful man-made poisons.



LETHAL DOSE RISES . . . As the percentage of soil organic is higher, the lethal dose (LD.50) of aldrin required for banana flies goes higher. Soil organic matter buffers the effects of poisons on the insects.

Deadlier poisons

But while this protective service to some degree is a natural matter, we are making the poisons of so much higher lethality and are using amounts large enough to go far beyond the soil's protection of the insects. We cannot expect, then, to be protecting ourselves when such practices and poisons suggest their accumulations in the soils, in the crops, and in our bodies.

Another plan

Instead of trying to kill insects marauding our crops, probably because of depleted soils, and thereby unwittingly poisoning ourselves, why should we not consider modifying the fertility of the soil as nutrition for the plants to enable them to ward off the insects, as the same plants must have done to survive before we domesticated them? Plants so nourished and so protected via the soil will not only give simultaneously larger yields per acre but higher quality as nutrition when consumed as feeds and foods.

Let's Live Magazine, May, 1959

Natural Organic Matter--

Man-Made Organic Supplements

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

In considering the soil, we commonly look at its organic matter as nature's supplement to the inorganic, or the mineral parts, for growing nutritious feeds and foods. But for folks unduly enthusiastic about the *organic* part, the use of *inorganic* salts is considered a doubtful treatment of any soil for better crop growth. Yet, the very soil itself consists of the inorganic rock substances--of rock and mineral origin--becoming soluble salts by which the creation of the organic part or the crops is possible. The inorganic part came first. The organic came second. The former supplements the latter, and vice-versa. But, among either there may be some kinds which may be injurious to the growing plants which, in their turn, may even be poisonous feed for animals, which live by consuming such organic creations.

Inorganic supplements

Feeds have long been calling for supplementations of both the inorganic and the organic kinds. Among the inorganic supplements there have been the elements sodium and chlorine in common salt; calcium and magnesium in limestones; calcium and phosphorus in bone meal and inorganic phosphates; iron in ferrous sulfate; copper in a similar combination; zinc also as sulfate; cobalt similarly; and iodine in potassium iodide. The list may be extended.

For many years too, feeds have been supplemented with the organic materials of higher nitrogen contents serving as "crude" protein supplements. Through the addition of such to the animal ration, the gains in the body weight of the animal per unit weight of consumed feed were increased. Very recently, instead of the crude proteins as feed supplements, use has been made of one or two of the amino acids--separated parts of the protein--to give decidedly more growth per unit of the carbohydrates as well as per unit of the "crude" protein eaten. More recently also, use has been made of specific man-made organic chemical supplements which do not finally become parts of the body tissue. Instead, they are simulated hormones of laboratory synthesis serving to speed up, or whip as it were, the cell growth and animal gain in weight into a higher rate. The synthetic female hormone of wide use in animal feeding, known as "diethylstilbestrol" is a good example. Only very small amounts need to be used because of the powerful--and potentially dangerous--effects of this laboratory attempt to duplicate the natural female hormone of body origin.

Hormones

It is well to remember that a body, of either sex, generates hormones of both male and female effects, but with decided dominance of that one corresponding to the particular sex responsible. We would not expect plants to create, by their own growth, similar organic compounds which will, when consumed by the animals, serve the same as hormones of animal origin. Such is, however, the fact reported by Dr. H. S. Bennetts of Perth, Australia, when sheep consume the common clover (Trifolium subterraneum) grown in that country so extensively. Unfortunately, this legume--serving as the ration's supplement to the non-leguminous forages--destroys many sheep by bringing on urinary calculi (kidney stones), prolapse of the uterus, and other troubles for which no simple or effective relief has yet been found. Here there is excessively rapid growth of only a part of the anatomy, and a very decidedly disturbed condition in the excretionary function because plants produce a hormone duplicating the disasters reported for the artificial hormone, diethyl stilbestrol. These observations raise the question whether the production of sex-hormones by the animals is not determined by the particular forages which the animal is taking. In practice, when the early fall growth of forages serves in this pre-breeding season as a "flushing" operation for increased conception, might that not be a case of giving the "nature-made," rather than "man-made" hormones?

Kansas report

The Kansas experiment station reported at the *Livestock Feeders Day* on May 21, 1953, on some feeding trials with sheep given stilbestrol, the man-made hormone supplement used as a tissue implant rather than via the digestive system. This was one of the 25 or more projects in animal feeding presented on that occasion and reported in their circular No. 297.

They reported that, "Gains were approximately one third larger in the Iambs receiving the hormone implants. The rate of gain was not increased by giving a second implant after 70 days of feeding." Very significant is their farther report that, "Where all the lambs received the hormone, the increased rate of gain was apparently due to greater feed consumption and the amount of feed per pound of gain was actually just as high, or a little higher, than in the lot of lambs receiving the same standard ration and where only half of the lambs were given implants."

Unfavorable results

That the lambs given stilbestrol were not healthy is clearly indicated by the deaths of some, and by the report that, "A smaller percentage of lambs given stilbestrol was selected for slaughter as compared with those given no implants. Abnormal development of the reproductive organs was found in the wether lambs given the implants and these abnormalities were capable of producing prolapse of the rectum as well as symptoms of urinary calculi. A high incidence of these difficulties has been reported in several commercial feed lots where the lambs have been given stilbestrol implants."

