FIRST ANNUAL REPORT

CONNECTICUT

Agricultural Experiment Station.

1876.

Concordia parvæ res crescunt.

From the Report of the Secretary of the Board of Agriculture.

HARTFORD:
PRESS OF THE CASE, LOCKWOOD & BRAINARD COMPANY.
1877.

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W. O. ATWATER, PH. D., DIRECTOR,
E. H. JENKINS, B. S., A. M., G. WARNECKE,
W. BALENTINE, B. S.

Compliments of

W. O. Atwater.

TO THE FARMERS AND OTHER FRIENDS OF AGRICULTURE IN CONNECTICUT.

In behalf of the Advisory Committee of the Connecticut Agricultural Experiment Station we take pleasure in calling your attention to the following report of the Director.

We deem it pertinent to remind the farmers of Connecticut that this institution is theirs exclusively. It was brought into existence in response to their demand. It is at work for them and, notwithstanding the difficulties incident to starting such an institution, the experiment has been a grand success. Wherever it is known it is favorably known. They have a right to take pride in the fact that they have the first regularly organized Experiment Station in the country, and that their example is being and bids fair to be followed in many other states.

In its work in connection with commercial fertilizers, in detecting and driving out frauds, placing the trade on a rational basis, encouraging honest manufacturers and sellers, and teaching farmers how to select their fertilizers wisely and use them with profit, its usefulness cannot be overestimated.

The Station is also directing its attention to other subjects of investigation no less useful, and in many respects more so. We trust it may have the support needed to carry them out successfully. To all who are looking and hoping for better times for our agriculture, such work as it is doing offers something fixed and definite in the sea of uncertainties in which we are drifting with as much prospect of wreck as reaching harbor.

We beg leave to make the following suggestions to our brother farmers:

1st. Inform yourselves thoroughly as to what the Station is doing. This information can be found in the reports and other publications of the Station.

2d. Have nothing to do with any dealer in fertilizers who refuses to place his articles under its supervision. In buying, endeavor to select those which furnish, in the best forms and at the lowest cost, the plant-food which your crops need and your soils fail to supply.

3d. Study carefully the suggestions of the Station with reference to experiments upon the farm, and, as opportunity allows, try them. Make a beginning, in no matter how small a way, and be as careful, accurate, and patient in conducting them as your abilities and opportunities will permit. The knowledge thus gained, even if fragmentary, will be valuable, and what will be necessary to make it complete, the Station will do its best to supply.

4th. Remember that patient, accurate, and thorough scientific investigations and experiments, whose utility may not be so immediately apparent to many practical men, will ultimately prove the most valuable work the Station can perform. It will do such work in proportion as it has the needed support.

5th. In all ways in your power try to coöperate with the Station, increase its usefulness and add to its support.

To Wesleyan University, whose laboratories with their apparatus and the services of its Professor of Chemistry have been placed at the disposal of the Station, and have very greatly facilitated its work and enhanced its success; to Mr. Orange Judd, whose money, time, and peculiarly valuable experience has been freely offered and drawn upon; to the Director, of whom less cannot be said than that his task has been one of great difficulty and delicacy, and his success most complete and gratifying; to the other gentlemen of the Station, whose work has in earnestness and efficiency been far in advance of their pecuniary reward; and to the other friends and helpers who have been many, the sincerest thanks of the farmers of Connecticut are due.

S. M. Wells, *Chairman*,
J. M. Hubbard, *Secretary*,
Of Advisory Com. of Conn. Ag'l Exp't Station.

FIRST ANNUAL REPORT

OF THE

Connecticut Agricultural Experiment Station,

1876.

The enterprise whose organization and early labors are set forth in the succeeding pages, represents an attempt toward the establishment of an institution where the rigid tests of scientific experiment may be used for gaining more certain understanding of the principles that underlie the right practice of agriculture.

Science, the definite knowledge that comes from careful observation and experiment, is becoming a more and more important factor of modern progress. That its applications are indispensable to the success of mining, manufactures, and commerce, has long been a universally acknowledged fact. That agriculture can be equally benefited thereby, is no less certain.

A remarkable proof of this is furnished by the growth of the European Agricultural Experiment Stations, which, since the establishment of the first one in Moeckern, Saxony, just twenty-five years ago, have increased until there are nearly one hundred in the different countries of Europe; Spain, Portugal, Greece, and Turkey being the only ones now without them.

That a large part of the pecuniary support of these institutions comes from farmers, is proof of their appreciation by practical men. The estimate in which they are held in the scientific world is indicated by the fact that all the larger

German universities and several of those of other European countries are provided with laboratories and other appliances especially devoted to agricultural research.

The efforts put forth in the same direction, and with such notable success, by several of our leading universities and agricultural and scientific schools, bear witness to the value set upon such work by the leaders in science in our own country. Its importance has impressed itself deeply upon our thinking farmers also. As we are informed by persons who have applied in person or by letter for information concerning the organization of the Connecticut Station, efforts, led by prominent agriculturists, are already in progress to secure the establishment of similar institutions in no less than eight of the other states, and steps are being taken in the same direction in several more.

With our soils depleted by years of irrational cropping, with untold amounts of fertilizing materials running to waste upon our farms, left unutilized at our manufactories, or exported to foreign countries where their worth is better understood; with hundreds of thousands of dollars lost in the purchase of poor fertilizers and the wrong use of good ones; with farmers deceived by the teachings of "science, falsely so called," until they distrust all science, and destitute of even the means of learning how to manage their soils, their fertilizers, their fodder materials, and their stock, so as most economically to utilize the products and the productive power of their farms; with what is sadder still, "the influence of old habits, old traditions, old prejudices, and all that loose sort of shadowy authority, which, intangible as the force of heathen sorcery, yet weighs upon our agriculture as superstition oppresses the dark corners of the earth," and, as the result of this, with what Washington has called "the most healthful, the most useful, the most noble employment of man," looked down upon as a profession; with the boys leaving the farm, because "smart men don't live by farming,"

and the busy walks of trade seem to offer better reward to ambitious talent, with the old homesteads, whence the best intelligence, enterprise, patriotism, and morality of the country have sprung, sold to foreigners or deserted; with all these facts, and those who know New England best know the picture is not too darkly drawn, there is need of some steps toward improvement.

There is another and a brighter side to this. Farmers are waking up. Improved modes of culture, implements, and stock; increased attention to careful experiments; the activity of farmers' clubs and agricultural societies; the rise of agricultural schools the better tone of the agricultural press; the influence of earnest, intelligent, and liberal men who are turning from commerce and the learned professions to farming; the current that the hard times are sending back from the overcrowded centers of population—doubly fortunate because of the accession to the country, and the fact that business and professional men make the best farmers; and, finally, the remarkably great and increasing interest in whatever pertains to the advancement of agriculture; these all give us good ground to hope that the farming of our older states has touched bottom and is coming up again.

One of the many means by which definite knowledge may be gained to replace uncertainty, incite and direct agricultural thought in more engaging and useful channels and lead to a more rational and profitable practice of farming, is the Agricultural Experiment Station.

A period in our history in which the public mind has been occupied with the intense excitement of sectional and party strife, seems to be drawing near its close, and we may look for a season in which men's thoughts will turn with greater interest to the higher arts of peace. With a more generous culture of science will come a more successful application of its methods and results to our agriculture. We may hope, that with the earnest and harmonious coöperation of its friends, much good may come from the labors of the Connecticut Agricultural Experiment Station.

I. General Statement.

The movement toward the establishment of an Agricultural Experiment Station in Connecticut, first assumed tangible form at the meeting of the State Board of Agriculture at Meriden, December 17–19, 1873. It was, however, the outgrowth of the work done in the State during nearly two decades previous, by the State Agricultural Society and the State Board of Agriculture, especially in connection with Prof. S. W. Johnson and others of the Sheffield Scientific School. To these labors, the leading position taken by Connecticut in matters pertaining to agricultural science, is chiefly due.

At the Convention referred to, after considerable earnest discussion, a committee was appointed to propose specific action. The chairman reported as follows:

"The committee instruct me to report, that it is their unanimous opinion that the State of Connecticut ought to have an Experiment Station as good as can be found anywhere, and they are of the opinion that the Legislature of the State ought to furnish the means for its immediate establishment, and for carrying it forward. They recommend that a permanent committee be appointed by this Convention to do such work as is necessary to bring this matter before the people and before the Legislature, and to accomplish the desired result, either by direct legislative action, or by whatever means may be necessary to effect it, this committee to begin now, and to continue until the work is done."

In accordance with this recommendation, an Experiment Station Committee, consisting of one prominent farmer from each of the eight counties of the State, was appointed to bring the matter before the legislature, and to take such other action as in their judgment would best conduce to the attainment of the object desired, the establishment of an Experiment Station in this State.

