FUTURE SOURCES OF SULPHUR AS PLANT FOOD.

GEORGE A. OLSON, AGRICULTURAL DIRECTOR, THE GYPSUM INDUSTRIES, CHICAGO.

Sulphur has always played and will continue to play a very important role in all life processes whether they be of vegetable or animal nature. Its use as a valuable plant food preceded that of commercial fertilizers and the history of early American agriculture is replete with information showing that sulphur in the form of gypsum has been beneficial in various ways to crops.[1]

It was surmised more than a century ago that the beneficial substance in gypsum was vitriolic acid or what we now recognize as the SO_4 radicle and not calcium, for the reason that plants did not respond to applications of burnt or slacked lime in a similar good manner.

The early investigators were unaware that the gypsum could induce definite chemical, bacterial and physical changes in the soil which would explain the ofttimes phenomenal result secured. Based on subsequent investigations it was discovered that such changes did occur and were partly, if not entirely, causes for enhanced yields. The most frequent cause for the increase of crops, however, was that gypsum provided the plants with available sulphur.

By comparing the sulphur content in Wolf's ash analyses the present methods of determining sulphur, it is now obvious that many investigators were misled regarding the quantity of sulphur that would be required to meet crop needs. Ideas regarding the sulphur requirements of plants underwent a rapid evolution when it was shown that only an insignificant part of the total sulphur was retained in the ash. Bacon has stated,[2] "From obscurity sulphur gained prominence over night and it was indeed startling to realize that, on the average, plants required more sulphur than phosphorus."

Previous to the discovery of the large amount of sulphur required by various crops, Dymond, Hughes and

[1]Crocker, William, The History of Agricultural Gypsum. Published by The Gypsum Industries, Chicago, Ill., 1922.

[2]Bacon, Raymond F., Relation of Sulphur to Fertilizers and Plant Growth, American Chemical Society, Milwaukee, September 13, 1922.

Jupe,[3] following observations with soils at Essex, England, deduced: "There is not enough sulphuric acid in the soil or supplied by rains for heavy yielding crops rich in albuminoids, either for the production of greater yields or highest feeding value and for such crops it should be included in the artificial manure."

Since no checks were made to determine the value of sulphur as plant food in early fertilizer experiments conducted in the United States it was impossible to ascertain the response of plants to sulphur treatment. This can be appreciated when one considers the composition of a 4-8-6 fertilizer containing in part ammonium sulphate, acid phosphate, and sulphate of potash. In a mixture of this kind the total ammonia nitrogen is 80 pounds; potash, 120 pounds; phosphoric acid, 160 pounds; and the sulphur trioxide, 394 pounds. Fertilizer manufacturers have supplied sulphur in large amounts in their mixtures.

In the west where the soils have not been treated with sulphur-containing fertilizers, it has been possible to differentiate between the importance of this element and with phosphorus. Olson and St. John[4] in the state of Washington, increased the yields of legumes 100 to 200 per cent with applications of gypsum and sulphuric acid. Reimer and Tartar[5] in Oregon obtained similar results and proved beyond any question of doubt that there was a real need for sulphur as plant food material.

[3]Dymond, T. S., Hughes, F., and Jupe., C. W. C., The Influence of Sulphates as Manure upon the Yield and Feeding Value of Crops., Journal Agricultural Science, 1:217-229, 1905.

[4]Olson, George A. and St. John, J. L., An Investigation of Sulphur as Plant Food, Washington Experiment Station, Bulletin 165, 1921.

[5]Reimer, F. C. and Tartar, H. V., Sulphur as a Fertilizer for Alfalfa in Southern Oregon, Oregon Experiment Station Bulletin 163, 1919.

Increase Per Acre Over the Cost of Materials Produced by Applications of Phosphorus, Gypsum and Lime.

NET INCREASE OVER CHECK

Crop	Phosphorus	Gypsum	Lime
Alfalfa	$8.14	$49.99	$4.08
Sweet Clover	6.30	38.25	2.85
Meadow Mixture	(a) .71	21.53	(a) 4.21
Red Clover	4.22	18.55	(a) 1.09
Wheat	(a) .23	18.89	4.53

a-Loss.

Likewise it has been shown that there is in Idaho soils a sulphur poverty. McDole and Christ[6] have stated:

"While phosphorus and lime have produced some increase in production, the gypsum has proved to be the most profitable material to use."

A very good idea of the value of the gypsum as a source of sulphur is manifested in the following table which appears on page 20 of Bulletin No. 136 of the Idaho Agricultural Experiment Station.

If acid phosphate which is approximately one-half gypsum had been applied instead of mono-calcium phosphate and gypsum the possibilities are that the increased yields would have been credited to phosphorus. From this and other similar experiments, there are reasons to believe that many of the results with acid phosphate have been misinterpreted in the past.

