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Sulphate of Ammonia

Its Source, Production
and Use

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Sulphate of Ammonia

Its Source, Production and Use

1916 Year-book, United States
Department of Agriculture:

"There is no question of the general value of commercial fertilizers in farm practise. The farmer who wisely and systematically applies commercial fertilizer to his fields will raise larger and better crops than his neighbor who, with similar conditions of soil, climate, and rotations, and equal industry applied to cultivation, does not use fertilizers. This statement applies with the same force to the rich soils of the Mississippi Valley as to the soils of the Eastern Cotton States or of New England."

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Sulphate of Ammonia

Its Source, Production and Use

FOR nearly a half century sulphate of ammonia has been extensively used to supply nitrogen to agriculture. It has become well and favorably known in all parts of the world where fertilization is a factor in the growth of crops. Because of its merits as a plant-food and as an ingredient in mixtures, and also because of its relation to other industrial processes, it has become one of the great nitrogen-carriers of the world.

Nitrogen and Other Plant-Foods

There are three substances that agricultural chemistry teaches us to regard as the principal plant-foods, namely, nitrogen, phosphoric acid and potash. These are also the elements that artificial fertilization is usually called upon to supply. Of these, nitrogen is the one that is almost invariably the most needed, and it is by far the most expensive. A pound of combined nitrogen—*i. e.*, nitrogen that is so combined with other substances as to be readily available for plant-food—costs in normal times from three to five times as much as a pound of phosphoric acid or of potash.

The Demand for Nitrogen

To appreciate what this means from a commercial point of view we need only remember that no remote Pacific islet is too far away to be rifled of its stores of guano, and that the nitrate deposits on the uninviting and distant coast of Chile were not too far off for exploitation by European capital.

Fleets of steamers are devoted to no other purpose than seining fish by the million to make them into fertilizers, and the unwieldy whale, formerly abandoned at sea when stripped of his bone and blubber, is now towed to the factory to make whale-guano. The cotton crop of the South and the abattoir industries of the Middle-Western States are eagerly levied on for cottonseed meal, tankage and dried blood, though these products have uses of a higher order. The waste from our kitchens and hotels is made into garbage-tankage, and we

APPROXIMATE AMOUNTS OF PLANT FOOD REMOVED FROM THE SOIL BY MAXIMUM CROPS

LBS 25 50 75 100 125 150 175 LBS

CORN 100 BUS.

COTTON 2 BALES

OATS 100 BUS.

WHEAT 50 BUS.

TIMOTHY 3 TONS

POTATOES 300 BUS.

TOBACCO 1000 LBS.

SUGAR BEETS 20 TONS

SUGAR CANE · PER TON SUGAR ·

RICE 100 BUS.

have reached out to Asia for her soy-bean meal as well. Even the nitrogen of the air we breathe, physically near enough but chemically inaccessible as plant-food except to the legumes, has for years been the object of laborious and costly scientific experimentation, and is now gradually being made available.

When we consider the scope of the demand for agriculturally available nitrogen, we may well be surprised that the stores of it that are obtainable from bituminous coal in the form of sulphate of ammonia have not been thoroughly utilized. This surprise is the more justifiable since the material lies close at hand and the process of recovery is one that has long been well known and approved in chemical manufacture. As a matter of fact, the vast stores of nitrogen laid up for us underground by the marvelous plant-life of the Coal Age have hardly been touched at all.

Historical

That it was possible to obtain available nitrogen in the form of ammonia from various organic substances was commonly known to medieval chemistry. This is indicated by the name "spirits of hartshorn" formerly applied to ammonia, due to its derivation from horns, bones, etc. As regards the derivation of nitrogen from coal in particular, Stauf, the German *Kohlenphilosoph*, is reported to have collected a cake of sal ammoniac from his crude coking-pits in the year 1771.

The actual production of ammonia in any quantity, however, unquestionably did not take place until some time after the discovery of coal-gas lighting by Murdoch in 1798, and it is certain that during the earlier years of the coal-gas industry the ammoniacal liquors were regarded simply as waste products whose disposal was a troublesome problem.