They report and illustrate also the enlarged prostate glands when they emphasize "the almost enclosed lumen of the urethra of the lamb given two implants. While these animals had shown no external, visible symptoms of distress, it would appear logical that farther closure of the urinary passage might result in symptoms similar to those produced by blockage of the passage by urinary calculi." The possible serious effects of the indiscriminate use of this hormone-like material in lamb fattening should deter any commercial feeders from using it until further work has indicated that it can be used safely without danger from heavy losses."

Since the chemical structures of the sex hormones resemble closely those of the coal-tar distillates, reported responsible for skin cancers of mice, it would seem well that such unusual growths of the tissue of the sex organs provoked by stilbestrol should be examined to learn whether they represent malignancy in this animal tissue. Just what such condition in animals means for their meat as food is also a matter that ought to disturb our confidence in our own good health by eating animals that appear to be quite far from good health before slaughter.

Much unknown

Much is still unknown in the creative processes of growing things when man-made supplements for increased rate of growth disturb the living processes to the potential destruction of the very organism itself. Instead of those growing things representing the natural survival of those most fit for their environment, they suggest man's attempts to keep the unfit alive. Much is still unknown about the nutritional values, or dangers, to the human consuming what he grows in his struggle to solve his problem of the proteins. Shall we not emphasize "nature-made" organic matter more and "man-made" organic supplements less?

Let's Live Magazine, June, 1959

SOIL AND PLANT COMPOSITIONS:

1. Too Much Nitrogen Or Not Enough Else?

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

That plants may go on a "nitrogen jag" has long been pointed out by the grazing cow when she lets the rich green spots of grass grow taller while she grazes the short grass all around them even shorter. These spots mark the liberal doses of nitrogen in her droppings that result in a luscious, massive growth. But the cow says, "No, thanks, I don't care for it."

Those tall, deep-green spots, fertilized by much nitrogen applied through her droppings, do not appeal to her as a balanced diet, perhaps, and so she bypasses them. At any rate, her body physiology directs her appetite to balance her ration if she can. The excess of nitrogen represents an unbalance to her, and she says so by refusal.

Trouble

"Too much is too much" only in relation to something else. If too much nitrogen is used in relation to the supply of phosphate, potash, calcium or other growth factors, the unbalanced situation causes trouble. It is the lack of balance in plant nutrition that is disturbing. This is merely saying that there is too much of some nutrients or not enough of others. That is the way it must be said when the absolute amount of each nutrient needed for each particular function is not yet known. We do know, however, that when an adequate amount of nitrogen is available, and other necessary factors are adequate, then growth and yield can be truly spectacular.

That animals do instinctively select food which provides a balanced ration was suggested by some work by Dr. George E. Smith of the Missouri Agricultural Experiment Station. In this test, rabbits were fed grasses grown on soil that had been treated only with nitrogen. This work was a part of the studies leading to the bio-assay of soil fertility by using the animal to measure the value of soil treatments, rather than a mere increase of yield in bulk or by measuring the total nitrogen to multiply by 6.25 and calling the result "protein."

Appears luscious, but--

Nitrogen fertilizer on the grass, it was true, made a large and luscious green growth that would seem a great tempter--if only the human eye judged it. It appeared equally significant as a means of growing more grass per acre--if just the growing of more grass were the most valuable part of our efforts to improve pasture production.

But the rabbits, when fed the grasses from areas with different soil treatments, had their own criteria for judging the resulting food values. The seemly beautiful green, nicely cured grass hay from the plots where nitrogen alone was used was not taken eagerly. It was consumed only as a partial defense against starvation, and it did not keep the rabbits from getting dangerously close to that before their death was prevented by shifting the ration. Other rabbits given grass hay from plots that had no soil treatment maintained themselves, consuming the ration more completely.

In dealing with a ration of fertility elements for plants, we too commonly consider the plant's ration as merely the sum of the separate items. We think of calcium, plus nitrogen, plus phosphorus, plus each of all the others necessary. These are taken into the plant and eventually delivered through it to the manger and thereby to the animal for its use. Through chemical analysis of plants--after we have burned off the carbon, hydrogen, oxygen and other contributions of weather origin--we believe that soil fertility is a collection of some 10 or more elements taken from the soil for the use of animal and human bodies.

Wrong concept

This concept suggests that, if that is all we need to do, we might just as well use a shovel and truck to haul calcium and magnesium as limestone from the crushes to the mineral box. As a curative help to an animal already in disaster this may have some value. It illustrates the widespread failure to appreciate the fact that plant nutrition is not as simple as limestone, plus phosphate, plus potash, plus any other thing in any amount merely dumped on the soil to produce crops to haul to the feeding rack.

An important matter in plant nutrition is the fact that *plants must eat where they are.* Unlike the cow, they can't pass up readily the place where there is too much nitrogen or, rather in the converse, where there is not enough of nutrient elements of distinctly mineral origin to better balance the nitrogen in their ration. Consequently, they run (their manufacturing business of synthesizing the fertility of the soil into organic combinations by means of air and water the best they can. As a result, plants must naturally vary widely in their chemical composition, even if folks in regulatory services contend that they do not.