This committee took hold of the work energetically. At its instance, and with the co-operation of the Secretary of the State Board of Agriculture, a series of farmers' meetings was held in different parts of the State during the winter, in which the subject of an Experiment Station was discussed, and its importance urged. The project found ready sympathy among the intelligent farmers and other friends of agriculture in the

State and numerous petitions in its behalf were presented to the legislature which convened in the following May (1874). A bill providing for an annual appropriation of $8,000 for the establishment and maintenance of a Station was proposed, but referred to the succeeding legislature. During the ensuing winter a second series of farmers' meetings was held, and a still larger number of petitions were signed and presented to the legislature of 1875. But the newness of the idea and the seeming largeness of the appropriation asked for, conspired with other causes to prevent the bill from becoming a law.

At this juncture an offer was made by Mr. Orange Judd of Middletown, in behalf of the Trustees of Wesleyan University, of free use of laboratories and appliances in the Hall of Natural Sciences, donated by him to that institution, and, on his own part, of $1,000 toward the payment of expenses, provided the legislature would appropriate $2,800 per annum, to carry on work appropriate to an Agricultural Experiment Station. In response to this offer, the following resolution was passed by an almost unanimous vote:

To promote Agricultural Interests.

Whereas, The Trustees of the University at Middletown, tender the free use of ample laboratories and other facilities for establishing and carrying on an Experiment Station, for the general benefit and improvement of agriculture and kindred interests of the State of Connecticut: be it

Resolved by this Assembly: Section 1. That the sum of seven hundred dollars per quarter for two years, is hereby appropriated to the University located at Middletown, Middlesex County, to be used in employing competent scientific men to carry on the appropriate work of an Agricultural Experiment Station, and the Comptroller is hereby directed to draw his order in favor of the Treasurer of the Board of Trustees of said University, for seven hundred dollars per quarter, for two years, beginning October 1, 1875; *provided* the said Treasurer shall satisfy the Comptroller that such money is expended in the employment of scientific men for making the experiments and investigations contemplated in this resolution; and that the said University shall superintend such experiments, and shall provide ample laboratories and buildings therefor, free of all charge.

Sec. 2. This resolution shall take effect from its passage.

Approved, July 20, 1875

The committee of the Board of Trustees of the University to whom the matter was referred, undertook the organiza-

tion of the work as soon as practicable. Through the co-operation of the State Board of Agriculture and the Farmers' Experiment Station Committee, an advisory committee, consisting of leading farmers from all of the eight counties in the State, was appointed, whose counsel, sympathy, and support have contributed very essentially to the success of the Station, both in its scientific work and in its relations with the agriculture of the State.

Arrangements were made by which the Professor of Chemistry of the college was relieved of a portion of his labor as instructor, and enabled to assume charge of the work as director. Early in October, soon after the opening of the college term, a chemist was upon the ground, and two others were afterwards engaged; so that on the 1st of January, 1876, the work of the Station was fairly started.

As thus organized, the working force of the Station included Dr. W. C. Tilden as chemist, and Mr. W. Balentine, a graduate of the Maine State Agricultural College, and Mr. R. B. Griffin, from the University of Vermont, as assistants. Since then the first- and last-named of these gentlemen have been called to other positions, and the services of Mr. E. H. Jenkins, formerly assistant to Prof. S. W. Johnson of the Sheffield Scientific School, and later from the University of Leipsic, Germany, and Herr Georg Warnecke, for some years past assistant in the Agricultural-Physiological Institute of the same university, have been secured. Very essential aid in the chemical and other work has been furnished by Mr. A. T. Neale, instructor in chemistry in the university. It would be hardly proper for me to speak as warmly as I feel inclined, of the skill, faithfulness, and success with which my associates have performed the labors that have devolved upon them. Their devotion to the cause of science has stood them in the stead of the pecuniary reward which the meagreness of the State appropriation has forbid their receiving, and deserves a worthier recognition than can be given in any words of mine.

The present report covers the period from the organization of the Station to the end of 1876, a little over one year.

It has been felt from the first that more abstract scientific investigations would afford not only the proper, but also the most widely and permanently useful work of an Agricultural Experiment Station. Such an institution will be worthy of the name in proportion as it carries on accurate and thorough investigations and experiments in agricultural science. But these require a great deal of thought and study in planning, and care and labor and time in executing. The Station was just beginning its career, and with very inadequate support. It was important to make such an impression upon the farming public as would, if possible, lead to its establishment on a firm and liberal basis. There was a bitter need of a better control of the trade in commercial fertilizers in the State. One of the chief arguments used in favor of the Station had been that by its means a fertilizer control system could be introduced. The demand that the first efforts should be turned in this direction was imperative. Precisely such means as this have again and again proved the most potent agencies in awakening the public to an appreciation of the value of science. What has been done, the following pages will indicate.

Over two hundred samples of fertilizers have been received during the year, of which nearly all have been analyzed. Some one hundred and sixty-two are reported herewith.

An effort to induce the farmers of the State to make experiments for themselves, in a rational and accurate manner, on the use of fertilizers, has been, as we trust, successfully inaugurated.

The introduction of the fertilizer control system, and the other details incident to the organization and first work of the Station, have involved a large amount of work and no little expense, outside and inside the laboratory. The sum given by the State would fall considerably short of covering the simple expense of analyzing the commercial fertilizers, had that work been paid for at fair rates. To attempt much else has been, of course, impracticable. Still some other work has been

begun. The latter includes investigations of various natural and artificial products of more or less value for manure, studies of the growth and composition of field crops and food materials, and some more abstract investigations, which it is to be earnestly hoped that the Station may be enabled hereafter to follow to their successful completion.

Investigations of seeds have also been undertaken by Messrs. Warnecke and Jenkins, in accordance with the methods which are followed in Germany and which these gentlemen have had the opportunity of studying with Dr. Nobbe, in the Experiment Station at Tharand. The introduction of investigations in this new and interesting branch of science into this country can not fail to be useful.

One very laborious, but, at the same time, very necessary and useful part of the work of the Station is the correspondence, which has become quite extensive. Besides ordinary business letters, a large number of requests for information in the line of agricultural chemistry and kindred topics with which the work of the Station has to do, have been received. As a matter of curiosity, of the letters of the year which had been preserved, those which could be considered as belonging to the class referred to were counted, and found to number over two hundred and fifty. They have come from nearly all of the older States, and many of the newer States and Territories of the Union. They have been replied to either by the printed circulars of the Station or by letter, as fully as the time and opportunity of the laborers would permit. We ask those who may feel that their communications have not received as ready and full answers as their importance would demand, to remember that many of their inquiries cannot be answered without previous study and experiment, and that even were the knowledge at hand, the putting of it in satisfactory form in individual letters consumes a great deal of time that is needed for other work. Still these inquiries are always welcome, and will be answered as well as is in our power. A large part of what follows in this report has been written, practically, in answer to such inquiries as are received at the Station.

The cordial sympathy and wide-spread interest which have

been manifested toward the Station and its work have been very encouraging.

Thanks are due to a number of persons for assistance in various ways, especially to Mr. J. R. Farrington, farm superintendent, and Mr. A. Farrington, of the last graduating class of the Maine State College, at Orono, and Mr. J. M. Hubbard of Middletown, Conn., for aid in field experiments; and to Messrs. I. C. Libby and W. A. Russell, of Wesleyan University, for assistance in numerous details of the work of the Station.

A very essential addition to the means for the prosecution of experiments has been afforded by the liberal offer, on the part of its proprietor, Dr. J. W. Alsop, Jr., of Middletown, of free use of lands and appliances of Arawana farm. The accuracy with which this farm has been surveyed, its thorough drainage and complete equipment, its systematic management and its ready accessibility to the Station give it an unusual fitness for purposes of experiment.

I may add that this report, and the work it details, are very far from being such as belong to an ideal Agricultural Experiment Station. They are rather the prospecting and clearing away about the mine, and the setting up of the machinery which must precede the digging of the precious ore.

W. O. ATWATER, *Director.*

ORANGE JUDD HALL, WESLEYAN UNIVERSITY,
Middletown, Conn., Jan. 1, 1877.

II. The Connecticut Fertilizer Control System.

The means adopted by the Station to regulate the sale of fertilizers in the State have been explained quite fully in Circular No. 4, of the Station. The facts that inquiries as to its details are being continually received, and that the last edition of that circular is nearly exhausted, seem to call for a repetition of its essential features here.

The plan is substantially the same as has, with various modifications of detail, come into quite general usage in Germany and other European countries. The essential features are—

1st, An agreement made with the Station by dealers in fertilizers to sell their wares by guaranteed analysis, the verification of the analysis being left to the Station; and,

2d, A provision whereby purchasers may have samples of the articles they buy analyzed by the Station at small cost, or for nothing.

In order to preclude all chance for mistake or cavil, as to the precise terms of the arrangement referred to, a form of agreement has been signed by the dealers who desired to place their wares, as sold in the State, under the supervision of the Station.

The form referred to is the result of the deliberations of a large meeting of manufacturers, sellers, and consumers of fertilizers, held at the Station, and of consultation with the Advisory Committee and with other parties interested. It is as follows:

BLANK B.