In 1842 the prize essay of Dr. George Fownes* mentioned the use of ammoniacal liquor from the gas-works as a manure for corn, remarking that the best use for this product would probably be found when it was reduced to a crude ammonium salt, as the chloride or sulphate, and scattered in the fields in small amounts. He suggested what the development of this comparatively untried nitrogenous fertilizer would be should its promised agricultural efficiency be realized, and laid much stress upon the economical advantages the farmers of England would gain from the presence of so vast a store of available nitrogen in their own country.

* Journal of the Royal Agricultural Society, IV., 498

Present Conditions

As far as it concerned the sulphate of ammonia, all that this prophet of the last century could have pictured to himself in his most optimistic moments has been more than realized. England alone now produces over four hundred thousand tons of sulphate of ammonia yearly, an amount many times larger than would have been produced by all the gas-works of Fownes' day had they been operated as he suggested, with due regard to the recovery of ammonia. The world's yearly production of ammonia from coal, reckoned as sulphate of ammonia, is now estimated as 1,500,000 tons, a large part of which is used in agriculture.

The Origin of Coal

Coal is the transformed residue of the vegetation of the Coal Age. From the chemical point of view it is organic matter, largely cellulose, that has undergone changes under the influence of heat and pressure

Fig. 2—Forests of the Coal Age. The large trees, *Lepidodendron*, and the feathery tree-ferns, *Cycadofilices*, in the left and the middle background are characteristic of the Coal Age flora.

and to which mineral impurities have been added. This vegetation consisted of trees, ferns, grasses, etc., which died and underwent partial decay and were covered by further layers of similar material, or by layers of sediment, such as clay. The length of time and the vast extent of this growth may be appreciated from the statement that a beech forest one hundred years old would supply enough material to form a vein of coal but three-quarters of an inch in thickness. And yet coal-veins twenty or thirty feet thick are frequent and masses measuring two hundred and fifty feet have been recorded.

We know but little of the conditions that prevailed on the earth's surface at that time. Possibly the heat of the sun and the rapidity of plant-growth exceeded by far our present tropical conditions. It has also been surmised that frequent electrical storms aided the fixation of nitrogen.

From the study of the fossil remains found in the coal and from other geological data, it has been possible to reconstruct an ideal view of the Coal Age forests (Fig. 2), and also to picture their destruction by torrential storms, the flotsam and jetsam of which we probably see in some of our more extensive coal-beds today.

The successive steps in coal formation may be said in a general way to be peat, lignite, sub-bituminous, bituminous, semi-anthracite and anthracite. These blend into one another in an almost unbroken line, ending at nearly pure carbon. Of these, bituminous (soft) coal is the chief source of ammonia.*

Coal Resources and Production

The possession of coal is one of the greatest national assets. The total resources of the world are estimated at 7,400,000 million tons, of which 4,000,000 million tons are bituminous. Of this, the United States is said to possess more than any other country, exceeding even the vast undeveloped areas of China.

The world's production is given as 1,345 million tons in 1914, of which 38 per cent. was produced in the United States, 22 per cent. in Great Britain, and 20 per cent. in Germany.

*A certain amount of ammonia is recovered from blast-furnaces in Scotland which use "splint" coal, and considerable is also obtained from coal and from peat treated in the recovery gas-producer. The use of such producers seems to be increasing.

Fig. 3—Flood Destroying Coal Age Forests. Coal fields are supposed to have originated from deposits of such debris.

The Mining of Coal

Coal is recovered from the earth by sinking shafts to the seam and mining the coal out in parallel rooms or galleries. This is done with the aid of coal-cutting machinery and explosives. The coal is hoisted to the surface, separated into sizes, and shipped. Fig. 4 is an excellent view of a coal-seam.

Nature and Composition of Coal

Coal is principally carbon together with smaller amounts of hydrogen, oxygen, nitrogen and ash-forming elements. Bituminous coals, suitable for coking, usually contain from 0.8 per cent. to 1.5 per cent. nitrogen, which may be recovered when, in the coking process, ammonia and other volatile gases are evolved. The quantity of nitrogen thus recovered in the form of ammonia is equal to about one-quarter of one per cent. of the total weight of the coal mined.