If there is much nitrogen, they weave this into chemical combinations with carbon, hydrogen, etc. that build a lot of green vegetable bulk which may not keep the plant from lodging and may not result in seed to keep the species multiplying. Plants must weave as the woof and warp permit. But the plant is doing as the soil conditions demand, whether we call it too much of some or not enough of others.

(Continued in July)

Let's Live Magazine, July, 1959

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

Both Soil and Plants are Responsible

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

Only slowly are we coming around to realize that the variable fertility of the soil brings about variation in the chemical composition of the vegetation grown on it. The name of the species, and even the variety of the plant, seem to have set up an implicit faith in the minds of many that they determine the plant's chemical make-up. That faith, or belief, is so completely accepted that even the section of federal controls concerned with proper labeling of foods and drugs, contends in print--and in court--that the soil does not influence the chemical composition of the crop it grows.

Animal knowledge

But when our animals, both wild, and domestic, demonstrate ; their discrimination within the same plant species and variety which they will take from one field and soil but not from another; or when the cow refuses to eat the grass growing taller and greener where there are fecal or urinary droppings, while she eats the short grass around it shorter, there is clear-cut evidence that different soils, or the same soil given different fertility treatments, cause different chemical compositions of the same kind of plant growing on them.

The Department of Soils of the University of Missouri, co-operated with the section in the Horticultural Department concerned with vegetable gardening in measuring some of the variations in chemical composition of Swiss chard. This was done according to some controlled variations in the soil fertility. Those soil variations were managed by means of the colloidal-clay technique, or by the adsorption of the cationic elements on the clay, and by some of the anionic elements held by some of those cations.

Elements used

The series of elements under carefully controlled applications to the soil included: calcium, magnesium, potassium, nitrogen, phosphorus, and sulfur. The amounts of clay mixed into some quartz sand could be varied, and served to control the total amounts of the nutrient elements available to the plants. The degree of saturation of the clay by each element was the means of varying the ratios of the amounts of one element to another.

The nitrogen and the calcium were the two elements of concern in one of the many tests. Either one varied through the four amounts, namely, five, 10, 20, and 40 milligram equivalents, (M.E.), while the other was held constant at one of those corresponding amounts. In one series, the calcium was held at 40 M.E. and combined with five, 10, 20, and 40 M.E. of nitrogen respectively, in triplicates. Then this latter series of amounts of nitrogen was combined with 20 M.E. of calcium; then another nitrogen series with 10 M.E. of calcium; and finally still another nitrogen series with five M.E. of calcium.

Then there was another complete set of series similar to the one above. The amounts of calcium varied through the four values of five, 10, 20, and 40 M.E. Each of these was used in combination with constants as 40, 20, 10, and five M.E. of nitrogen to give another group of four series.

It was by means of these combinations in the variations of nitrogen and calcium, both connected with protein synthesis by the plant, while the phosphorus, potassium, magnesium, and sulfur were constant at controlled values, that the plants were grown and put under chemical analyses for their concentrations, as percentages of their dry weight, of oxalate, total nitrogen, calcium, magnesium, and phosphorus.

Variations shown

Variations in the nitrogen as five, 10, 20, and 40 M.E. in combination with high calcium at 40 M.E. gave concentrations of calcium in the Swiss chard varying from 0.748 to 1.032 percent, respectively, in the increasing order with increasing nitrogen additions to the soil. The highest concentration of calcium in the chard was an increase of 38 percent over the lowest one. The mean of the four was 0.889 percent of calcium in the chard.

With the 20 M.E. of calcium as the constant soil treatment in combination with the varied nitrogen, there resulted the variation in concentrations of calcium from a low of 0.676 to a high of 0.784 percent. This was an increase by the latter over the former of 16 percent, but not in any order in relation to the increase in nitrogen applied. The mean was 0.739 percent.

Then with 10 M.E. of calcium, the varied nitrogen gave concentrations of calcium in the chard varying from 0.600 to 0.824. This was an increase of 37 percent, while the mean of the lot was 0.737 percent.

But when the calcium was held at a constant in the soil with five M.E. per plant and combined with the four variations in nitrogen, the concentrations of calcium in this vegetable "greens" spread from a low of 0.488 to a high of 0.820, an increase of 68 percent and a mean of the lot at 0.630 percent. In these four series the concentrations of only calcium varied as much as 16, 37, 38 and 68 percent. Can one say there are no differences in the chemical composition due to changes in the soil fertility?

Results

This illustrates the variations of the calcium concentrations in this vegetable because (1) the amount of calcium offered in the soil varied, and (2) another nutrient like nitrogen in the soil was varied in each series even though the amount of calcium there was constant.

According as the supply of calcium in the soil went lower, the mean concentration of it in the Swiss chard also went lower. But the effects of the individual combinations of calcium with nitrogen as soil treatments were not consistent in the order at which the concentration of calcium in this plant decreased. The four mean values of calcium concentrations in the plant for the four amounts of it in the soil (40, 20, 10, five M.E.) were 0.889, 0.739, 0.737 and 0.630. These serve to point out that with the highest and the lowest offerings of calcium in the soil, the concentrations in the plant, were decidedly the highest and decidedly the lowest. But for the two intermediate offerings in the soil, namely, 20 and 10 M.E., the means of concentrations in the plants were 0.739 and 0.732 percents. There was no wide spread. These suggest by the more uniform concentrations in the crop what the more favorable concentrations in the soil for it are.

