"Use Extra Soil Fertility to Provide PROTEIN"

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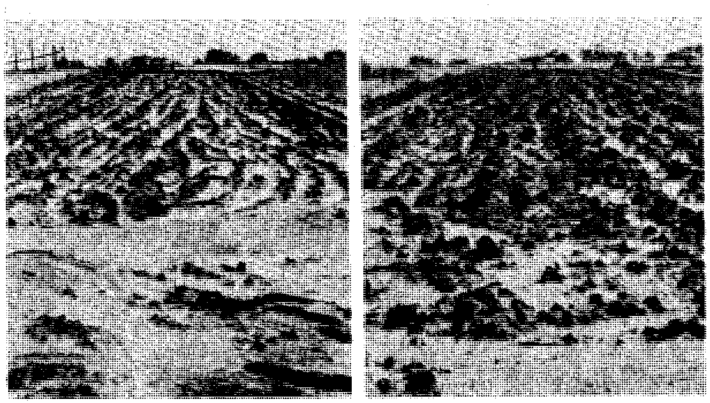
Soils that grow protein into the harvested crops must be given help in the form of fertilizers and leguminous green manures plowed under.

THE very mention of the word "protein" calls to one's mind the problem of providing this essential part of foods and feeds. In the kitchen, the lean meat is the first protein the housewife thinks about in her efforts to supply for her family a diet that is not deficient in this respect. On the farm, the word "protein" connotes bloodmeal, tankage, and other animal offal, or the many "meals," including cottonseed, soybean, gluten, bran, shorts, and other milling by-products. Whether it is a matter of feeding people or feeding live stock, the provision of plenty of protein is the first desire, but one not so simply nor so cheaply accomplished.

Supplying protein is a decidedly difficult problem in contrast to the ease of producing plenty of carbohydrate. Carbohydrates are readily and widely grown. But when it comes to the proteins they are so much less common that we think first of them as purchased supplements. In the distant past the pioneer grew them. In the recent past their ample supply on the market has permitted ready purchase. But very recently compelling economic conditions are apparently bringing us more and more to think about growing our own supplies. This is necessary in order to balance the carbohydrates and get extra margins of profit in having both as home-grown products.



Soil plowed out of a good grass sod (right) lessens erosion. Soil under corn and oats regularly plowed out of stubble (left) erodes seriously. Only fertile soils make good grass cover and strong soil body to hold up against beating rains. (Photo by courtesy of Soil Conservation Service-Research.)

Such will, of course, solve the problem of buying proteins but at the same time it will bring into clearer focus the necessity of putting fertility treatments on the soil. Fortunately, such rebuilding and conservation of the soil for the future not only provides protein now more cheaply, but also looks forward to make one highly independent of any market for his supply of it. We need more folks among the producers of milk and the growers of meat—which are our best protein foods—who will think more about providing most of their needed protein by building up the soil with its resulting conservation as an added profit.

Plants Produce Carbohydrates Abundantly, But Proteins Sparingly

Growing one's own protein, however, is not so simple a matter. The vegetable proteins we purchase are mainly seed parts. The yields of these per acre are determined by the fertility level of the soil. Making protein is a part of the plant's struggle to reproduce itself. Even for the plant, this is not a simple task. Legume forages, and the seeds of those like peas, peanuts, and beans are relatively rich in this requisite food constituent. But the high concentration of protein in the seed demands its having been first synthesized and put up in the forage part of the plant before it is localized and concentrated in the seed of the crop. Hence, the forages and hays of legumes, too, are rich in protein. It is this property that makes them good feed for the young or growing animals. However, legumes do not grow well nor do they manufacture much protein per acre, unless the soil supplies them generously with calcium, phosphorus, potasium, and the others of the soil-borne essential mineral elements that serve not only in the physiology of the plant but also in the life processes of animals and man as well.

All plants manufacture carbohydrates in fairly generous amounts. These are the basic compounds building up the plant body. The very growth of the plant spells carbohydrate construction. This process takes its necessary raw materials from the air as carbon dioxide which is combined with water through the power of the sunshine. Some few contributions and in small amounts, including potassium, magnesium, and iron are needed from the soil. But these serve only as helpers or catalysts in the construction process. They do not occur in the final or resulting carbohydrate compounds like sugar, starch, cellulose and others. This is the process of photosyntheses operating almost wholly on air and water as the raw materials that bring themselves to the plant and hence represent very little of a struggle by it. It is they that build the plant factory and serve as its fuel supply.