Fig. 4—A seam of Coal in a Coal Mine

The Ammonia Recovered from Coal

Assuming that ordinarily a four-foot vein of coal is about as thin as may be profitably worked, an acre would contain approximately 7,200 net tons. Fig. 5 shows graphically the fertility contained in this mass, based upon the average one per cent. of nitrogen found in coal. Were this wholly recoverable, we should obtain seventy-two tons of nitrogen, but owing to unavoidable losses in the mining and coking operations a much smaller quantity is actually obtained (a). The sulphate equivalent of the nitrogen contained and the amount recovered is shown in (b). At the rate of one hundred pounds per acre per year, the nitrogen contained in the acre of coal is sufficient to supply fertility in the form of sulphate of ammonia (c) to the acre of land overhead for 5,760 years. The amount recovered would last one-sixth as long—960 years.

Manufacture of Coke and By-Product Recovery

Early in the history of the iron and steel industry raw coal was recognized as a fuel unsuited to blast-furnace requirements. Before the middle of the seventeenth century coke began to replace it, and today it is almost universally used in smelting operations.

Coke is made by carbonizing coal; that is to say, by reducing it to carbon as far as practicable. When bituminous coal is subjected to heat its complex organic compounds are broken up and a part of them pass off as gas. If the heating is done under the exclusion of air, it is known as destructive distillation.

The gas and tar vapors are drawn off to the condensing apparatus, leaving behind the non-volatile or fixed carbon and the ash, which constitute the coke. Ordinarily the coke is silvery gray in color and has a cellular structure, the cell-walls of which are exceedingly hard.

Some coals, however, possess the coking property to a lesser degree than others, and make a soft friable coke, or even refuse to form lumps at all. The latter are called non-coking and are not used for coke-making.

(See illustration of complete plant at top of pages 12 and 13.)

Fig. 5

The coking operation, in fact, consists in melting the coal into a viscous mass, entirely losing its original shape. The evolution of the gas gives it a porous structure, the cell-walls being composed of the fused carbon and ash constituents.

Coking Methods

There are three methods in which the destructive distillation of coal is practised on a large commercial scale in this country, namely:

1. The beehive coke-oven, for coke alone, the by-products being lost. The combustion of the volatile part of the coal furnishes the heat needed for coking.

2. The coal-gas retort, specially designed to supply illuminating-gas. Coke, ammonia, tar, etc., are recovered as by-products.

3. The by-product coke-oven, primarily designed for producing metallurgical coke; yielding also ammonia, tar, illuminating-gas and other by-products.

The beehive coke-oven is simple in construction and operation, but because of the waste it causes will ultimately be replaced by ovens of the recovery type. This transition is now going on. In 1916 there were 65,605 beehive ovens in operation, producing 35,500,000 net tons of coke, which was 65 per cent. of the total metallurgical coke made in the United States.

A battery of horizontal coal-gas retorts is shown in Fig. 8. The capacity of this type of plant is suited to the gas consumption of the ordinary city, coke, ammonia, tar, etc., being recovered. The coke, however, is too soft for furnace or foundry use. The retorts carbonize from 400 to 600 pounds of coal in six hours and are usually heated

Fig. 7—Beehive Coke-Ovens

Fig. 8—Coal-Gas Retorts

with a part of their own coke. There are other types of retort, as the inclined and the vertical, that take charges of 1,200 to 1,500 pounds of coal, as well as chamber-retorts, which approximate the coke-oven in size and yield metallurgical coke.

The by-product coke-ovens are usually erected in plants large enough to supply coke to one or more blast-furnaces, although a number of plants have been installed especially to supply the increasing demand for domestic and fuel coke and gas. Such units treat much more coal than the usual retort gas-plant, and produce more gas, ammonia, tar and other by-products. From 40 per cent. to 50 per cent. of the gas made is consumed in heating the ovens, so the balance may be used for illuminating purposes. The ovens take charges of eight to twelve tons of coal at a time, and coke it in sixteen to twenty-four hours.