(Continued in August)

Let's Live Magazine, August, 1959

DIFFERENT SOILS,
DIFFERENT PLANT COMPOSITIONS

Both Soil and Plants are Responsible

(Part II)

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

The Department of Soils of the University of Missouri, co-operated with the section in the horticultural department concerned with vegetable gardening in measuring some of the variations in chemical composition of Swiss chard according to some controlled variations in the soil fertility. Those soil variations were managed by means of the colloidal-clay technique or by the adsorption of the cationic elements on the clay and by some of the anionic elements held by some of those cations.

Variation

In this test it was clearly demonstrated that calcium, which is the inorganic element required from the soil for our bodies in larger amounts than is any other element, varies in its concentration in the Swiss chard. This variation is not only according to the variable amount of calcium active in the soil, but also according to the company it keeps with varied amounts of nitrogen there. Now that nitrogen in its various chemical forms is applied to the soil so extensively and so generously, there are decided variations in the concentrations of other elements in the vegetable greens consumed by both man and animals.

The concentrations in the Swiss chard of the magnesium, coming from a constant supply in the soil, varied with the different levels of calcium there. The mean values for the concentrations of magnesium in the plants were 0.437, 0.705, 0.520, and 0.425 for the accompanying 40, 20, 10, and five M.E. of calcium. Between the highest and lowest, the former was an increase of 65 percent over the latter. This tells us that the metabolic functions within the plant are also factors, or determiners, of the amounts of fertility elements taken from the soil.

Plant function

The plant's performance in building concentrations of elements within itself are functions not entirely of amounts offered as soil fertility. Only at certain amounts of each element in its relation to each of the others as their combination represents a "balance," or suitable integration of their separate nutritional effects, are there the maximum effects of each expressed in the plant growth in what would seem to be most efficient growth and higher values of it as feed and food.

The imbalance of the fertility in the soil seems to reflect itself in the oxalic acid which the chard synthesizes, as an organic compound that combines with the calcium and magnesium that makes insoluble and indigestible oxalates of them. It puts them out of chemical action in the plant. These interrelations are best shown in the bar graphs in Figure 1.

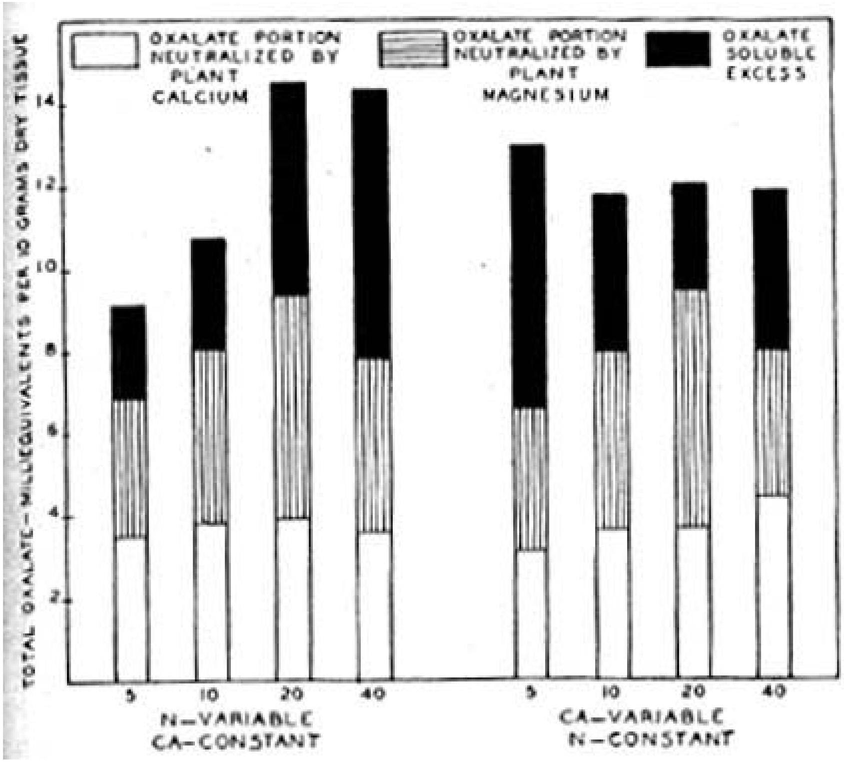


CHART SHOWS RESULTS . . . Variations in the calcium and magnesium equivalents as oxalates in Swiss chard (as percent of dry matter) when grown on soil given various treatments of nitrogen with constant but different amounts of calcium, and vice versa.

By increasing the nitrogen as the variable in the soil, while the calcium and other elements were constant, each increase put (1) higher concentrations of calcium into the plant, save for the highest application of nitrogen, (2) more magnesium there in the same order, and (3) pushed up the concentration of oxalate tremendously By increasing the calcium as the variable while nitrogen and other elements were constant, each increase put (1) more calcium into the plant, (2) more magnesium there, save for the highest offering of calcium, and most significantly, (3) almost the same amounts of oxalate as its means of reducing the excesses of those two elements by making insoluble and also indigestible when eaten.

