

(2) by changing the kind; and (3) the amount of bonding materials used. By combining these factors, suitable bodies may be obtained having any texture or porosity for the penetration of liquids of any density. The state of subdivision of the residue which is to be separated from the liquid or gas is of course the final criterion of the permissible size of the voids. In organic extraction work it is particularly desirable to have a porous medium, which gives the most rapid filtration possible with the complete retention of the residue.

Another feature of these thimbles is the fact that no blank extractions have to be made to be sure that the materials are fat-free, as in the case of paper or other organic materials, as, being of a refractory nature, they can be readily cleaned by being ignited at a temperature high enough to dispel any organic material. This also allows of their repeated and indefinite use, so long as no easily fusible inorganic material is ignited in them.

Messrs. Ross and Benner in their work at the Agricultural Experiment Station at the University of Arizona, on the filtration of soil solutions and the separation of "black alkali" in certain characteristic western soils, showed that filters of this material not only filtered more rapidly without changing the concentration of the solution and absorbed less than any other type of filter on the market, but required less washing, were very much more durable and could be cleaned and sterilized by igniting at the proper temperature. For further details, I would refer you to the original paper which is being read in another section of this meeting.

For the extraction and filtration of tanning materials, Mr. R. C. Oberfell describes in the *Journal of the American Leather Chemists' Association* for November, 1911, an ingenious device in which a porous Alundum dish substitutes the asbestos mat, or the mixtures of asbestos and kaolin, for removing the insoluble material in tanning materials. Absolutely clear fil-

trates were obtained in from $\frac{1}{2}$ to 2 minutes without the use of any asbestos or kaolin mixtures in these dishes as against from 82 to 130 minutes using the official method of filtration with the mat, at a consequent saving of about 98 per cent. of the time of filtration, the results of the analyses in each case checking within the allowable error. Where the dish alone was used, no previous saturation or preparation of the filtering medium was necessary, as is the case in the official method.

For organic extraction work on rubber, vulcanized products, fats, waxes, soaps, bitumens, cereals, etc., the proper filtering body for any solvent can be easily made and is apparently limited only by the texture, which must be fine enough to retain the residue and prevent it from penetrating the pores of the thimble. Rapidity of flow and extraction can in this way be increased many times over that obtained with the ordinary extraction thimble.

The chemist of a large rubber reclaiming plant in the west has recently had made an ingenious type of thimble consisting of two thimbles semi-circular in cross-section so made that when fitted together side by side, they occupy no more room than a single thimble, allowing two samples to be extracted at the same time in the same solvent. This method would apply, of course, only in cases where the residues only were desired, the filtrates from the two samples being mixed. The scheme worked out very well at a great saving of time and solvent, and there is no reason why this idea could not be followed out further, and any number of sectional extraction thimbles made to fit one extraction tube.

The application of this type of inorganic extraction thimble has not been limited to liquids, as recent tests indicate that it can be used successfully for the filtration of gases and the separation of dust and fume from air, smoke, producer gas, etc., quantitatively.

RESEARCH LABORATORIES,
NORTON COMPANY,
WORCESTER, MASS.

ADDRESSES

FERTILIZER CHEMISTRY—A REPORT OF PROGRESS.¹

By PAUL RUDNICK.

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While it is too early to obtain figures on the consumption of fertilizers in this country for the year just passing, all indications justify the belief that there has been the usual material increase over the tonnage consumed in the previous year, which was estimated, in round numbers, at about 5,750,000 tons, an increase of about 14 per cent. over that of 1909. The average increase in the consumption of commercial fertilizers in the past decade has been something over 11 per cent. annually.

This material increase in the consumption of commercial fertilizers naturally brings up the question of materials entering into this commodity.

¹ Chairman's address delivered before the Division of Fertilizer Chemists, American Chemical Society, December 27, 1911.

The production of organic ammoniates, such as blood, tankage, etc., cannot, under present conditions, keep pace with the greatly increased demand for them. The consumption of nitrate of soda is, of course, keeping pace proportionately with the increased consumption of commercial fertilizers in general. The consumption of cyanamide in this country shows a decided growth, and a plant for its manufacture is now being operated in this country at Niagara Falls. Other products of the utilization of atmospheric nitrogen, such as basic calcium nitrate, do not appear to have gained a foothold in this country as yet. While the annual production of sulfate of ammonia has been greatly increased with the increased installation of retort coke ovens, a great deal more of this valuable ammoniate could be assimilated easily. From the standpoint of conservation of our resources the time should be close at hand when the nitrogen

in practically all the coal consumed will be saved and converted into ammonium sulfate. It is exceedingly interesting to realize that practically all coals contain sufficient sulfur to combine with the nitrogen for production of ammonium sulfate and two different processes are now operated commercially on this plan.