The plants usually comprise from thirty to several hundred ovens, that at Gary, Indiana, having 560 ovens. The capacity of this plant is 10,000 tons of coal per day, which corresponds to an output of one hundred tons of sulphate of ammonia. In 1917 there were fifty-two operating by-product plants, having nearly 7,500 ovens. These produced about 22,500,000 tons of coke and recovered over 300,000 tons of ammonia reckoned as sulphate, or 85 per cent. of the total ammonia production in the United States.

Fig. 6—Model of By-Product Coke-Oven Plant

Recovery of Ammonia from Coal-Gas

The gas given off from the coal during the coking operation consists of a mixture of hydrogen, methane, carbon monoxide, carbon dioxide and nitrogen, with vapors of water and tar. The latter exist partly as finely divided mist mechanically suspended in the moving gas. There are also present small quantities of ethylene, naphthalene, benzol and other hydrocarbons, together with the impurities, ammonia, sulphuretted hydrogen, carbon disulphide and cyanides.

Fig. 9—By-Product Coke-Ovens, pusher side. Pusher and lorry shown, latter charging oven with coal.

Smithsonian Institution, Washington, D. C.

The removal of the ammonia, in which we are particularly interested, has usually been accomplished by cooling the gas and washing it with water, in which the ammonia is easily absorbed, forming ammonia or gas liquor. This is similar in character, whether coming from coke-ovens or from gas-works, and is treated in the same way. It is a complex mixture, containing ammonia in various combinations. Some of them are classified as the volatile ammonia (ammonium carbonate, sulphide, hydro sulphide and cyanide) because the ammonia is given off on moderate heating. The others, as the sulphate, sulphite, thio-sulphate and chloride, are classed as the fixed ammonia, since they are not volatile at ordinary temperatures.

The early method of making sulphate of ammonia from the gas liquor was by simply running enough sulphuric acid into it to neutralize the free ammonia, and evaporating until the salt crystallized out. This was a crude process and produced an impure salt of inferior

Fig. 10—The Coke "Pusher," about to push coke from oven

Fig. 11—Coke being pushed from oven. This and the preceding view are of opposite sides of same plant

grade. It was succeeded by the distillation process, in which steam is forced through the liquor, carrying off the ammonia with it, the fixed ammonia being freed by the addition of lime or other alkali. The mixture of ammonia and steam is then led into sulphuric acid, with which the ammonia unites to form the sulphate. The general arrangement of a two-still plant of simple type is shown in Fig. 12.

The ammonia is driven off from the liquor by live steam in one of the two cast-iron columnar stills, as shown, and passes from the top of the still down to the saturating boxes, which are of wood lined

Fig. 12—Early type of Ammonia Plant

with lead. In them the ammonia gas is forced to bubble through the acid, and the salt which forms is then dipped out of the box with a long-handled copper ladle and drained on the board between the two saturators. A pile of salt is shown draining between the two boxes on the right. The sulphate is further dried by whirling in a centrifugal, and may then be bagged for shipment.

Coke-oven plants of later construction have adopted a method of ammonia recovery in which the oven-gas passes directly into the sulphuric acid bath and is deprived of its ammonia. This is known as the direct method as distinguished from the older process, which is styled the indirect. There are several variations of the direct method, as put forth by different constructors, but one that is extensively used in this country is shown in Fig. 13. The gas from the ovens is partly cooled and passes through a tar-extractor, and then to the saturator containing the dilute sulphuric acid. A certain amount of gas liquor is obtained in the coolers, which is distilled and the ammonia passed into the saturator with the oven-gases.

The quality of sulphate made by the direct or the indirect process is the same, both being marketed on the usual 25 per cent. guarantee basis.

Sulphate of ammonia is usually packed for shipment in 200-pound bags, or in bulk carloads where convenient.