Nature's revelation

Nature demonstrates everywhere this simple fact that the plant, per se, does not determine its final chemical composition as nutritional values to man and beast. The fertility of the soil is the main determiner of that. The plant as a species has limits within which it operates. Those operations are limited also by the fertility of the soil.

For quality as nutrition in our vegetables we must (1) choose the species and (2) manage the fertility of the soil growing them. Then, if as our animals do, we take them raw and fresh "right off the stump," we shall demonstrate our eating as one for health's sake just as our wild animals demonstrate how they use their food and not drugs and medicines to keep themselves healthy.

(Continued in September)

Let's Live Magazine, September, 1959

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

Phosphorus in Crop Varies with Nitrogen Applied

(Part III)

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

In the preceding article, the concentrations of calcium and magnesium were reported for Swiss Chard, pointing out how widely these properties varied when the amount of nitrogen applied to the soil was varied. Those chemical examinations of this vegetable demonstrated clearly that fertilization with the nitrogen salt, ammonium nitrate, (1) decreased the concentrations of the ash--or inorganic--elements, calcium and magnesium in the chard; (2) increased its concentration of nitrogen; and, (3) increased the crop yield as "greens."

It is significant that the first effect listed above was a decrease and the last two were increases--all brought about only by increasing applications of this one fertilizer salt. Those data point out clearly the error in the common belief and contention that soil fertility treatments, giving increases in crop yields, bring no changes in the concentrations of the essential elements, and no changes in the nutritional values of such vegetable crops. Yet there was a decrease of the bone-building element, calcium, within each unit weight of the chard when its yield was increased. More yield from heavier fertilization gave less nutrition as calcium per unit of this food.

Increased oxalate

Then, to make still larger the mistake in disregarding such changes in the concentrations of the elements caused by changes in the soil fertility, there occurred a higher concentration of the oxalate synthesized by the crops according as the soil treatment with nitrogen was increased. Oxalate is the organic substance which makes both the calcium and magnesium insoluble as compounds with it and thereby indigestible.

All this suggested itself as really a case of "adding insult to injury" in terms of food quality or nutritional values of the crop. First there was "injury" in the lowered concentrations of the calcium and magnesium. Then, second, there was "insult" in the increased oxalate made by the plant to make even those lowered concentrations insoluble and indigestible.

Major role

Since calcium plays its major role in the building of our bones, with almost its total in our skeletons; and since it is in combination mainly with phosphorus there, though also in other body parts, like the blood, it is significant to note how the concentration of phosphorus in the vegetable, Swiss Chard, was modified by the fertilization of the soil with the nitrogen salt.

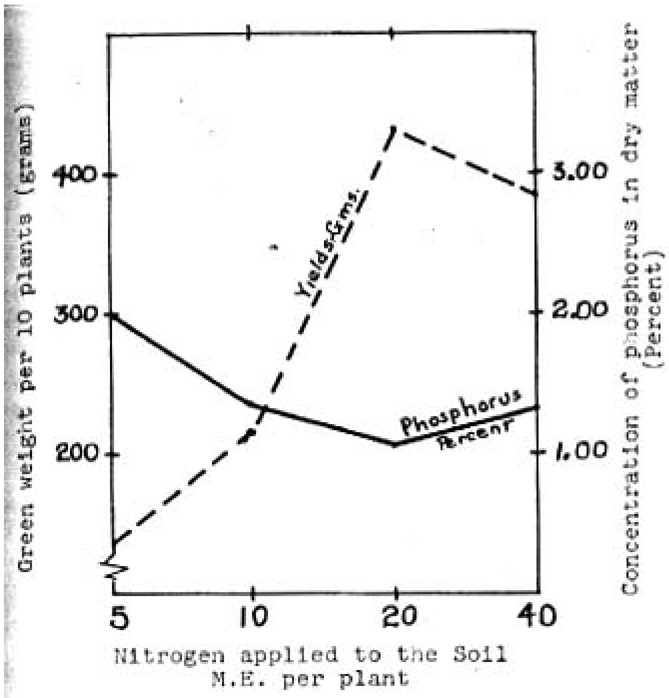


FIGURE I . . . Fertilizing with more nitrogen applied to the soil pushed up the yield of Swiss Chard. But it pushed down the concentration of the phosphorus, to reduce its delivery of this bone-building nutrient per unit weight of the crop.

Here again, the chemical data pointed out that the concentrations of phosphorus in the chard decreased as more nitrogen was applied to the soil. (See Figure 1.) This property of these "greens," as single determinations, varied from a low of 0.85 percent to a high of 2.67 in the dry matter. This makes the plant look like a decided deceiver when it plays the phosphorus it gives us per mouthful over a range as wide as 300 per cent difference. This happened when the phosphorus offered by the soil was constant. Such deception in the bone-building element, phosphorus, which plays important enzymic roles also in giving the body energy, was brought about because the company it kept with the nitrogen was the disturber of its behavior.

Total amounts

Phosphorus was measured only in its total amounts, and not in its different possible combinations with calcium as different solubilities. In nature, the element phosphorus is almost universally coupled with four units of oxygen per one of itself. This makes the phosphate anion, two of which with three of calcium ions to give tricalcium phosphate. This is a rather insoluble compound. But the two phosphate radicals may also make their combination with only two calcium and two hydrogen ions, as dicalcium phosphate. This is an acid phosphate of a bit higher solubility. Then, again, the two phosphate anions may also combine with only one calcium--coupled with four hydrogen ions--to give their most soluble and acid compound, mono-calcium phosphate.

