But it seems to me that the difficulties of our time plead loudly for a broadening of the purpose and a shapening of the weapons of anthropology. If we elect to stand where we have done a new science will respond to the needs of state and society; it will spring from medicine and psychology, it will be the poorer in that it knows little of man's development, little of his history or pre-history. But it will devote itself to the urgent problems of the day. The future lies with the nation that most truly plans for the future, that studies most accurately the factors which will improve the racial qualities of future generations either physically or mentally. Is anthropology to lie outside this essential function of the science of man? If I understand the recent manifesto of the German anthropologists, they are determined it shall not be so. The war is at an end, but the critical time will be with us again, I sadly fear, in twenty to thirty years. How will the states of Europe stand then? It depends to no little extent on how each of them may have cultivated the science of man and applied its teaching to the improvement of national physique and mentality. Let us take care that our nation is not the last in this legitimate rivalry. The organization of existing human society with a view to its future welfare is the crowning task of the science of man; it needs the keenest-minded investigators, the most stringent technique, and the utmost sympathy from all classes of society itself. Have we, as anthropologists, the courage to face this greatest of all tasks in the light of our knowledge of the past and with our understanding of the folk of to-day? Or shall we assert that anthropology is after all only a small part of the science of man, and retreat to our study of bones and potsherds on the ground that science is to be studied for its own sake and not for the sake of mankind? I do not know what answer you will give to that question, yet I am convinced what the judgment of the future on your answer is certain to be.

Karl Pearson

SULPHUR AS A FERTILIZER

Information concerning the relation of sulphur to plant nutrition and growth has been accumulating during the last decade, and the mass of data has now become so important that it demands recognition of all investigators of nutritional problems. Indeed, it seems to me that much of our past experimental field work dealing with the influence of fertilizer elements upon plants has been so loosely done that we are under the necessity of reexamining the whole matter.

Although the value of sulphur, particularly in the form of gypsum, was recognized at an early period in our national history, the lack of uniform success with it soon led to its neglect as an important fertilizer. And after the invention of acid phosphate about the middle of the last century, the development was almost wholly toward soluble fertilizers containing nitrogen, phosphorus, and potassium. Sulphur was not included as a part of a complete fertilizer, although it was recognized as necessary to plant growth. The soil was thought to contain enough sulphur, and plants to need so little of it, that it was added to the soil only incidentally, as in acid phosphate, potassium sulphate, or ammonium sulphate, along with the three elements forming the so-called "complete" fertilizer.

Experiment station workers and other students of mineral nutrition of plants fell into loose ways of working with fertilizer salts. They have not hesitated to use sulphur-containing nitrogenous compounds when testing the influence of increased nitrogen on plant growth. Similarly the acid phosphate has been used in testing the effects of phosphorus; and potassium sulphate has been used when potassium was under observation. In comparing various forms of fertilizer elements we find the superphosphate for instance pitted against bone meal; or potassium sulphate against potassium chloride; or ammonium sulphate against sodium nitrate as a source of nitrogen. It is evident that such tests as these are all invalid if sulphur itself is shown to be an important fertilizer element. For the experiments have at least two variables, and it would be impossible to ascribe differences in growth to one element with any certainty that the other element was not partly responsible for the result. The recent facts brought out in regard to sulphur should lead at once to a widespread reexamination of these problems, with more rigidly designed and controlled experimentation.

The basic facts brought out are briefly summarized here. In the first place, soil studies have shown that sulphur is one of the rare necessary elements. Soils are generally no richer in sulphur than in the fertilizer elements, nitrogen, phosphorus and potassium. This scarcity of sulphur in normal soils is probably related to the ready leaching of sulphur into drainage water. At the same time improved analytical methods have demonstrated that crop plants require more sulphur than was formerly supposed. They remove it from the soil fully as rapidly as they remove any of the other elements which may become limiting factors. The normal sulphur content of soils is sufficient for from fifteen to seventy crops, provided there are no additions from outside sources, as from rainfall. Even if we count in the rainfall sulphur, it is probable that sulphur is just as often a limiting factor as is phosphorus, or nitrogen, or potassium. For two of the last named elements do not leach as readily as sulphur. The important point is this: If sulphur *is* a limiting factor, addition of any other fertilizer is useless, and a waste, just as much as would be the use of gypsum as a fertilizer if phosphorus were the limiting factor.

Instead of thinking of the N. P. K. formula as representing a "complete" fertilizer it is time we began work solely from the standpoint of limiting factors, including not only these three, but S, Ca, Mg, and any other factors which influence crop production. The early failures with gypsum were probably due to the fact that phosphorus or some other element besides sulphur was limiting growth, or that sulphur at any rate was not the thing needed. These remarks must not be construed as argument for the discontinuance of any of the fertilizer elements now in common use. It would be a grave error to try to replace them with sulphur when they are deficient, but we can no longer ignore sulphur as one of the very important fertilizer elements.