..... hereby agree with the Connecticut Agricultural Experiment Station, as represented by its director, that all fertilizers offered for sale in the State of Connecticut, by ..... or by..... authorized agents, at any price above fifteen dollars ($15.00) per ton, except crude fish-scrap, shall be placed under its supervision in the following manner:

1. ..... hereby agree that all fertilizers above described

shall be guaranteed to contain certain minimum percentages of one or more of the following ingredients:

Nitrogen.
Phosphoric Acid (1); Soluble (2).
Phosphoric Acid; Reverted (3).
Phosphoric Acid; Insoluble (4).
Potash (5).
Sulphuric Acid. Chlorine (6).

(1). Anhydrous Phosphoric Acid or Phosphoric Oxide, P_2O_5.
(2). In any form of combination soluble in distilled water.
(3). In any form of combination soluble in a neutral solution of Ammonium Citrate at a temperature not exceeding 100 Fahrenheit.
(4). In any form of combination not soluble as above.
(5). Anhydrous Potassium Oxide K_2O, or its equivalent Potassium, in any form of combination soluble in distilled water.
(6). Anhydrous Sulphuric Oxide SO_3, Chlorine, Cl; the same being of importance in Potash Salts for distinguishing between "Sulphate" and "Chloride."
The object of these specifications (1–6) is simply to define, in chemical language, the terms "Phosphoric Acid," "Soluble," "Reverted," etc., as ordinarily employed.

2. ..... also agree that the above guarantee shall be always subject to verification by analyses made at the Station.

3. ... . also agree that all fertilizers above described shall be at all times open to the inspection of the Station, as represented by its Director, Chemists, or any member of its Advisory Committee.

Signed.

Date.

NOTE.—The signer or signers will insert in the proper blank spaces their names (of person, firm, or corporation), and the pronouns *I* or *we* and *myself* and *my* or *ourselves* and *our*.

As filled out, this would read, I, A. B. or we, C. D. & Co., hereby agree, etc., and would be signed, A. B., or C. D. & Co. The chemical terms used in the specifications are not very familiar to others than chemists but are put in the above form so as to define accurately the terms used, and thus leave no opportunity for perversion or mistake.

The signer of this agreement is not expected to specify in this blank the composition of the wares he sells, but he does

bind himself to fulfill the requirement of the State law,* by accompanying every package of fertilizer sold, with a plain statement of the analysis, using the above terms, and to guarantee the article to be equal to the analysis.

In brief this agreement binds the signer simply to state what he sells and guarantee what he states, the verification of the statement being left to the official analysis of the Station. With the fulfillment of this guarantee the responsibility of the seller will naturally end. The Station provides that buyers who wish to determine whether the articles they purchase are equal to the guarantee, may have control analyses made at little or no expense. It is believed that no simpler nor more efficient way can be devised to place the trade in fertilizers on a secure basis, insure confidence, and benefit all concerned.

The following list includes those who have already signed the above agreement.

IN CONNECTICUT.

QUINNIPIAC FERTILIZER CO., New Haven.
STRONG, BARNES, HART & CO., "
LEONARD B. BISHOP, New Haven.
ROBERT B. BRADLEY, "
GEORGE W. MILES, MILFORD.
C. L. WILLARD, Hartford.
RODNEY KELLOGG, "
F. ELLSWORTH, "
A. C. STERNBERG, "
H. B. KING, Rockville.

*The law concerning sale of fertilizers, as given in the General Statutes of Connecticut, Revision of 1875, Title 16, Chapter XV, is as follows:

SECTION 15. Every package of fifty pounds or more of commercial manure sold, or kept for sale, at over one cent a pound, unless prepared essentially from fish and sold as such, shall be marked with its weight and the name and place of business of the manufacturer, or seller, and with a true analysis of the chemical elements and their several amounts contained therein.

SEC. 16. The Secretary of the State Board of Agriculture may procure the analysis of any fertilizer offered for sale, and prosecute any persons who violate the provisions of the preceding section.

Title 20, Chapter XII, provides for fines to be imposed for violations of the above.

JOHN P. BARSTOW, Norwich.
ARNOLD RUDD, New London.
SOUTHMAYD & GARDINER, Middletown.
W. E. WHEELER, Stratford.
D. B. WARNER & SON, East Haddam.
JOHN S. WELLES, Hebron.
PECK BROTHERS, Northfield.
GEORGE W. MILLER, Middlefield.
P. W. BENNETT, "
G. S. ALLYN & Co., Mystic Bridge.
BOSWORTH BROS., Putnam.
J. O. & E. SMITH, South Canterbury.

OUTSIDE OF CONNECTICUT.

W. H. BOWKER & Co., 43 Chatham st., Boston, Mass.
MATFIELD FERTILIZER Co., 13 Doane st., Boston, Mass.
N. JACKSON & SONS, Boston, Mass.
PACIFIC GUANO Co., Boston, Mass.
J. A. BYRNES, Springfield, Mass.
H. J. BAKER & Co., 215 Pearl st., New York.
HOBSON, HURTADO & Co., 63 Pine st., New York.
MANHATTAN BLOOD GUANO Co., 38 Platt st., New York.
THE MAPES FORMULA & PERUVIAN GUANO Co., 158 Front st., New York.
G. E. WHITE, 159 Front st., New York.
ATLANTIC AND VIRGINIA FERTILIZING Co., 52 Broadway, N. Y.
RAFFERTY & WILLIAMS, Foot 44th st., East River, N. Y.
H. PRESTON & SONS, Greenpoint, L. I.
RUSSELL COE, Linden, New Jersey.
LISTER BROTHERS, Newark, New Jersey.
WALTON, WHANN & Co., Wilmington, Del.

Directions for sending samples of fertilizers for analysis, may be found in Circular 1, of which copies may be had on application at the Station. It is of the utmost importance that in sampling and sending, the directions therein given should be strictly followed.

Analyses of Fertilizers.

As this work is paid for in large part from public funds, those analyses which are of public interest will be performed gratuitously. Preference will be given to articles furnished by Farmers' Clubs or Agricultural Societies, and to those whose novelty, importance, or extensive sale give them special interest to the farmers of the State. Where duplicates of the same brand, equally well selected and authenticated, are received, the Director will select from them for analysis at his discretion. The results of analyses will be sent directly to the party furnishing the sample. They will also, where gratuitous, be held at the service of the Station and of the State Board of Agriculture for publication and for general use. For analyses made in the interest of private individuals, the latter will be charged a moderate fee, and will entirely control the results. No sample will be analyzed for public use, unless selected and forwarded in accordance with the stated directions, and accompanied by statements as to the sample itself, address of manufacturer, seller, and sender, and other facts required. Blanks are prepared for receiving these facts, and those desiring analyses are requested to apply for them at the Station.

When purchasers desire control analyses, to determine whether the wares they buy are as guaranteed, it is recommended that the samples be taken by the buyer and seller jointly, and forwarded by them with proper specifications, and names of both parties, to the Station. Such control analyses will be performed gratuitously so far as public interest and the ability of the Station will warrant. Preference will, of course, be given to articles sold under supervision of the Station.

Working of the Connecticut System.

At the annual meeting of the State Board of Agriculture, in Meriden, December, in 1873, in an address on "Commercial Fertilizers at Home and Abroad," some comparisons were drawn between commercial fertilizers in use in Connecticut, and similar articles sold in Germany, where the control sys-

tems were in vogue, the analyses published by Prof. Johnson in the Connecticut Agricultural Report for 1869, and quite full statistics of the trade in fertilizers in Germany the same season, being used as data. From these it appeared that the farmers of Connecticut were paying on the average at least 60 or 70 per cent. more for the valuable ingredients in their fertilizers than their brethren on the other side of the Atlantic. The cost of the raw materials is no greater here than there. In fact, large quantities are exported to the other side of the Atlantic, to be there manufactured into fertilizers. Nor is the cost of manufacturing much greater with us. The difference was shown to be due, practically, to the large amount of inferior materials in our markets. The German fertilizer control system was explained, and the suggestion was ventured that if a similar plan were adopted in Connecticut, farmers might buy fertilizers as cheaply and as confidently here as in Europe. It may be interesting to notice in how far this prophecy has been confirmed by actual experience in this State.

Among the commercial fertilizers analyzed during the past year were some 35 samples of articles sold outside of the supervision of the Station, mostly in 1875, before its establishment, and some 77 samples sold in 1876, under its supervision. The number of these articles seems ample, and the range in quality is certainly wide enough to afford a fair exhibit of the effect of the supervision exercised by the Station. Basing the comparison upon the costs of the valuable ingredients, as determined from composition and selling prices, it stands as follows:

Valuable Ingredients.*	Average Cost per Pound.	
	In fertilizers sold before establishment of Station.	*In fertilizers sold under supervision of Station.*
Nitrogen	47.00 cts.	* 23.00 cts.
Soluble Phosphoric Acid	18.00 cts.	13.98 cts.
Insoluble Phosphoric Acid	11.36 cts.	5.51 cts.