Variation in the amount as total phosphorus does not tell us how it varied in these different combinations with calcium serving in the plant's or other body processes as different degrees of acidity, and different activities of both the phosphorus and the calcium in nutrition.

These facts make the combination of phosphorus and calcium a more unique one of these soil-borne elements in the warmblooded bodies than is generally appreciated. They connect such bodies more directly and strongly with the soil fertility than we are apt to believe in speaking of "soil and nutrition."

(Continued in October)

Let's Live Magazine, October, 1959

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

Soil Nitrogen and Vitamin C in Plants

Part IV

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

The variable fertility of the soil causes the plant to vary in its chemical composition. This includes not only the concentrations of chemical elements it takes up from the soil, but also the compounds it creates, whether these serve as materials of construction of the plant's body or as tools in the energy-releasing and tissue-building processes. Nitrogen, applied now so extensively and generously as a fertilizer salt when by no means a large share of the application is taken by the crop, is disturbing even the concentration of the vitamin C synthesized by spinach (Bloomsdale long-standing) for example, for the high concentration of which vitamin this garden "greens" is commonly recommended.

In some studies by the Missouri Agricultural Experiment Station, the nitrogen of the soil was varied through a range of 5, 10, 20 and 40 milligram-equivalents (M.E.) per two plants, with each amount in combination with one amount (in replicates of 10) of that same series of allotments of calcium. This study demonstrated what such soil treatments--used particularly to modify the protein production by legume crops--would do in modifying the production of vitamin C in this garden vegetable, considered a good dietary source for this vitamin.

More like carbohydrate

Vitamin C is not similar to proteins in either chemical composition or molecular structure. In fact, it is more nearly like a carbohydrate, or like glucose. It contains six carbon atoms, and six of oxygen, just as glucose does. But where the latter has 12 of hydrogen, this vitamin has but eight, and by no means in similar molecular arrangements. These atomic and molecular properties make it resemble the sugars and not the proteins. It is very likely a modification, by the plant's metabolic processes, of the sugars of photosynthetic origin.

Vitamin C a catalyst

The variations in the amount of the nitrogen applied to the soil gave decided variation in the amount of this preventer of scurvy in relation to the yield of the crop. These facts are graphically shown in Figure 1.

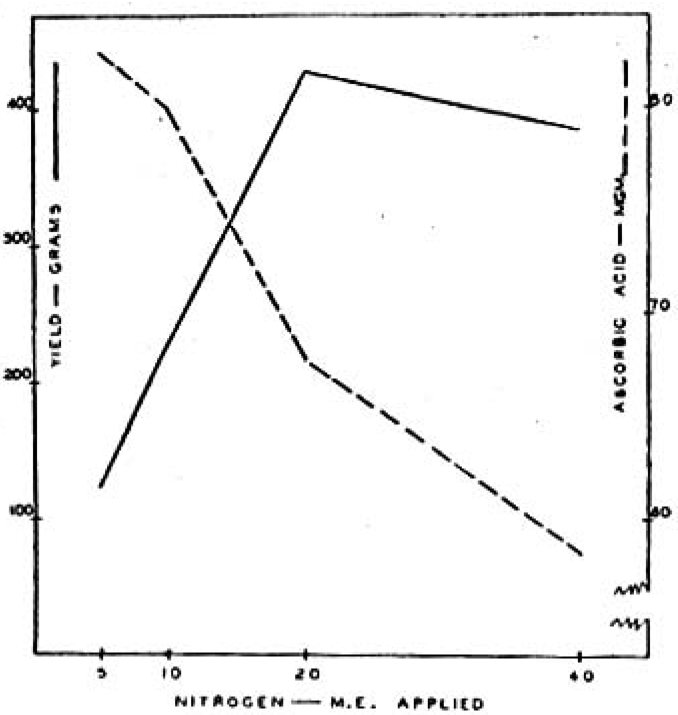


FIGURE I . . . When the crop yield goes up, the concentration of the vitamin C in it goes down. This is a catalyst (internal "whip" or stimulator) for the crop, considered a nutrient for humans consuming it.

With the increased applications of nitrogen, the first three of those gave increased yields, one over the other, but the fourth and highest application did not extend the increase. Instead it reduced the yield. The concentration of the vitamin C in the plants was highest in the smallest crop. Here, then, the concentration of the vitamin shows an inverse relation to the vegetative bulk produced. As there is more growth, that extra production seems to carry on without requiring such high concentrations of the vitamin C, which is a catalyst or tool and not part of the construction of the tissue. This suggests that vitamin C serves as a stimulator of the speed of the chemical processes within the plant, much as the rider's whip serves in case of the race horse.

Unbalance results

Seemingly, when the fertility elements in the soil are out of balance, with even only one element like the nitrogen in this case responsible as either a deficiency or an excess, then the plant increases the concentration of the catalyst. Seemingly, it "whips" the chemical processes more to bring about the growth of the plants.