Fig. 13—Ammonia Saturator in Modern By-Product Coke Plant. The gas passes through the reheaters at the right and then down pipes 2, 3, etc. to the saturators

RECOVERY OF SULPHATE OF AMMONIA AND OTHER PRODUCTS OF COAL DISTILLATION

Fig. 14—A net ton of coking-coal yields about 1,440 lbs. of coke, or 72 per cent. by weight, together with 9 gallons of tar, 22 pounds of sulphate of ammonia, $2\frac{1}{2}$ gallons of crude benzol, and 10,000 cubic feet of gas. Of the latter, about half is needed for heating the ovens so that the balance, 5,000 feet, is available for other purposes

Descriptive of Sulphate of Ammonia

When pure, sulphate of ammonia $(\text{NH}_4)_2\text{SO}_4$, is a white crystalline salt, soluble in twice its weight of water, and volatile—*i. e.*, if heated slowly over a flame it will pass off leaving no residue. The American-made salt contains 25 per cent. ammonia (NH_3) , or 20.56 per cent. nitrogen, and is therefore the richest of the commercial nitrogenous materials. This test corresponds to 96.97 per cent. pure sulphate of ammonia, and is a high degree of purity for a commercial article produced and sold by the carload. This standard is bettered by the recently introduced dried-and-ground grade, which is guaranteed to analyze 25.25 per cent. ammonia, equivalent to 20.75 per cent. nitrogen. The color varies slightly, being generally gray. Sulphate does not readily absorb moisture from the air, therefore it can safely be stored for indefinite periods without loss of strength. Upon application, its plant-food is quickly made available to the growing crop. Ordinarily ten or twelve days are sufficient for the formation of nitrate

A cubic foot of sulphate of ammonia weighs approximately 53 pounds, enough ordinarily to fertilize one-half acre. A bushel ($1\frac{1}{4}$ cubic feet) weighs $66\frac{1}{2}$ pounds and contains $16\frac{3}{4}$ pounds of ammonia ($13\frac{1}{2}$ pounds nitrogen). This quantity of sulphate completely dissolves in about nine gallons cold water or in half that amount of boiling water. The molecular weight corresponding to the formula $(\text{NH}_4)_2\text{SO}_4$ is 132.14; specific gravity 1.77.

nitrogen in the soil, depending somewhat upon weather and soil conditions. The healthy, dark-green color of the leaves is sure evidence that this change has occurred. Commercial sulphate usually contains from 1 to 2 per cent. of moisture.

The World-Wide Importance of Sulphate of Ammonia

Sulphate of Ammonia is produced by a majority of the civilized nations of the world, depending to a certain extent on their supply of coal. As regards consumption, it may be said that farmers all over the world have found sulphate of ammonia beneficial in the growing of their crops. Not only in the countries of Europe and in the United States, but also in many parts of Asia, Africa and Australia there is an increasing demand. Large quantities are used for growing rice in Japan, sugar in British Guiana, the Dutch East Indies, Cuba, and Hawaii, and for raising cotton in India and Egypt.

The Action of Sulphate of Ammonia in the Soil

1. Fixation of Ammonia in the soil.

Nitrogen to be available for plants must be present in the nitrate form. Experiments have been carried on, however, which indicate that some plants under proper conditions utilize ammonia nitrogen without further change in its nature. While this may be accepted as a fact, it must be recognized that the actual amount so used is small and that the value of ammonia as a plant-food for the usual field crops practically depends on its nitrification in the soil. The changes which the ammonia in the sulphate undergoes seem to be dual in character—*i. e.*, physical and chemical. The question as to whether

the ammonia is physically absorbed, the sulphuric acid thus freed reacting with the calcium, or whether double decomposition occurs between the sulphate and certain soil compounds, as calcium carbonate, has yet to be clearly defined. Indications are that a combination of both takes place.

Ordinarily, the first change to occur in a soil fertilized with sulphate of ammonia is the absorption of ammonia by various humous compounds, such as the silicates of aluminum, calcium and sodium and the hydrated oxid of iron, and the liberation of sulphuric acid. More ammonia is released by the subsequent reaction between the remaining sulphate of ammonia and calcium carbonate, one of the most important and abundant of soil substances. This ammonia also enters into combination with the humous compounds, the decomposition process going forward until all the ammonia in the sulphate is combined or until the supply of reacting compounds fails. Small quantities of calcium sulphate are also formed as a product of these changes, the chemical nature of which is indicated by the formula:

2. Nitrification: Formation of nitrates under bacterial activity.

The oxidation of the combined ammonia proceeds rapidly in most soils under ordinary conditions. There is a theoretical middle step in the formation of nitrates from ammonia, namely, nitrite nitrogen. The changes to the nitrite and nitrate forms are effected by distinct types of soil bacteria, but usually take place so quickly that the former stage does not seem to appear. Small quantities of nitrous acid produced during these changes are absorbed by the calcium carbonate not already concerned in breaking down the sulphate compound.