* The number of articles containing potash was so few, and its quantities so small, that it is omitted in the above comparisons.

If, instead of taking the fertilizers all together, we select a single class, and one of the most important ones, the nitrogenous (ammoniated) phosphates, the comparison will stand as follows:

Valuable Ingredients.	Average Cost per Pound.	
	In fertilizers sold before establishment of Station.	*In fertilizers sold under supervision of Station.*
Nitrogen	59.4 cts.	24.9 cts.
Soluble Phosphoric Acid	19.5 cts.	15.1 cts.
Insoluble Phosphoric Acid	21.1 cts.	5.6 cts.

In brief, the average actual cost of the fertilizers sold under the supervision of the Station is less than half that of those sold before the Station was established.

To make such a comparison as the above fully accurate and reliable, it would be necessary to take into account the total quantity, composition, and price of each article sold in the State, which is of course impossible. While, on the one hand, more of the better than of the poorer articles were sold before the establishment of the Station, on the other there are doubtless a good many inferior articles which we did not get hold of at all. The figures, probably, under-rate rather than over-rate the benefit which must accrue to the farmers of the State from the thorough enforcement of the "control system."

The amount annually paid for commercial fertilizers by the farmers of Connecticut is variously estimated at $500,000 and upward. Single towns are stated to use from $30,000 to $50,000 worth per annum. Taking the lower estimate ($500,000), if the Experiment Station can save only one-tenth or one-fifth instead of the one-half indicated above, the annual saving in the first cost of the fertilizers bought by the farmers of the State would be from $50,000 to $100,000 per annum. And when we consider the loss in the use of land and in tillage where poor articles are applied, and the advantage that arises from being certain of the quality of articles bought, and from the more rational use that comes with better understanding of their nature, it is clear that the benefit must be much greater than these figures indicate.

Some minor changes in the provisions and execution of the system above described may, in the light of experience, seem advisable. I think the requirement that packages of fertilizer be accompanied by analyses in the above terms, should be more rigidly enforced. An alteration of some of the details of the State law relating to the sale of fertilizers, seems to me worthy of consideration. With the law as it is, and until the results of another season's experience are known, I do not feel warranted in proposing any alterations.

III. On Fertilizer Control Systems in general.

A very considerable number of inquiries, in person and by letter, from persons interested in the introduction of fertilizer control systems in several other states, show that the interest in this subject is wide and increasing. It is certainly important. I trust, therefore, that a further discussion of this topic may not be out of place here.

By way of introduction to the merits of the question I cite the following from an article by Prof. S. W. Johnson, on "Science as a Means of Agricultural Progress," in the Tenth Annual Report of the Sheffield Scientific School:

"It is just about twenty-five years since in Germany, as here, the trade in superphosphates, guano, and similar commercial fertilizers, began. The same stupendous frauds, by adulteration and dilution of good things, were practiced there as they have been, and, we have great reason to fear, still are, carried on here. But the experiment station has perfectly cured and rooted out these evils in all the districts where it has been established and appreciated. The experiment station there is prepared to furnish the farmer at small cost with an analysis of any fertilizer he proposes to buy. The farmers avail themselves of this aid. They will buy no fertilizer without an exact statement of its composition, and they buy with the understanding that any deficiencies in the stipulated amount of fertilizing matters shall be made good or deducted from the payment. Under such circumstances manufacturers can sell nothing that is not substantially what it claims to be. A further result of this system is that low grade fertilizers are little sought, and those makers who can supply the best article, of uniform

quality and at the lowest rates, have the business. With large sales the dealers prosper, while the consumers are satisfied with their purchases, and instead of trying to see how they can get along with small use of purchased fertilizers, they are studying how to use the greatest quantities to advantage. The fertilizer market in Saxony and Prussia, where the experiment station has the universal sanction and confidence of the farmers, is just as settled and satisfactory as any branch of trade, and the farmers there buy superphosphate, guano, potash salts, etc., with as much security of fair dealing as we can feel in the purchase of sugar or nails."

The methods adopted in various places for the regulation of the trade in commercial fertilizers are essentially of two kinds; either,

First, The enactment of laws requiring fertilizers sold, or offered for sale, to be accompanied by analyses, and in many cases the appointment by government of inspectors whose duty it is to analyze and report upon fertilizers offered for sale in certain territories; or

Second, The provision of means whereby, either in addition to, or without such legal enactment as the above, purchasers shall be enabled to have specimens of the articles they buy analyzed under official authority, and at little or no cost to themselves.

The laws in force in several states, requiring commercial fertilizers sold to be accompanied by analyses, are very useful when supplemented by one or the other of the above forms of control, but without such supplement are apt to be little more than a dead letter.

The first plan has been adopted in several of our states, and may, with proper care, be made effective. The second is, I believe, of German origin. It is the outgrowth of long experience, and has, with varied modifications, come into very general usage in Germany, and been adopted in other European countries. The fundamental idea of

THE GERMAN FERTILIZER CONTROL SYSTEM

is that commercial fertilizers shall be guaranteed by the seller to contain certain stated percentages of valuable ingredients, (nitrogen, phosphoric acid, or potash,) that the buyer shall be provided with means by which he can have the particular article he is purchasing tested, and that in case it falls essentially below the guarantee, the deficiency shall be made good by the seller. It has come to be regarded as a matter of course that the analyses will be made at the Experiment Stations, and that stations must be provided at which this as well as other useful work shall be done for farmers. In each of a number of German stations, several hundred analyses of fertilizers are made every year. Many of the stations are controlled by agricultural societies, which, in that country, are thoroughly organized, and receive a good deal of money from the government, a not unconsiderable part of which is devoted to the support of their stations. In return for this, analyses are generally made for the members at reduced rates, or gratuitously. In many cases manufacturers and dealers pay certain specified sums, often quite large, for the privilege of having their wares under the supervision of the station, it being at the same time stipulated that the latter shall make analyses for their customers free of charge. The composition of the fertilizers is always guaranteed, and the object of the analyses is simply to learn whether the article is up to the guarantee.

The following "Order of the Prussian Royal Minister of Agriculture, concerning the Control of the Trade in Fertilizers, Food-materials and Seeds," (translated from the *Landwirthschaftlichen Versuchs Stationen* XIX, 4, s. 317), will give an idea of the views to which experience has led in Prussia. This order (*Erlass*) is directed to the heads of the Central and Provincial Agricultural Societies of Prussia, which along with the pecuniary aid received from the royal government, are subjected to regulations in their organization and management which a Secretary of Agriculture, if there were such an officer in the President's Cabinet, would scarcely think of proposing in our country:

"The Agricultural Societies and the Experiment and Control Stations which they support, have, in their control of the trade in fertilizers, fodder materials and seeds, to consider first of all the interests of agriculture, and consequently the interests of all farmers, and not simply those of their own territory. Accordingly, a requirement of the strictest reliability must be made of every manufacturer who is allied with the station, as a condition of that alliance. This reliability does not exclude the manufacture of wares of different grades, poorer

ones with the rest, provided the poorer articles are sold only as such, with an open statement of their contents, and general appellations, such as "bone meal," for instance, are not used for inferior articles, so as to deceive inexperienced consumers, who look more at the price than the quality of the wares. It will, therefore, appear urgently advisable that certain minimum contents be fixed, below which manufacturers under the supervision of the station shall not be allowed to reduce their wares. In no case does it seem to be allowable to permit the manufacturers and dealers to handle both guaranteed and unguaranteed wares, or even to be content with fulfilling their obligations in the territory of the stations, and at the same time to sell poorer wares outside that territory. The moral guarantee which lies in the fact of their standing under that control, might, with such dealing, be only too easily misused, and the credit of the society impaired. The excuse that manufacturers are compelled by competition to sell inferior articles under incorrect brands, can not be looked upon as justifiable."

The order goes on to say that "the position of the society will be best maintained by entering into no further connection with the manufacturers than is involved in accepting their guarantees of the contents of their wares, and their security for the restitution to be made" if the articles fall below the guarantees, and states a most important point in the following words:

"The office of the station is to provide all members of the society who buy of the dealers under its control, opportunity for a speedy and authoritative determination of the actual composition of the wares purchased. In case samples come in too sparingly in this way, it may be the duty of the station to take other means to get samples of individual brands of manufacturer's wares, avoiding so far as possible the stock-control (inspection of goods in store), and to publish the results. It may be fairly presumed that the agricultural public is sufficiently educated to draw its own inferences as to the reliability of individual firms from such publications, and the differences therein shown between the guaranteed and actual composition of the wares. Should these differences continue to be too great, the firm in question should be warned that its connection with the control must cease. This negative criticism would suffice to insure the needed reliability."