It is a well recognized fact that organic ammoniates must be used in commercial fertilizers in addition to the inorganic ammoniates because of the demand for good mechanical condition, that is, a commercial fertilizer must work in the seed drill or other distributing apparatus without clogging. It is obvious, therefore, that with the increased consumption of commercial fertilizers, there must also be an increased production of organic ammoniates to meet with this requirement. Since the production of organic ammoniates has not been able to keep pace with the increased consumption of commercial fertilizers, very careful thought and study will be required to prevent exclusion of suitable materials by arbitrary methods of analytical control. Unless we can expand our supply of organic ammoniates, the cost of this very necessary class of fertilizer ingredients, which has already increased by leaps and bounds owing to the greatly increased demand, will soon become prohibitive. From a conservation standpoint, it also becomes imperative to utilize any organic nitrogenous material which is now going to waste, if it can be so treated or produced, that it can be shown to have a proper fertilizer value.

There is another point which may well be brought out in this connection, namely that experience has shown that varying availability in the ammoniates of a complete commercial fertilizer is highly desirable, so that there shall be more or less available nitrogen for the plant during the greater period of its growth and not only immediately after the application of the fertilizer.

A great deal of work has been done on the question of making the phosphoric acid in phosphate rock available by cheaper and more efficient means than by acidulation with sulfuric acid. None of the many proposed processes for this purpose, however, has as yet proved sufficiently satisfactory to be operated commercially. Under existing conditions, basic slag is practically confined to the Eastern States. It is to be hoped that a suitable method for producing available phosphoric acid from phosphate rock, other than by acidulation with sulfuric acid, will soon be discovered.

More experimental evidence that phosphate rock itself cannot be used profitably as a fertilizer is accumulating right along. The proposal to use a source of phosphoric acid of little or no availability is in striking contrast to the demand for high availability in the sources of nitrogen, even if the great difference in unit cost is considered.

In this connection the important role of sulfur recently brought out by the Wisconsin Agricultural Experiment Station is of the greatest interest. It is stated that some crops require even more sulfur

than phosphoric acid and that the superior results obtained with acid phosphates over other phosphates may not be due entirely to a difference in availability but to the additional sulfur supplied by acid phosphate in the form of calcium sulfate.

Germany continues to be practically the only valuable source of supply of potash salts, and the German potash controversy is so familiar to all that it need only be mentioned in passing. One of the results of this controversy has been to stimulate the search for sources of soluble potash salts in this country to the greatest activity. In spite of repeated denials it appears certain that the source of potash recently announced in Maryland deposits is feldspar and that the proposed method of treatment consists in heating with salt and niter cake. The consensus of opinion, at the present time, is not favorable to the idea that it is possible to utilize feldspar as a profitable source of potash. Fusion or calcination with sodium or calcium compounds causes a material reduction in the percentage of potash, which is already low enough at best in the feldspar itself. The cost of lixiviation and concentration is admittedly prohibitive. The question of utilizing water-insoluble potash is being agitated even in Germany. One of the German Agricultural Experiment Stations reports successful results from the use of finely ground phonolith, apparently a product of the weathering of feldspar, somewhat similar to the zeolites in its nature. Other investigators, however, were unable to obtain such results and insist that this material is worthless as a source of available potash.

The report that the Department of Agriculture had located deposits of soluble potash salts seems to have been premature; it is now understood that sources, not deposits, were meant. It is also announced in this connection that the U. S. Geological Survey has begun actual field operations in the search for deposits of soluble potash salts. A well is being sunk at Fallon, Nevada, and it is to be hoped that the search will prove successful. A cooperative laboratory has been established at Reno, where prospector's samples will be examined. The possibility of finding commercial potash deposits in the arid regions of the west seems to be further indicated by the fact that potassium nitrate is usually present in considerable proportions in alkali soils and indeed the finding of small deposits has been repeatedly reported. The most recent report indicates that such deposits were located in Idaho. So far such deposits have been very small and of very low potash content.

The functions of manganese and boron in the soils are of interest from a fertilizer standpoint. The results so far reported seem to indicate that their function is a catalytic one.

In this connection it is important to note that the A. O. A. C. at its meeting this year adopted as a provisional method a modification of the official method for determining water-soluble potash, consisting in leaching out the water-soluble potash from the sample with hot water much in the same manner that water-soluble phosphoric acid is removed in the determination

of insoluble phosphoric acid. Considerable work has been done on this subject by the Committee on Potash of this Division and the results of the work of this committee indicate that the modified method will give much more nearly the actual proportion of potash put into the fertilizer by the manufacturer. In the official method an average of 0.3 per cent. of water-soluble potash becomes insoluble in the course of extraction.