The Maintenance of Healthy Soil Conditions

It is necessary that there be sufficient quantities of calcium carbonate in the soil to decompose the sulphate and to absorb the nitrous acid produced during the oxidation of the fixed ammonia. The break-

Fig. 15—U. S. Productions, Imports and Consumption of Sulphate of Ammonia

ing down of lime compounds and the formation of calcium sulphate which, under some conditions, readily leaches from the soil, probably tend to reduce the supply of calcium. In soils of an alkaline nature, as those of California, these changes often prove beneficial inasmuch as an unhealthy tendency is thereby checked.

The Use of Sulphate of Ammonia in Mixed Fertilizers

By far the largest portion of the sulphate of ammonia that is used by the farmer in this country comes to him in the form of mixed fertilizers. There are several reasons for this. In the first place, the manufacturer has been prompt to see the economy to him in the high nitrogen test, as it saves money in freight and in handling. The high test also enables him to utilize lower-grade nitrogenous materials that are useful as conditioners and at the same time maintain his regular formulas.

Moreover, sulphate of ammonia mixes well with all the other fertilizer ingredients commonly in use, *viz.*: acid phosphate, the potash salts, cottonseed meal, tankage, fish-scrap, etc., and is not subject to loss by chemical action when so mixed. It is highly important that a

fertilizer once properly mixed shall remain so until used, so that it may pass the State Inspection analysis, and that it shall later on reach the farmer in fine, dry, drillable condition. Good mechanical condition is in fact essential, since it saves time in spreading and enables each plant to be supplied with its proper share of food. This point is duly appreciated by the manufacturer and the farmer, but has not always been given due weight in Experiment Station recommendations. A deficiency in analysis may be overcome by using more fertilizer, but a caked mixture practically cannot be used at all. The manufacturer has learned by experience that sulphate of ammonia has a distinct advantage in these respects, and in due course this advantage is transmitted to the fertilizer consumer either in quality or in price.

Sulphate of Ammonia as a Separate Application or Top-Dressing

When a nitrogenous material alone is required, sulphate of ammonia may be applied by itself with good results. For this purpose the dried and ground sulphate is especially adapted, as it is in excellent mechanical condition and may be easily and evenly spread by any fertilizer distributor or by hand.

Such separate applications or top-dressings are often recommended in early spring for timothy and grass crops, and also for fall-planted

Fig. 17—Applying Sulphate of Ammonia in Grain-Drill

grain, particularly when the latter receive a mineral fertilizer low in nitrogen at time of planting. This method of fertilizing is one that is widely advocated in Europe and can profitably be followed here. In the Southern States it is quite customary to apply some soluble quick-acting nitrogen to cotton or corn soon after planting, for which purpose sulphate of ammonia has proved admirably adapted.

It should be borne in mind that sulphate of ammonia supplies nitrogen alone, and does not afford either phosphorus or potash.

Remember:

100 pounds of sulphate of ammonia contains $20\frac{1}{2}$ pounds of nitrogen. To furnish that amount requires about 132 pounds of nitrate of soda, 290 pounds cottonseed meal, 1,650 pounds ordinary fertilizer, or two tons of good stable-manure.

Amount to Apply

Generally speaking, an application of 100 pounds per acre may be made with profit on any crop that needs nitrogen. Larger amounts, say, 200 pounds to 300 pounds, are frequently used where experience has shown that the soil and conditions are adapted to its use.

Lime

The liberal use of lime at frequent intervals is recognized as one of the fundamentals of profitable agriculture. For most farm crops soil acidity must be neutralized by lime before the cost of tilling or fertilizing is justified. Ignorance on this point has caused crop failure and loss to many farmers in the past.

It is doubtless true that continuous heavy applications of sulphate of ammonia will ultimately exhaust the lime in the soil. This draw-back it shares with other essential fertilizer chemicals and indeed with stable-manure and with green manures. As far as this concerns the use of commercial fertilizers containing sulphate of ammonia, the effect may be regarded as negligible, however. The actual amount of sulphate in a 500-pound per acre application would not ordinarily exceed 25 pounds. This would be counteracted entirely by 25 pounds of ground limestone.