These are the words of the man who stands at the head of the agricultural interests of the country where commercial fertilizers are as well understood, and the trade in them as well regulated, and probably better, than any other in the world. They represent the results of long experience, and are worthy of most careful consideration. Now, note that in this it is taken for granted that fertilizers will be bought and sold on guaranteed analyses, and that the whole security for the validity of the guarantee is based upon a provision of means by which the purchasers may have tests made of the articles they buy. The farmers there are educated up to the point where "it may be assumed" that they will be able to judge of the value of the wares from the analyses, and, as

Prof. Johnson says, they "buy superphosphates, guano, potash salts, etc., with as much security of fair dealing as we feel in the purchase of sugar or nails," and "with large sales the dealers prosper," while "consumers, instead of trying to see how they can get along with small use of purchased fertilizers, are studying how to use the greatest quantity to advantage."

The gist of the whole matter is that if farmers will have reliable wares, they must understand what they are buying. What is thought in Germany of depending upon inspection by officers appointed for the purpose, may be inferred from the direction to "avoid so far as possible, the selection of the samples from dealers' stocks," the idea being, as I understand it, that the samples should, as far as practicable, come from lots actually sold to farmers.

The case was well put by Professor Eichorn, of Berlin, who, from his official connection with the Prussian Bureau of Agriculture, as well as from his long experience in the agricultural Experiment Stations, is as well prepared to judge of the matter as any one. In conversation with the writer, he remarked that while he considered the control system exercised by the Experiment Stations, through analyses of fertilizers as absolutely indispensable, as well for the protection of the consumer from fraud as for the encouragement of honest dealers, yet that their chief utility consisted in the interest and vigilance in these matters, that they excited among the farmers themselves.

Experience in England has led to the same results. Some years ago the fertilizer market there was in the condition in which it has been until recently in Connecticut, and is still in other parts of the Union. To-day it stands just about as it does in Germany.

At the risk of too much repetition I cite* the substance of a conversation with Dr. Voelcker, chemist of the Royal Agricultural Society. In response to the question as to what he considered the cause of this great improvement, replied,

* From a lecture on "Commercial Fertilizers at Home and Abroad." Report of Conn. Board of Agriculture, 1873.

"Competition." "But do you not attribute it in great measure to the increase of knowledge on the part of farmers, as to what constitutes good fertilizers, and to their increased vigilance in securing such?" "Certainly," was the answer. "The one is the result of the other; years ago farmers used to buy their guanos and superphosphates without much reference to what chemical analysis would say of them, looking rather to the way that they were recommended, or their practical experience with them, and to the money they cost per ton. By this plan, manufacturers were tempted to make inferior articles, and sell them at cheap rates. But farmers have learned that a guano with twelve per cent. of nitrogen is worth more than one with only ten per cent., and that a real *superphosphate*, containing soluble phosphoric acid, is worth more than one in which the phosphoric acid is insoluble, and they therefore give the preference to such articles. The result is a competition based upon goodness of quality, rather than low price. And so a ton of superphosphate, or bone-dust, costs no more than it used to, and is more valuable by half, and further, by this means, the inferior articles and humbugs by which our markets have been infested are more effectually kept away."

Here again the great benefit comes, not from legal enactments nor from government inspection, but from better understanding which the farmers have got by being their own inspectors, and the just and healthy competition which this has caused among dealers. Dr. Voelcker makes three or four hundred analyses per annum for the members of the Royal Agricultural Society.

If there were any place where the trade in fertilizers could be efficiently controlled by government inspection it would seem to be France. The security afforded by the system of government inspection, the *surveillance* there in vogue, in the purchase of materials liable to adulteration, is, to Americans familiar with the subject, something remarkable. This system has been applied to commercial fertilizers in the form of various legal enactments which, commencing in 1834, have been made more and more stringent until they culminated in the law of 1867, which requires a label with analyses to accompany fertilizers sold or offered for sale, and punishes misrepresentations of the quality of the article with heavy fines. And yet, in 1868, M. Grandeau, in a report of an examination of the German Experiment Stations, undertaken at the instance of the French Minister of Agriculture, after describing their control system, pithily remarks that "this is the only way to 'moralize' (*moraliser*) the trade in commercial fertilizers." Thirty years effort to suppress frauds by law failed to effect its purpose, even in France, and the government was obliged, in 1875, to take the matter into its own hands and provide for the inspection and legal prosecution which the farmers were unable to carry out. Legal restraint had failed to either educate the farmers or elevate the tone of the trade to a level high enough for safety.

Fear of punishment for fraud does not induce sellers to offer the very best goods that can be furnished for the money. They will do this when they find they must to make sales, when the farmers refuse the poorer wares and select the best.

I have insisted strongly upon the need of means whereby purchasers shall be enabled to have samples of fertilizers they buy analyzed at small cost or for nothing. The importance of this is well illustrated by some of the facts that have come under the notice of the Station. One of the worst frauds discovered was an article sold to several members of a Farmers' Club, who had taken special pains to have some of the fertilizers they were about to purchase analyzed in advance, but had, in this case, taken the assurance of an agent that his article, which was being newly introduced, "had been analyzed and was excellent." Another of the poorest articles analyzed was one of a number of samples sent by the manufacturers, who had no idea the article would be analyzed, to another Farmers' Club, and brought by the latter to the Station for examination. There was nothing in its appearance to indicate that it was other than a first-class article.

I do not wish to disparage the work done in the various states in the inspection of fertilizers. It has served an excellent purpose. The vigor of its prosecution in some States has given it a success in many respects brilliant; and even if the fees have, in some cases, been so large as to bring the office of fertilizer-inspector into too close relations with politics; yet the protection against fraud has certainly saved to the tax-payers many fold the cost of the inspection, and in some cases, surely, the work has been so poorly paid as to render it almost a charity on the part of the officer.

The character, far above suspicion, of every one holding these offices of whom I have had personal knowledge, will relieve me of any imputation of ill-intent when I say that there seems to me to be no assurance that all who may come into these places will bring, in their personal character, such guarantee of freedom from prejudice and defence against charges of unequal dealing. To err is human. I believe that the men on whom falls a duty so delicate as the making of examinations and reports of such importance in their bearing upon the reputations and moneyed interests of manufacturers and dealers, should not have their own revenues affected in any way by the number or results of the analyses they make.

To resume; as between the inspector system and the experiment station system of regulating the trade in fertilizers, understanding by the one the relegation of the charge to inspectors, whose duty it is to select samples for analysis from stocks for sale, and report the results; and, by the other, the plan of securing from dealers the guarantees of composition, and providing farmers with means to have these guarantees verified at little or no cost, I believe the latter is decidedly preferable, and, chiefly, because:

1st. It insures more perfect security, better goods and fairer prices. An analysis of a sample of a given brand sold at one place and time is not a certain criterion of the quality of lots

sold at other places and times. The best articles are, it is true, of reliable and nearly uniform composition, but not all are of this character. Further, in the case of articles newly introduced, the analysis to be published the following winter or spring, does not give the farmer the needed information at the time of purchase. And, finally, it must, if I judge the matter rightly, be much more potent than any other in elevating the tone of the trade in fertilizers. As long as men can make large profits by selling poor goods, some will try to do it in spite of law, inspection or fines. But when dealers find farmers selecting the best articles that can be had for the money, they will bestir themselves to furnish such, and frauds will die a natural death.

2d. By making the consumer his own inspector, it incites him, and through him the community, to a closer study of the nature and uses of fertilizers. So long as farmers depend upon the examinations made by an inspector, they will be inclined to assume that the wares in the market are "all right," and give little further heed to the matter. But if they are encouraged to examine for themselves, if they have analyses made of the fertilizers they actually buy and use, they will be led to learn what the analysis means, and, from that, to study further into the chemistry of their fertilizers, their soils and their crops. The understanding that comes from such study is certainly no less important to farmers than protection against fraud.

In short, where farmers are too listless or little advanced to make use of the advantages an experiment station would offer, and the desire or means to educate them to do so are lacking, legal restraint and hard work of inspection may be relied upon. But when farmers are measurably intelligent and want to grow more so, and where the tares are not only to be rooted out, but the most and best wheat to be grown, there the Experiment Station is in place.

Just how such a system as I am advocating will be best introduced in any given case, will depend upon circumstances. The guarantee from dealers may be secured by law, if proper steps are taken to enforce it. But whatever the law may do or leave undone, the moral effect of the action of individuals, if it can bring the same result, will be worth a great deal more, just as any reform or right conduct is of more value when it comes from the convictions and free will of the responsible parties, than when they are forced to it.

One most important point to be secured is the mutual cooperation of leading farmers and dealers. The rather remarkable success in this respect gained here, was due to several causes. The people were educated up to the point where they saw the good of it. The plan was initiated and executed with the aid of the Advisory Committee of the Station, a body which includes some of the most influential farmers of the State. The movement was made to appear, as well as to be, one on the part of the farmers, and dealers saw it was for their interest to join. Nearly forty individuals, firms, and companies, including many of the heaviest manufacturers in the country, and nearly all the more influential ones who sell in Connecticut, have allied themselves with the Station. They have done so because they have seen that this was the surest means to secure the best patronage, exclude illegitimate competition, and put their trade on the most just and profitable basis.