Some striking correlations of the ascorbic acid, or vitamin C with the inorganic composition of the spinach were evident. When the concentrations of this vitamin were high in the spinach, those of magnesium and nitrogen were low. Neither potassium nor magnesium suggested any connection of themselves with the ascorbic acid. Of added interest was the fact that the concentrations of calcium and phosphorus--usually associated more prominently with anabolic than with katobolic or respiratory processes--were parallel to those of this vitamin.

These facts exhibited by the spinach suggest that within the plant, like within our bodies, there are variations in the processes of metabolism to make adjustments for the variation in the nutrients which the soil offers to feed the plant. Unfortunately for the plant, it is fixed in location and limited in the volume of soil which its root zone can encompass. It cannot break out, like some hogs, and help itself to the better feed of its choice from the neighbor's lot. Perhaps we shall be appreciating more the need to consider the nutritional quality, rather than only the yield, of the vegetables as they represent nutrition for us.

(Continued in November)

Let's Live Magazine, November, 1959

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

Varied Soil Potassium Means Varied Organic Values

Part V

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

In the preceding reports it was shown how the variation in the supply of nitrogen in the soil brings about wide differences in the inorganic compositions of vegetable crops, especially in the concentrations of the calcium, the magnesium and the phosphorus. Then it brings also wide variations in concentration of the vitamin C, an organic compound of nutritional value; and also of the oxalate, another organic compound created by the plant.

But the oxalate prohibits the calcium and magnesium from serving in their functions as soluble and active nutrient elements. It is well, therefore, that attention be given to another soluble inorganic element commonly added to the soil in fertilizers and also leached from the soil--namely, potassium--to see how the variation of it causes varied plant compositions.

Three soybean crops

In studies at the Missouri Agricultural Experiment Station, soybeans were grown on soil which was varied only in the amount of "available" or exchangeable potassium in it. All other elements were at fixed values at the outset. Since the soybean crop is a legume, and can therefore take nitrogen from the atmosphere for its synthesis of protein--if it has the legume bacteria for root-nodule production--the first crop was grown on the soil which was kept sterile or free of those necessary bacteria. Since the bacteria may be accidentally introduced, the second and third crops, grown on these soils to test the effects of the exhaustion of the soil fertility on the plant composition, were not kept sterile. They had nodules and took or "fixed" nitrogen from the atmosphere because of the bacterial inoculation introduced on planting the second crop to serve also for the third crop.

Here, then, we could see the effects of varied potassium on the chemical composition of the soybean plants when this same plant species was behaving physiologically as a non-legume in the first crop, then as a legume in the second and third crops. We could also observe the effects of exhausting the soil of its fertility, since three successive crops of soybeans from the same "mother-source" of seed were grown and carefully removed--roots and all--from the soil for analysis of each crop.

No additions of fertility were made after the initial soil treatments. The largest crop yields when growing as the non-legume, first crop; the lowest yields as the legume, second crop; then the intermediate yield as another legume crop under more soil fertility depletion are shown in Figure I.

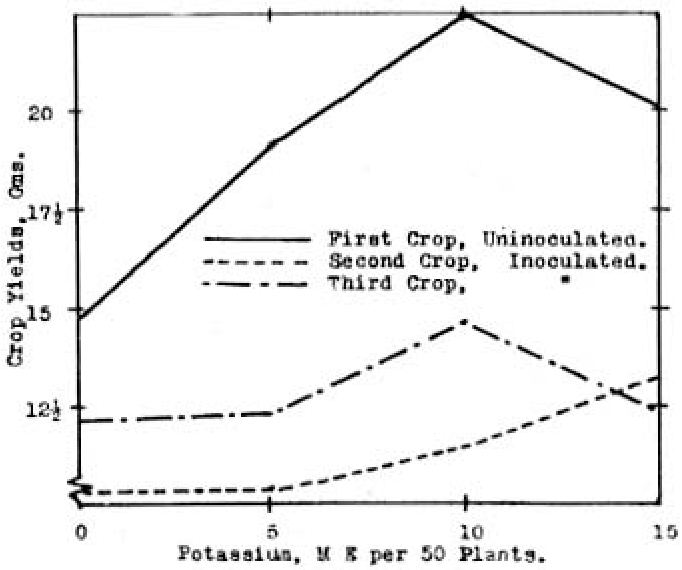


FIGURE I . . . The largest yields resulted when the soybeans were growing as the non-legume, first crop; the lowest yields as the legume, second crop; the medium yields as the legume, third crop when the fertility was nearly exhausted.

Sugar/starch effects

While many extensive chemical analyses were made, it is significant to note--at this time--the effects of the varied supply of potassium in the soil on only the sugar and starch in the plant tissue as the concentrations of them are related to the yields of the crop. You are doubtless familiar with the differences in sweetness of peas, if you have observed different varieties of them for this quality. There are differences in sweetness also according to the different soils on which the same variety is grown.

Perhaps your "sweet-tooth" is not sensitive to sugar in "greens" but even the cow has a "sweet-tooth" when by spraying saccharin (a sweet, non-sugar chemical) on crops, one can tempt her to take plants she would otherwise not eat.

The sugar represents the form in which the plant produces its combinations of carbon, hydrogen and oxygen as carbohydrates, the plant's own energy foods and ours also, from air and water by means of sunshine power. Starch, also a carbohydrate but of different molecular arrangement, is the plant's storage or reserve form of its energy food supply.