Proteins, in contrast, are not so simple in chemical composition, nor are they so abundantly synthesized by the plant. Carbohydrates seem to be the starting point for their construction. This conversion is brought about not by sunshine power but rather by the "life" processes of the plants. Proteins vary widely in their chemical composition. They are still a kind of mystical chemical compounds as to their particular structural make-up. There are infinite kinds of

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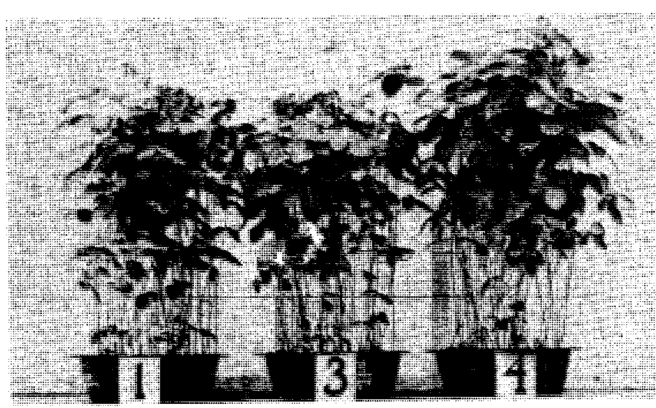
them, too. We know they are combinations of complex compounds called "amino acids," which are the simple building stones or structural parts of all proteins.

Unfortunately, these amino acids cannot be synthesized either by the animal or the human body processes. We and higher animals below us all depend on plants to synthesize these for us from the simpler elements. The plant, in turn, is highly dependent on the soil fertility, that is, calcium, phosphorus, nitrogen, and other nutrients, for help in synthesizing them. These amino acids are the components of its own proteins within which alone the life processes of cell multiplication or growth can be carried forward.

For carbohydrate production the soil must provide the plant mainly with potassium. For protein production more than this rather common element of soil fertility is needed since the plant's construction of sugars, through the help of potassium is the forerunner. Seemingly these sugars are both the raw materials and the energy source from which amino acids and their combinations as proteins are built up by the plant. But this is possible only when many additional soil-borne minerals are also provided. The chemical structure of amino acids suggests that they might have initially been sugar-like compounds into which some nitrogen, some phosphorus, and some sulfur are connected. But this protein compounding process—unlike sugar production—does not proceed under just sunshine power. It goes forward in the dark. It is powered through combustion of some carbohydrates or through a process that may well be called biosynthesis or "life" synthesis rather than photo-or "light" synthesis as is the case with carbohydrates.

Even though calcium is not a chemical part of the resulting protein compounds, it plays its important roles in their synthesis. We must have calcium or lime present for—and connect it with—protein production by plants much as potassium is connected with carbohydrate production by them. So when we need to lime the soil for legumes we now know that we are not fighting soil acidity, but rather we are fertilizing or supplying some soil fertility by which we grow more protein more effectively along with the production of carbohydrates. More fertility in the soil is the means by which plants do more than make energy feed values in their carbohydrates. It is this means, contributed by the soil rather than the weather, that



Increased crop yield as bulk does not necessarily mean delivery of more protein, even by a legume like the soybean.
The smallest of these crops provided more protein, more phosphorous and more calcium than the largest crop exceeding its weight by 25 per cent. (*Photo courtesy Missouri Agricultural Experiment Station.*)

makes protein synthesis possible. Growing our own protein means less attention to the weather and more concern about treating the soil with manures.

Unfortunately, we have not appreciated how important soil fertility converted into protein is in the process of multiplication of cells or in any of the processes of reproduction and growth. Protein is also protection against disease in the body's resistance. Better soils for better feeds to give better bearing of young, better milk production and better health has not been our thought so much as have more feeds for increasing the body weight through laying on of fat. Likewise in thinking about fertilizers and other soil treatments for crops, our measure of their efficiencies has been the increase in plant bulk. We have not looked to the better food quality in the crop that was given lime or other fertilizers on the soil growing it. Instead we have been satisfied with more quantity or more tons. In milk production, too, the value of protein supplements has been measured mainly in more gallons (mainly water) of milk, or more pounds of butter fat, which is an energy food. We still don't measure their effects in the pounds of protein output in the milk as brought about by the protein input of the feed. Quality of forage feeds in terms of better body growth, better reproduction, better meat or better milk in solids-other-than-fat, has not yet become the main reason for our closer attention to growing more and better proteins rather than buying them. Such qualities have not yet been appreciated as the more deeply significant reason for building up our soils to a higher level of fertility.

Newer Criterion in Terms of Quality Needs Emphasis

Protein-producing power per acre should be the newer criterion for evaluating land. Not gallons of milk per acre, but rather pounds of cheese-protein per acre would be a good measure of efficient dairy farming. Agriculture originally was primarily a food-producing effort. Fundamentally it is still the sustainer of life. In the recent past, however, it has attempted to swing itself into the industrial class, but shortages of foods push one back quickly to agriculture for the production and consumption of them rather than their sale as even Victory gardens testify. Conservation of soil may well measure its own efficiency, not by reporting how little soil is eroding, but how much protein per acre we are producing by use of the land without loss of it.

Such is the philosophy of some of the trials being carried out on the Missouri Soil Conservation Service Farm operating under the cooperative efforts of the Soil Conservation Service Research and the Missouri Experiment Station. Pounds of beef per acre from grass-cover intended to prevent erosion testify forcefully that merely keeping the water from running off may not help much toward more and better grass. In fact, contour furrows in the pasture may even hold so much water as to make bluegrass a poor feed during a period of high rainfall. In these trials, pastures only contour-furrowed caused loss in animal weight on this area of heavy clay subsoil under a shallow surface soil.