IV. Chemical Memoranda.

We receive frequent requests for information about the chemistry of fertilizing materials and crops, and the meaning of the chemical terms most commonly used in referring to them. Brief answers to these have been attempted in the circulars of the Station. As the supply of these latter is exhausted, while the questions continue to come, and the information must be useful, we feel constrained to make the

following explanations, even at the risk of some repetition of what has been said elsewhere.

Animal and vegetable substances, such as flesh, bone, wood, grain, manure and the like, contain three classes of materials: Water, Organic Matters, and Mineral Matter or Ash. If we heat a piece of wood, a wisp of hay, a bone, or a portion of manure or soil, in an oven, the water will be dried out. If we put the dried material in the fire, the *Organic Matter*, which consists mostly of the chemical elements, carbon, oxygen, hydrogen, and nitrogen, will be burned away, and there will remain the *Mineral Matter* or *Ash*. The ash of these different materials generally contains more or less potash, soda, lime, magnesia, iron, alumina, silica, phosphoric acid, sulphuric acid, chlorine, or other ingredients. The proportions of these vary widely in different substances, from the large quantities to the merest traces.

Moisture.—All fertilizers contain more or less water, which, of course, has no commercial value, and serves to make them heavier and relatively poorer in valuable ingredients. In the analysis, that which is removed by heating to 212° Fahrenheit, (or, in some cases, to a somewhat higher temperature,) is designated as Moisture. By subjecting the dried material to a higher temperature, the Organic and Volatile Matters are driven off, and the Ash remains. By treating this ash with strong acids, all that is of any value is dissolved.

Sand and Insoluble Matters.—The residue, which resists the action of both fire and strong acids, consists or silica and other mineral matters. These possess no fertilizing value, and are classified as Sand, etc.

Nitrogen, Ammonia.—In our ordinary fertilizers, much or all of the nitrogen exists in unavailable forms. By more or less rapid alterations, by decay or otherwise, which take place in the soil, these are changed to other compounds, which the plant can readily use as food. Of these latter, nitric acid, which contains nitrogen combined with oxygen, is one; ammonia, which consists of nitrogen and hydrogen, and is represented by the chemical formula, NH_3, is another. Fourteen parts by weight of nitrogen unite with three parts of hydrogen to form seventeen parts of ammonia. Accordingly 14 parts of nitrogen are said to be equivalent to 17 of ammonia, or what is the same thing, 100 parts of nitrogen are reckoned as equivalent to 121 parts of ammonia. In pure sulphate of ammonia, all the nitrogen is in the form of ammonia. In Peruvian guano, some of the nitrogen exists as ammonia also. In our other ordinary fertilizers, there is little or no ammonia. The very common practice of reckoning nitrogen as ammonia in fertilizers which do not contain it in this form, is incorrect, misleading, and therefore wrong, and ought to be abolished.

Ammonia combined with sulphuric acid, forms sulphate of ammonia; nitric acid combined with soda, forms nitrate of soda.

Phosphoric Acid: Soluble, Reverted, and Insoluble.—By

Phosphoric acid is understood the compound of phosphorus and oxygen, which is represented by the chemical formula, P_2O_5.* This combined with lime, forms phosphate of lime. The phosphate of lime which occurs in bones, and in South Carolina and other fossil and mineral phosphates, contains three parts of lime to one of phosphoric acid. This is often called bone phosphate, and is insoluble in water. When the bone phosphate is treated with sulphuric acid, the latter takes part of the lime to itself, forming sulphate of lime, and leaves the phosphoric acid in the form of a *superphosphate*. This last is soluble in water, and when used as a fertilizer can be taken up by the plant at once, while the bone phosphate is slowly available as plant-food. Phosphoric acid which has been rendered soluble, often enters into other forms of combination, with lime, alumina, &c., which, though insoluble in water, are soluble in citrate of ammonia. The terms, REVERTED, reduced, and precipitated, are applied to it when in this form. The reverted phosphoric acid ranks in solubility, and consequently in value, between the Soluble and Insoluble. The Soluble and Reverted are sometimes classed together, as *Available* Phosphoric Acid.

In some analyses the percentage of phosphoric acid is not stated separately, that of "bone phosphate of lime" being given in its stead. Sometimes the expression "soluble bone phosphate of lime" is met with, which is certainly a misnomer. 100 parts by weight of phoshoric acid unite with about 118 parts of lime to form 218 parts of bone phosphate; 100 parts or pounds of phosphoric acid are said therefore to be equivalent to 218 parts of bone phosphate. I lay especial stress on this point, because those not familiar with chemistry are apt to be deceived in comparing analyses in some of which the term phosphoric acid, and in others the term bone phosphate is used. It would be more accurate and clear, and, in every way, better to discard the term bone phosphate of lime in analyses of fertilizers, and speak only of phosphoric acid.

POTASH, or potassa, is the compound of the metal potassium with oxygen, which is represented by the chemical formula, K_2O or KO. This combined with sulphuric acid, forms sulphate of potash. Potassium and chlorine together form chloride of potassium, or "muriate of potash," as it is called by dealers.

* Or PO^5. This compound is also called phosphoric oxide, phosphoric anhydride, and anhydrous phosphoric acid. Several other compounds, which may be regarded as consisting of this united with water, are also known as phosphoric acid. One of these latter is sometimes indicated by the formula, PO_5, HO. 100 parts of this would contain 88.8 parts of the anhydrous phosphoric acid. Certain manufacturers, in stating the composition of their wares, give for phosphoric acid the amount of this hydrated phosphoric acid to which the anhydrous acid actually present would correspond. Thus an article containing 10½ per cent. of phosphoric oxide would be stated to contain 12 per cent. of phosphoric acid. Though this is in accordance with the more modern chemical theories of the constitution of acids, yet, being contrary to universal usage, it is, even when the chemical formula is given, calculated to mislead those who are not familiar with chemistry.

CaO, CaO, CaO } P_2O_5 + $H_2O.SO_3$, $H_2O.SO_3$ = CaO, H_2O, H_2O } P_2O_5 + CaO,SO3, CaO,SO3

3CaO, P_2O_5 + 2 $H_2O.SO_3$ = 2 H_2O, CaO, P_2O_5 + 2CaOSO3

Bone phosphate of lime — sulphuric acid — Superphosphate — Sulphate of Lime

By adding to ordinary potash lye from ashes, a proper amount of sulphuric acid and boiling the liquid down, we might, with proper care, obtain a solid substance, which would be a sulphate of potash. If we were to use hydrochloric (muriatic) acid instead of sulphuric, we should obtain a chloride of potassium or muriate of potash. It is customary to reckon the potassium of salts as "actual potash." In the sulphates this term expresses the amount of potassium oxide, potassa, or potash present. In the muriates it represents the amount of potash which the potassium would make if it were combined with oxygen instead of chlorine.

100 lbs. of pure sulphate of potash contains about 54 lbs. of "actual potash." 100 lbs. of sulphate of potash are therefore said to be equivalent to 54 lbs. of actual potash, and vice versa, 54 lbs. of potash in the sulphates are reckoned as equivalent to 100 lbs. of sulphate of potash. In the "muriates" 100 lbs. of chloride of potassium are reckoned equivalent to about 63 lbs. of potash, and vice versa.

The following figures will be found useful in calculations of the composition of fertilizers:

NITROGEN COMPOUNDS.

Parts of Nitrogen.		Parts of Ammonia.
14.	are contained in	17.
100.	"	" 121.43
82.35	"	" 100.

Parts of Ammonia.		Parts of Sulphate of Ammonia.	Parts of Nitrogen.		Parts of Sulphate of Ammonia.
17.	are contained in	66.	14.	are contained in	66.
100.	" "	388.2	100.	" "	471.4
25.8	" "	100.	21.2	" "	100.

Parts of Nitrogen.		Parts of Nitric Acid.	Parts of Nitrogen.		Parts of Nitrate of Soda.
14.	are contained in	54.	14.	are contained in	85.
100.	" "	385.7	100.	" "	607.1
25.9	" "	100.	16.47	" "	100.

Parts of Nitric Acid.		Parts of Nitrate of Soda.	Parts of Nitrate of Soda.		Parts of Ammonia.
54.	are contained in	85.	85.	correspond to	17.
100.	" "	157.4	100.	" "	20.
63.5	" "	100.	500.	" "	100.

PHOSPHORIC ACID.

Parts of Phosphoric Acid.		Bone Phosphate.
100.	correspond to parts of	218.3
45.8	" "	100.

POTASH (POTASSA).

Parts of Sulphate of Potash.		Parts of Potassa.	Parts of Chloride of Potassium.		Parts of Potassa.
100.	contain	54.08	100.	correspond to	63.17
184.9	"	100.	158.3	" "	100.

NITROGEN AND AMMONIA.