Some definite information as to how long it may be before harmful effects result from continued applications of sulphate, without lime, is given by the experiment on a rotation of corn, oats, wheat and grass

at the Pennsylvania Station (Bulletin 146). In this test 750 pounds of a mixture containing 6.5 per cent. nitrogen, 6.5 per cent. phosphoric acid and 13.5 per cent. potash was applied every other year, different sources of nitrogen being used.

The total yield from the sulphate of ammonia plots at the end of the five-, ten-, fifteen- and twenty-year periods was ahead of any other form of nitrogen, both in weight and in value. The increase over the check (no treatment) plots, was 41 per cent., though no lime was applied during the test.

This fertilization was a very heavy one, being equivalent in ammonia contents to 3,000 pounds of the ordinary "2-8-2" mixture, and in so far as the sulphate usually contained in such a mixture, to 6,000 pounds every other year. Such amounts are not usual in ordinary farm practise, and in market garden and truck districts where they are possible, liming is recognized as necessary at much less than twenty-year intervals.

EXPLANATION OF TABLE ON PAGE 23.

This table has been prepared in order that the prices of sulphate of ammonia, nitrate of soda, and cottonseed meal, which are usually quoted per 100 pounds or per ton of 2,000 lbs., may be readily compared with those for the organic nitrogenous fertilizers such as dried blood, tankage, fish-scrap, etc., for which prices are usually quoted per unit of ammonia—*i. e.*, for each 1 per cent. of ammonia in a ton of 2,000 lbs.

Examples: If a price of \$3.10 per unit for dried blood has been quoted, we find on the same line of the table the equivalent quotation for sulphate of ammonia would be \$3.87½ per 100 lbs. If the current quotation for sulphate of ammonia were \$3.00 per 100 lbs., the difference would represent the saving made by using it.

If, however, a comparison with cottonseed meal is desired, the price equivalent to \$3.10 per unit of ammonia is found by the table to be \$21.70 per ton for the 7% grade, at or below which price the meal must be obtained before it is an economy to use it, on the basis of the available nitrogen supplied. The market value of approximately 1.5% phosphoric acid and 1% potash, contained in the meal, or more, according to guarantee or analysis, should be added to the table value to give the total value.

Table for Sulphate of Ammonia, Nitrate of Soda and Cottonseed Meal.
Showing Prices by Weight Equivalent to Prices Per Unit of Ammonia.

Quoted Price per Unit of Ammonia per ton 2000 Lbs.	Equivalent Price of 100 Lbs.	Equivalent Price of 100 Lbs.	Equivalent Price of 2000 Lbs.
	SULPHATE of AMMONIA 20.56% N 25% NH ₃ Test	Nitrate of Soda 95% Test 15.54% N 18.9% NH ₃	COTTONSEED MEAL 5.8% N 7% NH ₃ Grade
\$2.40	\$3.00	\$2.268	\$16.80
2.45	3.062	2.315	17.15
2.50	3.125	2.363	17.50
2.55	3.188	2.41	17.85
2.60	3.25	2.457	18.20
2.65	3.312	2.504	18.55
2.70	3.375	2.552	18.90
2.75	3.438	2.599	19.25
2.80	3.50	2.646	19.60
2.85	3.562	2.693	19.95
2.90	3.625	2.741	20.30
2.95	3.688	2.788	20.65
3.00	3.75	2.835	21.00
3.05	3.812	2.882	21.35
3.10	3.875	2.93	21.70
3.15	3.938	2.977	22.05
3.20	4.00	3.024	22.40
3.25	4.062	3.071	22.75
3.30	4.125	3.119	23.10
3.35	4.188	3.166	23.45
3.40	4.250	3.213	23.80
3.45	4.312	3.26	24.15
3.50	4.375	3.308	24.50
3.55	4.438	3.355	24.85
3.60	4.50	3.402	25.20
3.65	4.562	3.449	25.55
3.70	4.625	3.497	25.90
3.75	4.688	3.544	26.25
3.80	4.75	3.591	26.60
3.85	4.812	3.638	26.95
3.90	4.875	3.686	27.30
3.95	4.938	3.733	27.65
4.00	5.00	3.78	28.00
4.05	5.062	3.827	28.35
4.10	5.125	3.875	28.70
4.15	5.188	3.922	29.05
4.20	5.25	3.969	29.40
4.25	5.312	4.016	29.75
4.30	5.375	4.064	30.10
4.35	5.438	4.11	30.45
4.40	5.50	4.158	30.80
4.45	5.562	4.205	31.15
4.50	5.625	4.253	31.50
4.55	5.688	4.30	31.85
4.60	5.75	4.347	32.20
4.65	5.812	4.394	32.55
4.70	5.875	4.442	32.90
4.75	5.938	4.489	33.25
4.80	6.00	4.536	33.60
4.85	6.062	4.583	33.95
4.90	6.125	4.631	34.30
4.95	6.188	4.678	34.65
5.00	6.25	4.725	35.00
Difference	\$0.0625	\$0.04725	\$00.35