Three pasture areas were under test as separate areas fenced out of a large uniform bluegrass pasture in 1942. One was given no treatment; one was given furrows on the contour for water conservation; the third was renovated by some surface tillage and fertilizer applications. During the four years of the records the pounds of beef produced per acre were, (a) 115, with no soil treatment, (b) 103, with contour furrows, and (c) 151, with renovation through fertilizers. These results point out clearly that merely holding back water was of no help as more feed value. Rather it was even of detriment. They point out positively that the soil treatments with extra fertility made more protein per acre. This was the report by the cattle, as they measured it, when the human eye could scarcely distinguish differences in forage yields. More protein per acre goes back to more fertility in the soil, when animal physiology is testifying.

More protein means healthier plants
Putting more calcium-clay into the sand (left to right) to help these legume plants make more protein protected the soybean crop from attack by a fungus.

Calcium-Potassium Ratio in Fertility Controls Protein Production

When the plant is building protein it, too, does this with varying degree but according to the nutrients it gets. Quite contrary to expectations, more bulk of forage per acre is not necessarily proof of higher concentration of protein in the forage or hay. Experimental studies have shown that it is not necessarily the large tonnage per acre that makes the most protein per acre. Rather it is the combination of nutrient mineral elements in the soil, or the fertility ration we feed the plant that encourages its internal activity in protein production rather than mere storage of carbohydrates. Plant diets from the soil must conform to certain ratios of the nutrient elements to each other much as economic animal feeding demands certain nutritive ratios.

These nutrient ratios for plants are suggested by the different degrees of soil development, for example, in the United States. On the highly developed or leached soils of northeastern, eastern, and southern United States, which originally grew only forests and where the ratio of calcium to potassium is low or narrow, we may well expect carbonaceous or woody crops today. In the Midlands of the United States which originally grew grass with many natural legumes on less leached, calcareous soils,—and also grew buffalo without purchased protein supplements—the crops were originally proteinaceous. Here the soil fertility suggests a high or wide ratio of calcium to potassium. This concept in terms of the calcium-potassium ratio gives us the natural principle by which we can visualize the synthetic activities of the plant as either those of making mainly carbohydrates or making proteins as well. Plants making mainly carbohydrates build much bulk readily through sunshine power. But when plants build proteins, they burn much of these carbohydrates in converting them into proteins. As a consequence, this gives less bulk per acre. We can, therefore, not be certain that much crop means much protein, nor that even the crop, whose pedigree says it is a legume, is rich in protein.

Experimental trials have demonstrated the truth of this principle. The soybean hay crop was much larger when potassium was liberally used in contrast to calcium or lime to nourish the crop. But when calcium was higher in relation to the potassium (with phosphorus amply supplied), the crop was only four fifths as large. But this lesser bulk contained more total protein than the crop that was 25 per cent larger. Coincidently the phosphorus in the smaller crop was almost twice as concentrated and the calcium almost three times as in the larger crop.

It may seem difficult to believe that we can have less yields as bulk or tonnage per acre and yet have greater yield in the form of nutrition as protein and minerals when the plants are properly fed through the soil. But this less bulk can be offset by using extra potassium also. We need not hold down the tonnage yield. Instead we can use potassium for that increase and then also extra nitrogen, calcium, and phosphorus to get a higher concentration of protein along with it.

More Home-Grown Proteins Mean More Conservation of the Soil

All this testifies to greater satisfaction in the better production of protein in the crop and in the production of protein in milk or meat from feeding that crop if we produce it ourselves by managing the soil accordingly. When more home-grown feeds go into the dairy barn, the margin of profit usually increases. When more fertility is put into the soil under those feed crops, the margin is pushed up still more. One need not see that increase as more tons of hay, and thereby needs not pitch more of it. But one can see it in terms of higher efficiency in what it does for milk production by better animal health, by regular reproduction, and similar performances by the cows that eat it. These contributions by the cow to the bank account are usually more significant as more proteins rather than mainly more carbohydrates can be liberally fed. Grown at home, the proteins are not so disturbing in our generous use of them as when this liberality constantly causes the extra ring of a cash register in the feed store.

While soil conservation is such a constant thought in our minds calling for most grass as vegetative cover against erosion, and when such forages must be marketed mainly through the cow, we need to think about growing protein within them or as home-grown supplements to them. The protein problem is one that calls for production of more of our own to cover the shortage in its bulk and quality rather than for national proclamations for more equitable distribution. Protein as food for humans is ultimately a plant product brought to us, most commonly through the animal's reconversion for our better use of it. Protein cannot be made by our crops drawing on only air and sunshine. They must draw on plenty of lime, phosphorus, potassium, nitrogen, and other fertility elements in the soil. By supplying more fertility to the soil more of this essential that carries life, namely protein, can be provided while at the same time we are making a more conservative use of that natural resource, the soil, by which all of us must be fed.

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