Nitrogen, per cent.		Ammonia, per cent.	Ammonia, per cent.		Nitrogen, per cent.
1.0	corresponds to	1.21	1.0	corresponds to	.82
1.5	" "	1.82	1.5	" "	1.24
2.0	" "	2.43	2.0	" "	1.65
2.5	" "	3.04	2.5	" "	2.06
3.0	" "	3.64	3.0	" "	2.47
3.5	" "	4.25	3.5	" "	2.88
4.0	" "	4.86	4.0	" "	3.29
4.5	" "	5.46	4.5	" "	3.71
5.0	" "	6.07	5.0	" "	4.12
5.5	" "	6.68	5.5	" "	4.53
6.0	" "	7.29	6.0	" "	4.94
6.5	" "	7.89	6.5	" "	5.35
7.0	" "	8.50	7.0	" "	5.76
7.5	" "	9.11	7.5	" "	6.18
8.0	" "	9.71	8.0	" "	6.59
8.5	" "	10.32	8.5	" "	7.00
9.0	" "	10.93	9.0	" "	7.41
9.5	" "	11.54	9.5	" "	7.82
10.0	" "	12.14	10.0	" "	8.24
10.5	" "	12.75	10.5	" "	8.65
11.0	" "	13.36	11.0	" "	9.06
11.5	" "	13.96	11.5	" "	9.47
12.0	" "	14.57	12.0	" "	9.88
12.5	" "	15.18	12.5	" "	10.29

PHOSPHORIC ACID & BONE PHOSPHATE.

Phosphoric Acid, per cent.		Bone Phosphate, per cent.
1	corresponds to	2.18
2	" "	4.37
3	" "	6.55
4	" "	8.73
5	" "	10.92
6	" "	13.10
7	" "	15.28
8	" "	17.46
9	" "	19.65
10	" "	21.83
11	" "	24.01
12	" "	26.20
13	" "	28.38
14	" "	30.56
15	" "	32.75
16	" "	34.93
18	" "	39.30
20	" "	43.66
22	" "	48.03
24	" "	52.39
25	" "	54.58
30	" "	65.49
35	" "	76.41
45	" "	87.32

UNITS OF AMMONIA AND POUNDS OF NITROGEN—COMPARATIVE COSTS.

Unit of Ammonia at		Unit of Nitrogen at		Pound of Nitrogen at
$1.00	corresponds to	$1.21	corresponds to	6.07 cents.
1.25	" "	1.52	" "	7.59 "
1.50	" "	1.82	" "	9.11 "
1.75	" "	2.12	" "	10.62 "
2.00	" "	2.43	" "	12.14 "
2.25	" "	2.73	" "	13.66 "
2.50	" "	3.04	" "	15.18 "
2.75	" "	3.34	" "	16.70 "
3.00	" "	3.64	" "	18.21 "
3.25	" "	3.95	" "	19.78 "
3.50	" "	4.25	" "	21.25 "
3.75	" "	4.55	" "	22.77 "
4.00	" "	4.86	" "	24.28 "
4.25	" "	5.16	" "	25.80 "
4.50	" "	5.46	" "	27.37 "

ACTUAL POTASH (POTASSA) IN POTASSIUM SULPHATE AND CHLORIDE (MURIATE).

Parts of Sulphate of Potash.		Parts of Potash.	Parts of Chloride of Potassium.		Parts of Potassa.
1	contains	.54	1	corresponds to	.63
2	contain	1.08	2	correspond "	1.26
3	"	1.62	3	" "	1.90
4	"	2.16	4	" "	2.53
5	"	2.70	5	" "	3.16
6	"	3.24	6	" "	3.79
7	"	3.79	7	" "	4.42
8	"	4.33	8	" "	5.05
9	"	4.87	9	" "	5.69
10	"	5.41	10	" "	6.32
12	"	6.49	12	" "	7.58
14	"	7.57	14	" "	8.84
16	"	8.65	16	" "	10.11
18	"	9.73	18	" "	11.37
20	"	10.82	20	" "	12.63
22	"	11.90	22	" "	13.90
24	"	12.98	24	" "	15.16
25	"	13.52	25	" "	15.79
26	"	14.06	26	" "	16.42
28	"	15.14	28	" "	17.69
30	"	16.22	30	" "	18.95
35	"	18.93	35	" "	22.11
40	"	21.63	40	" "	25.27
45	"	24.34	45	" "	28.43
50	"	27.04	50	" "	31.59
55	"	29.74	55	" "	34.74
60	"	32.45	60	" "	37.90
65	"	35.15	65	" "	41.06
70	"	37.86	70	" "	44 22
75	"	40.56	75	" "	47.38
80	"	43.26	80	" "	50.54
85	"	45.97	85	" "	53.69
90	"	48.67	90	" "	56.85
95	"	52.38	95	" "	60.01
100	"	54.08	100	" "	63.17

V. On the Costs of Nitrogen, Phosphoric Acid, and Potash in Commercial Fertilizers.

We frequently receive questions like the following:

What are the cheapest forms in which I can buy phosphoric acid?

Can I get nitrogen most economically in guano, fish, sulphate of ammonia, or what?

What is the cheapest and best source of potash?

One of the principles advocated by the Station as of most fundamental importance to the farmer in the purchase of commercial fertilizers is that he should *select those which furnish, in the best form and at the lowest cost, the ingredients of plant-food that his crops need and his soil fails to supply.*

How to determine what ingredients are deficient in a given soil, and what materials will best supply them, will be discussed in another place.* We seek here to illustrate, by a few examples, some of the principal sources from which farmers can most conveniently obtain the valuable ingredients of our ordinary commercial fertilizers, and at what costs. The unmixed materials chiefly, are referred to here. The costs of the ingredients in the compound manures are shown in the tables in the report which follows.

The following statements and tables will illustrate the costs of nitrogen, phosphoric acid, and potash, in some of the more common commercial fertilizing materials obtainable in the larger markets. The articles designated by Arabic numerals, 1, 2, 3, etc., are selected from the list analyzed at the Station, and may be found with the same numbers in the report which follows. Those designated by letters, A, B, C, etc., are from price lists or statements of dealers in Boston, New York, and Philadelphia, of dates between September, 1876, and January, 1877, and represent the composition as guaranteed at prices stated. The lower prices are understood to be cash for lots of one ton thereabouts at the larger markets where they are offered. For smaller quantities, on time, or at a distance from the principal markets, they would, of course, be higher. The German tables referred to are those of Wolff.†

* See article on "Farm Experiments," etc.

† *Düngerlehre*, 1875, pp. 199–9.

NITROGEN.*

Nitrate of Soda. The article of 95 per cent. purity has been offered by Boston and New York dealers at prices varying 3½ to 4½ cts. per lb., according to quantity, time of payment, etc. Wolff's tables give average composition of German article at 15.5 per cent. nitrogen. An article, I, with 95 per cent. of nitrate of soda or 15.65 per cent. nitrogen, would, at 4 cts. per lb., or $80.00 per ton, bring nitrogen at 25.56 cts. per lb. At $70.00 per ton, at which price it could now be bought in ton lots, the nitrogen would come to 22.4 cts. per lb. No. 163, guaranteed 95 per cent., contained 16.02 per cent. nitrogen equal 97.31 per cent. nitrate of soda, and was sold at $75.00 per ton, which brings nitrogen at 23.4 cts. per lb.

Sulphate of Ammonia is offered in Boston and New York at from 4½ to 5½ cts. per lb. The lower prices are apt to apply to casks of 1,500 lbs. or thereabouts. It is stated by dealers, offering it to range from 24 to 27 per cent. ammonia, averaging 25 per cent. Wolff's table gives for average article, 20 per cent. nitrogen, which corresponds to 24.29 per cent. ammonia. Samples No. 3 and No. 161 gave respectively 20.51 and 20.53 nitrogen equal 24.90 and 24.92 ammonia. The price of 3 in 1875 was 97.50 per ton, which makes nitrogen 23.8 cts. per lb.; that of 161 in 1876, $90.00 to $100.00 per ton, bringing nitrogen from 22 to 24.4 cts. per lb. An article, II, with 20.0 per cent. nitrogen, at $90.00 per ton, would furnish nitrogen at 22.5 cts. The same at $100.00 would bring nitrogen at 25 cts.

Dried Blood is offered at quite varying rates. That with 12 to 14 per cent. ammonia, corresponding to 9.8 — 11.5 per cent. nitrogen, is quoted by New York and Boston dealers all the way from $35.00 to $60.00 per ton. A New York circular quotes it at from $3.50 to $4.50 per unit of ammonia. There is little doubt it can be bought by farmers for cash in lots of not less than one ton at $3.50 and less per unit of ammonia. It has been bought and sold by dealers in large quantities during the past season at very much lower rates than this.† Wolff gives 11.7 per cent. of nitrogen, 1.0 per cent. of phosphoric acid, and 0.7 per cent. of potash, as the average for dried blood. It is customary to take only the nitrogen into account in

* 14 parts by weight of nitrogen are contained in 17 parts of ammonia, 100 parts of nitrogen correspond to 1.21 of ammonia, and 100 of ammonia to 0.824 of nitrogen.