Four levels of potassium were used, namely 0, 5, 10 and 15 milligram equivalents (M.E.) per 50 plants, as the varied additions to the soil. The crops were harvested before the blossoms formed, and analyzed as vegetable matter and not as seed harvests.

The differences in the concentrations of the sugar and the starch in the soybeans grown in triplicates for each of the three successive crops at the four levels of potassium in the soil, or the twelve conditions, are shown graphically in the two figures. They show the impressive revelations of what varied compositions and nutritional values are brought about in the vegetation when only one nutritive element, potassium in the soil, is varied.

Vegetative yield

The Figure 1 reveals also how the crop which is a legume by pedigree, but behaving as a non-legume in the absence of nodule bacteria, grows more vegetative yield when it may be losing nitrogen from the plants to the soil, or may have less nitrogen in the crop (roots and tops) than there was in the planted seed. Then, behaving as a legume in cooperation with nodule-bacteria, how it may be taking nitrogen from the air and building itself higher in concentration of protein by that means, but may be giving smaller vegetative yields.

The first crop behaving as a non-legume contained less nitrogen than the 318 mgms. of the planted seeds by 26.0, 23.8, 17.9 and 23.6 mgms., or underwent losses of 26.0, 23.8, 17.9 and 23.6 per cent, respectively. The behavior of this crop vacillated between that of a non-legume and a legume.

As the fertility of the soil was lowered by successive crop removals, the soybeans moved to store more starch and to fix less nitrogen from the atmosphere. They became a crop to fatten more than to grow animals so far as the nutritional services they offered are concerned.

When the non-legume behaviors represented but crop bulk of lower sugar and higher starch according as there was increasing potassium fertilization (Figure II) while the legume behaviors represented high sugars and low starch in the second crop and before the soils were more highly exhausted by successive cropping, can any one in truth and in honesty contend that the fertility of the soil is no factor of significance in controlling the chemical composition of the crop growing on the soil?

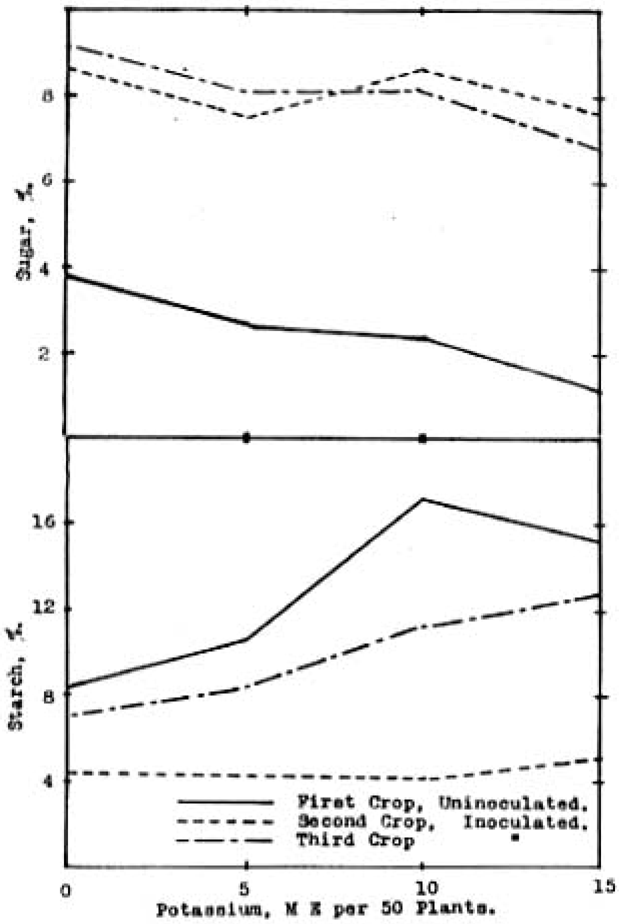


FIGURE II . . . The higher concentrations of sugar after the crops were inoculated (second and third crops) in contrast to the low concentrations before inoculation (first crop) were most marked. The low concentration of starch in the first of the two legume crops (second crop) is very noticeable. The second legume (third crop) went up in starch to suggest non-legume behavior by a legume brought about by depletion of the soil fertility.

Only slowly will we realize that it is the soil that creates and sustains us, with wide differences in quality thereof as the fertility of the soil varies. Here is a clear cut exhibition of the much neglected fact that the soil determines the chemical compositions, both inorganic and organic of the crops we grow.

(Continued in December)

Let's Live Magazine, December, 1959

DIFFERENT SOILS, DIFFERENT PLANT COMPOSITIONS

"Balanced" Soil Fertility Requires High Phosphorous

Part VI

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

The essential nutrient element, *phosphorus,* represented an unusually large part of the earlier kinds of commercia1 fertilizers. They carried then, and still carry, nitrogen, phosphorus and potassium as their fertility contents for legal and labelling purposes under the common N-P-K symbols. There was originally a wide ratio between the phosphorus and each of the other two constituents of the fertilizers when the mixtures were labelled 2-10-2 and 2-12-2, with the three elements present in the 1-5-1 and 1-6-1 ratios respectively.

"Pushing up" dangerous?

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

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

"Hidden hungers"

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

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

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

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

(Continued in January)