On page 26 of Soils Report 33 of the Illinois Agricultural Experiment Station it is shown that wheat, straw, corn stover, oat straw, soy bean hay, and alfalfa hay contain 9 to 100 per cent more sulphur than phosphorus. The amount of sulphur which is annually leached from soils and carried down streams into salt waters is enormous as compared with phosphorus.

The Ohio River[7] carries away annually about 2,200,000 tons of sulphur in solution which is equivalent to the sulphur in approximately 12 million tons of gypsum. This loss of sulphur is more than three times the quantity that is applied in the form of fertilizer. In the drainage of the Mississippi Valley approximately 6,700,000 tons of sulphur in solution annually are emptied into the Gulf of Mexico. In addition there are about 3,400,000 tons more in the sediment which annually empties into the Gulf of Mexico. In the United States as a whole the writer has estimated that 20,000,000 tons of sulphur are dissolved in the waters which pass down stream and empty into the Gulf of Mexico, the Atlantic and the Pacific Oceans.

Besides the enormous loss of sulphur other plant foods are carried away in solution and sediment to augment the ocean salinity and build up the ocean floor. In the Mississip-

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[6]McDole, G. R. and Christ, J. H., Farming Practices for the Cut-Over Lands of Northern Idaho., Idaho Experiment Station Bulletin 136, 1925.

[7]McHargue, J. S. and Peter, A. M., The Removal of Mineral Plant Food by Natural Drainage Waters, Kentucky Experiment Station, Bulletin 237, 1921.

pi Valley, it has been estimated that $4,000,000,000 of plant nutrients are lost per annum.

The taking away of our upland forests and the careless method of tilling these and other rolling lands are the direct causes for the floods and the destruction of lives and property. It is also the cause for the waste of enormous quantities of plant food materials and soil.

Knowing the causes they can be remedied. The lost soil materials such as gypsum and other calcium salts, which in the natural state helped to keep the soil open and receptive to water must be replaced and the lands unsuitable for agriculture must be reforested. The rolling land suitable for agriculture must be terraced, strip farmed, put into clover crops or grasses. By these practices it is possible to reduce losses of soil and plant food minerals and to avoid damages by floods.

We have accounted for enormous losses of sulphur and as the future welfare of our nation depends so much on the fertility of our lands it is well to consider the sources of supply of sulphur which have helped to prevent plant starvation.

There are about 600,000 tons of sulphur in the fertilizers which are annually added to soil. The principal source, however, comes from the burning of coal. The amount returned to the land if all of the sulphur in coal were volatilized would be approximately 13,400,000 tons annually or 6,000,000 tons less than is carried away in our drainage system. It is more than likely that the amount of sulphur escaping into the air does not exceed 7,000,000 tons annually or 12,400,000 tons less than is removed. This is in accord with Sir A. D. Hall's views[8] that the rains on the average wash three times as much sulphur out of the soil as is carried down from the air.

Most of the coal is consumed in the industrial centers and these are also the places where most of the sulphur in the rain water appears. The polluting of the air with smoke is objectionable from a health standpoint. Not only are the visible rays which we call light shut off but also the violet light rays which medical science has discovered are essential

[8]Hall, A. D., The Soil, and Introduction to the Scientific Study of the Growth of Crops New York, 1915.

to life. There is also great economic waste in permitting the carbon to escape as smoke.

It has been demonstrated that coal can be converted into fuel oil and according to views expressed by experts connected with the United States Federal Bureau of Mines this oil will soon take the place of coal as fuel and the skies in the great municipalities will then be as clear as those in the open country. Simultaneously more of the ultra violet light rays and less of the sulphur will be made available.

For economic reasons the trend in the manufacture of fertilizers is toward the production of highly concentrated plant foods, such as ammonium phosphate, potassium phosphate, phophoric acid, urea, ammonium nitrate, and leuna saltpeter. In the state of Ohio[9] it is already noted that the farmers are purchasing more units of nitrogen, potassium and phosphorus per ton of fertilizer than before, and competition will require additional units of these elements. It will have the tendency to eliminate sulphur as one of the products, because it is considered economically unprofitable at the present time to transport sulphur great distances. With the elimination of sulphur in the fuel the needs for this plant food may be more keenly felt and as a result effort will be made to recover it in the waste products. Fortunately such changes in our supply of sulphur as are bound to occur will not seriously affect agriculture. This is due to the fact that we have large deposits of gypsum strategically located near various farm centers in the United States.

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[9]Barnes, E. E., Trend of Fertilizer Sales in Ohio, Ohio Experiment Station, Bimonthly Bulletin, March-April, 1927.