Add value of phosphoric acid and potash, according to guarantee or analysis, to obtain total values.

DIAGRAM OF THE PRODUCTS DERIVED FROM COAL AND SOME OF THEIR USES

Table for Sulphate of Ammonia, Nitrate of Soda and Cottonseed Meal.
Showing Prices by Weight Equivalent to Prices Per Unit of Ammonia.

Quoted Price per Unit of Ammonia per ton 2000 Lbs.	Equivalent Price of 100 Lbs.	Equivalent Price of 100 Lbs.	Equivalent Price of 2000 Lbs. COTTONSEED MEAL
	SULPHATE of AMMONIA 20.56% N 25% NH ₃ Test	Nitrate of Soda 95% Test 15.54% N 18.9% NH ₃	5.8% N 7% NH ₃ Grade
\$2.40	\$3.00	\$2.268	\$16.80
2.45	3.062	2.315	17.15
2.50	3.125	2.363	17.50
2.55	3.188	2.41	17.85
2.60	3.25	2.457	18.20
2.65	3.312	2.504	18.55
2.70	3.375	2.552	18.90
2.75	3.438	2.599	19.25
2.80	3.50	2.646	19.60
2.85	3.562	2.693	19.95
2.90	3.625	2.741	20.30
2.95	3.688	2.788	20.65
3.00	3.75	2.835	21.00
3.05	3.812	2.882	21.35
3.10	3.875	2.93	21.70
3.15	3.938	2.977	22.05
3.20	4.00	3.024	22.40
3.25	4.062	3.071	22.75
3.30	4.125	3.119	23.10
3.35	4.188	3.166	23.45
3.40	4.250	3.213	23.80
3.45	4.312	3.26	24.15
3.50	4.375	3.308	24.50
3.55	4.438	3.355	24.85
3.60	4.50	3.402	25.20
3.65	4.562	3.449	25.55
3.70	4.625	3.497	25.90
3.75	4.688	3.544	26.25
3.80	4.75	3.591	26.60
3.85	4.812	3.638	26.95
3.90	4.875	3.686	27.30
3.95	4.938	3.733	27.65
4.00	5.00	3.78	28.00
4.05	5.062	3.827	28.35
4.10	5.125	3.875	28.70
4.15	5.188	3.922	29.05
4.20	5.25	3.969	29.40
4.25	5.312	4.016	29.75
4.30	5.375	4.064	30.10
4.35	5.438	4.11	30.45
4.40	5.50	4.158	30.80
4.45	5.562	4.205	31.15
4.50	5.625	4.253	31.50
4.55	5.688	4.30	31.85
4.60	5.75	4.347	32.20
4.65	5.812	4.394	32.55
4.70	5.875	4.442	32.90
4.75	5.938	4.489	33.25
4.80	6.00	4.536	33.60
4.85	6.062	4.583	33.95
4.90	6.125	4.631	34.30
4.95	6.188	4.678	34.65
5.00	6.25	4.725	35.00
Difference	\$0.0625	\$0.04725	\$00.35

Add value of phosphoric acid and potash, according to guarantee or analysis, to obtain total values.

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