Since the Cruciferæ and Leguminosæ are known to use quantities of sulphur in their metabolism, crop plants of these families must be the ones most likely to suffer from deficiency of sulphur. Recent work by Reimer[1] at the Oregon Agricultural Experiment Station is very significant and deserves the attention of agriculturists and scientists all over the country. He has found that many of the soils of Oregon are deficient in sulphur, and that addition of sulphur-containing compounds of almost any kind may lead to very remarkable increases in the yield of alfalfa or clovers upon such soils. His experiments extended over several years, and involved a variety of soils. The increased production ran from 50 to 1,000 per cent. in alfalfa, with application of such sulphur-containing materials as gypsum, superphosphate, flowers of sulphur, etc. Addition of phosphorus without sulphur had practically no effect, showing that the acid phosphate was valuable only for its sulphur content in this case. The possibility of such increases is a challenge to agriculturists everywhere in these times of under production.

The best results seem to come when the sulphur is used as a top dressing on the legume crop. The usual custom in the United States is to fertilize the cereals, wheat, etc., and allow the legumes to get the effects a year or two later. Sulphur applied in this way does the legume crop little good, for most of it disappears out of the soil by leaching before the legume comes in the rotation. The early successes were most notable when application of the sulphur fertilizer was made directly to the crops most needing it, the legumes. These convert the sulphur into the organic form, and if used as green or stable manures provide sulphur for succeeding crops in a nonleaching form. It seems quite clear that we

[1] Reimer, F. C., "Sulphur as a Fertilizer for Alfalfa in Southern Oregon," Oregon Agr. Coll. Exp. Sta. Bull. 163, 1919.

are applying our sulphur fertilizers at the wrong place in the rotation when we use them with the cereal grains which require little sulphur. Top dressing in legumes would be the logical time in the rotation to provide the sulphur when it is known to be deficient in amount.

While the results obtained by Reimer are certain not to be duplicated on certain types of soils in the eastern United States, as for instance on soils deficient in lime, or on acid soils, the results indicate that it is worth while to test out the value of sulphur generally through the country. The fact that the early users of gypsum over a century ago had similar results with soils in Pennsylvania and Virginia should encourage renewed experimentation with sulphur fertilizers, under conditions that preclude confusing one limiting factor with another. As already suggested, the early failures were probably caused by the soils being deficient in phosphorus rather than sulphur in some cases, or deficient in both at once, or at any rate not in sulphur alone.

We know enough now to make our tests crucial as to which element or elements limit production. The only way we can know the facts will be by actual tests. The system of soil fertility upon which our vast expenditure for fertilizers is based should be examined and tested with open unprejudiced minds. The tests of sulphur containing fertilizers should be made over wide areas in the eastern United States, for there must be many soils in which sulphur is deficient for optimum nutrition of high sulphur-requiring plants. In many cases where superphosphate has been used with success, it may be the sulphur, rather than the phosphorus that is the valuable element. In such cases substitution of the cheaper gypsum might yield as satisfactory results as the more expensive fertilizer.

American agriculture would be vastly benefitted by extensive experimentation along the lines suggested, with strictly controlled conditions under which alone can we have a proper interpretation of results. With our expenditure for fertilizers much in excess of a hundred million dollars annually, it is highly important that our fertilizer practise should be put upon a rational basis at the earliest possible moment.

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ERIC DOOLITTLE

Eric Doolittle, Flower professor of astronomy and director of the Flower Astronomical Observatory died September 21, 1920. In 1917 he was called upon to organize and conduct the U. S. Shipping Board Navigation School at Philadelphia. In attempting to teach the large number of men suddenly thrust upon him and to attend to the correspondence, registration and other necessary details without assistance, none being provided or immediately available, he greatly overtaxed his strength and collapsed under a slight stroke. Although later he was able to resume his university duties, he never fully recovered and did but little observing thereafter. In May, 1920, he became ill again. When his condition became serious he was removed to the University Hospital on June 24, at which place he died.

Professor Doolittle was born in Indiana in 1870. In 1876 his father, C. L. Doolittle, became professor of mathematics and astronomy at Lehigh University. The son graduated there as a civil engineer. After practising this profession for a year he was instructor in mathematics at Lehigh for a year and at the University of Iowa for two years. After spending a year in graduate work in astronomy at the University of Chicago, he became instructor in astronomy at the University of Pennsylvania in 1896, where his father has been called in the meantime as professor of astronomy.

The Flower Observatory was established in 1896. Eric Doolittle was placed in charge of the new 18-inch refractor with its superb Brashear lens. The telescope was made with a long focus, 30 feet, for double star observation. He immediately began his observations of double stars. He used the telescope almost