The theory of the action of fertilizers continues to engage the efforts of many research workers both in this country and abroad as a part of their work on the biochemistry of soils and plants. It has become very evident that the plant food theory is inadequate. Applications of commercial fertilizers which produce large and profitable increases in crops are not nearly sufficient in all cases to replace the elements removed by the plants from the soil. Much attention has been attracted to the discoveries regarding the presence in soils of protozoa which live on and destroy beneficial soil bacteria, of fungi which are harmful either directly to the plants or perhaps to the soil bacteria and of the toxic action of certain constituents of the soil which are either excreted by the plant roots themselves or may be produced by decomposition in the soil. It is easy to believe that fertilizers may exert a beneficial action on the soils to which they are applied by suppressing the activity or harmfulness of such organisms or substances, but it does not follow that this constitutes the entire explanation of the action of fertilizers. The idea that fertilizers may act in part by rendering soluble or otherwise releasing unavailable elements of plant food from the soil is plausible, but lacks confirmation and cannot in any event explain completely the mechanism of the action of fertilizers.

It is more than likely that the theory advanced by Dr. Cameron at our meeting a year ago, namely that no simple explanation can be hoped for, but that the entire matter is inextricably bound up with a large number of other modifying factors such as climatic and meteorological conditions, tilth, drainage, seed selection, etc., is the best we have at present.

It may be well to point out in this connection another possible partial factor in the action of fertilizers. Loeb (*Science*, 34, 653 (1911)) recently announced that the presence of both potassium and calcium chlorides in sea water is necessary because they exert a protective action on the organisms with which he experimented. These organisms die very quickly in pure distilled water or in a pure sodium chloride solution, as well as in a pure cane sugar solution, and somewhat less quickly when potassium chloride is present in addition to sodium chloride. When both potassium and calcium chlorides are present, however, in addition to sodium chloride, the animals can live for several days. The best proportion of these three salts is that existing in sea water and it is of interest to note that the relative proportion of these salts in human blood is the same as in sea water, although the concentration in blood is much less.

Taking into consideration the fact that practical experience has shown complete fertilizers to be almost

uniformly of much more proportional value in producing increased crop yields than incomplete fertilizers, is it not possible that at least a part of the action of complete fertilizers may consist in a similar protective action of their soluble constituents on the cells of the plant? That some action of this sort exists would seem to be further indicated by the results of the extensive researches published on the calcium-magnesium ratio in soils.

With the enormous amount of research work now being carried on in this field, it seems quite likely that we shall soon come to a fairly comprehensive and clear understanding of the more important phases of the mechanism of the action of fertilizers in producing crop increases, so that the most efficient manner of application may be determined with a reasonable degree of accuracy by scientific methods. This is a problem in which producer and consumer alike are interested and its solution will constitute an important chapter in the conservation of our resources.

Efficiency has come to be an important watchword in our every-day life, and much has been accomplished in this direction in agriculture by the use of improved farm machinery. President Taft, in his address on "Conservation of the Soil," before the National Conservation Congress, at Kansas City, last September, quoting from the Yearbook of the Department of Agriculture for 1898, pointed out that between the years 1855 and 1894, the time of human labor required to produce 1 bushel of corn declined on an average from 4 hours and 34 minutes to 41 minutes, and the cost of the human labor required to produce this bushel declined from 35 $\frac{3}{4}$ cents to 10 $\frac{1}{2}$ cents. Between 1830 and 1896 the time of human labor required for the production of a bushel of wheat was reduced from 3 hours to 10 minutes, while the price of the labor required for this purpose declined from 17 $\frac{3}{4}$ cents to 3 $\frac{1}{3}$ cents. Between 1860 and 1894, the time of human labor required for the production of a ton of hay was reduced from 35 $\frac{1}{2}$ hours to 11 hours and 34 minutes, and the cost of labor per ton was reduced from \$3.06 to \$1.29. In 1899 the calculation made with respect to the reduction in the cost of labor for the production of seven crops of that year over the old-time number of production in the fifties and sixties shows it to have been \$681,000,000 for one year. But while it is possible to say that in the future there may be improvements in machinery which will reduce the number of necessary hands on the farm, it is quite certain that in this regard the prospect of economy in labor for the future is not to be compared with that which has been effected in the last 30 years.

To these words of President Taft I wish to add that much profitable progress has also been made in the selection of seeds and in the material and profitable increases of crop yields from the use of commercial fertilizers. While the use of commercial fertilizers commonly shows a material profit, there is doubtless much fertilizer used wastefully because unscientifically. Greater efficiency in this respect can be developed only on the basis of a scientifically accurate theory of the action of fertilizers.