† It would be hardly fair to quote the wholesale rates at which a large part or the whole product of a slaughter-house is contracted, for the season, to jobbers or manufacturers, since individual purchasers must expect to pay higher for small quantities. On the other hand, the claim that such articles as dried blood, meat scrap, and bone black, which are largely used in the manufacture of fertilizers, should not be quoted at the actual prices at which farmers can buy them in retail lots of a ton, on the ground that the price would rise as soon as such a demand should spring up, is hardly a valid one. It is right that every man should know at what price he can get the articles he wants and buy them where they can be had best and cheapest. Until the demand for exceptionally cheap articles brings them up to the same level as others smaller purchasers ought to have the benefit of their cheapness.

valuations. The samples in the following report ranged from 8.92 per cent. to 11.48 per cent. nitrogen. No. 160 gave 11.48 per cent. nitrogen and 1.35 of phosphoric acid. At $45.00 per ton, the price charged for this, taking into account the phosphoric acid, the cost of the nitrogen was 18.2 cts. per lb. Leaving the phosphoric acid out of account, the nitrogen cost 19.6 cts. per lb. An article, III, at $3.50 per unit of ammonia, would bring nitrogen at 21.3 cts.

PHOSPHORIC ACID, SOLUBLE.

The most important sources of this material, by itself, in our markets, are the so-called acid phosphates, or "plain superphosphates," made from South Carolina, Canada, or other mineral and fossil phosphates, dissolved bone-black, dissolved bone-ash; and the superphosphates imported from Europe. A sample of English superphosphate, No. 53, gave 23.28 per cent. soluble, and 8.67 insoluble acid. At $61 per ton, the price of the article, supposing the values to be in the ratio 15 : 6, the soluble acid would come at 11.5 cts., and the insoluble at 4.6 cts. per lb. Dissolved bone-black, with 15–18 per cent. soluble phosphoric acid, is offered by price-lists and statements of New York and Boston dealers, at from $30 to $36 per ton. An article IV, at $33 per ton, with 15 per cent. soluble phosphoric acid, would (leaving out of account any reverted or insoluble acid that might be present) bring the soluble acid at 11 cts. per lb. In an article, V, at the same price, with 16½ per cent. soluble acid, the latter would cost 10 cts. per lb. A superphosphate made from Charleston phosphate, is announced in a circular of the manufacturers to yield (average of three analyses given) 10.5 soluble, and 4.3 per cent. reverted phosphoric acid. If an article, VI, of such composition were sold at $30 per ton, the price at which it is stated that this could be offered in the larger cities of Connnecticut, the soluble phosphoric acid would cost 10.5, and the reverted 7.0 cts. per lb. A superphosphate shown at the Centennial Exhibition in Philadelphia last summer, was guaranteed to yield 30.44 soluble, and 1.66 reverted phosphoric acid, and offered at $65 per ton. In a superphosphate, VIII, at $65 per ton, with 31 per cent. of soluble acid, the latter would come to 10.5 cts. per lb. Superphosphates are offered in New York at from 10½ to 11 cts. per lb. for the soluble phosphoric acid, though with the stipulation that the reverted acid shall be counted as soluble. In the above calculations, the insoluble phosphoric acid which may be present along with the soluble and reverted, when not specifically mentioned, is left out of account.

PHOSPHORIC ACID, INSOLUBLE.

The most important sources of phosphoric acid alone, in the insoluble form, now in our markets, are, so far as my observation goes, the fossil and mineral phosphates of South Carolina, Navassa, and Canada, the phosphatic guanos of some of the islands of the

Caribbean Sea, and spent bone-black. A South Carolina phosphate, IX, with 26 per cent. of phosphoric acid, is quoted at $20 per ton, making phosphoric acid a little under 4 cts. per lb. Bone-black, X, with 32 per cent. phosphoric acid, is quoted at $30 per ton, which would bring the acid at 4.7 cts. per lb. According to information at hand, however, it can now be bought in lots of a ton for cash, at prices which would bring the phosphoric acid at considerably under 4 cts. per lb.

POTASH.

SULPHATES are offered of various grades, from 65 per cent. sulphate of potash, = 35.15 actual potash, to the 87 per cent. sulphate, = 45.36 per cent. actual potash, or higher. The 65 per cent. is quoted at $55–$60; the 70 per cent. at $60–$65; and the 80 per cent. at $65.00 to $72.00 per ton. A sulphate of 65 per cent., XI, at $55 per ton; an article of 70 per cent., XII, at $60, and one of 80 per cent., XIII, at $67.58, would each furnish potash at 7.8–7.9 cts. per lb. No. 162, with 31.72 per cent. potash, corresponding to 59.12 per cent. sulphate, was sold at $60 per ton, which brought potash at 9.4 cts. per lb. No. 184, with 40.66 potash, corresponding to 75.19 per cent. sulphate, was sold at $65 per ton, at which rate the potash cost 8 cts. per lb. The prices for smaller lots than one ton of these, as of other materials, will be, of course, higher. I may add that I have seen lower quotations for ton lots than any of those mentioned.

CHLORIDES, with 80–85 per cent. chloride of potassium, corresponding to 50.53 per cent. actual potash, are offered at from $60 down to $50 and lower, per ton. I have seen quotations at $45.00 and less for ton lots. An article, K, with 50 per cent. potash, at $55 per ton, would bring potash at 5.5 cts. per lb. In an article, L, of the same composition, at $50 per ton, it would come to 5 cts. per lb. No. 33, with 80.08 per cent. chloride, = 50.56 potash, was sold at $60 per ton, and furnished potash at 6 cts. per pound. This was, however, an old price. The lowest offers that I have seen for these and other similar fertilizers were to farmer's clubs.

NITROGEN AND PHOSPHORIC ACID.

In calculating the cost of these ingredients in articles furnishing them both, the proportion falling to each depends, of course, upon that ascribed to the other. A common method of calculation consists in ascribing a fixed value to each pound of one ingredient, subtracting the total value at that rate from the whole cost, charging the rest to the other ingredient, and computing the cost of the latter on that basis. The calculations in the table which follows, are made upon the plan explained, elsewhere,* which is based upon certain assumed ratios of value between the two ingredients in different articles.

Just what this ratio should be in a given case, is, of course, difficult to decide. Nitrogen exists in its most available forms in nitrate of soda and

* Article VI.

sulphate of ammonia, in which it costs as above about 25 cts. per lb. In dried blood it may be had at about 20 cts. per lb. Soluble phosphoric acid can be had in high grade superphosphates, at from 10 to 12½ cts. per lb. The ratio between the costs of nitrogen and phosphoric acid, in their most available and concentrated forms, is thus about 2 to 1. In the valuations adopted by Profs. Johnson and Goessmann, and most other chemists in this country during the past few years, nitrogen has been generally taken at a little less than double the value of soluble phosphoric acid. Among the European valuations, those of Stoeckhardt in 1866, give a ratio between nitrogen in its best forms and soluble phosphoric acid, of a little less than 2 to 1, and those of Wolff in 1876, give a ratio of nearly 2½ to 1, these rates being based, of course, on the costs of materials. Since these ingredients are furnished in the best forms, each by itself, in articles of enough commercial importance to fix the market value, the determination of the ratio of their values, within a reasonable degree of closeness, is not difficult. But when we come to the materials which furnish nitrogen and phosphoric acid together, the case is different. To determine just what are the relative values of a pound of nitrogen and a pound of phosphoric acid in Peruvian guano, bone, fish, slaughter-house refuse, or castor pomace, is quite another matter.

In valuations current in this country, nitrogen in these substances has been reckoned as worth all the way from two to five times as much as phosphoric acid, pound for pound. Considering the fact that the nitrogen is generally in quite readily, and the phosphoric acid often in very slowly available forms, there is ground for varying ratios. A full discussion of this subject would require more space than either the knowledge at our disposal or the necessary limits of this article would permit. In brief, however, I do not find it easy to see why if nitrogen is worth only about twice as much as phosphoric acid, pound for pound, when both are in their most available forms, it should be worth three or four times as much, as is sometimes assumed, in bone, in which both occur in much less available forms. Too little is known at present of the effect of decomposing nitrogenous matter in bone, fish, castor pomace and the like, in dissolving, diffusing, or otherwise rendering available the phosphates with which it is so intimately connected, to enable us to form any accurate estimate of its value on this account. I confess that in the light of the little knowledge that we do have, it seems to me more just to preserve ratios of valuation of nitrogen and phosphoric acid in bone the same, or nearly the same, as in the most available forms. In fish, animal refuse, and other materials which contain considerable nitrogenous matter other than that so intimately mingled with the phosphate, and in a form probably more ready to decompose, it seems reasonable to give the higher relative value to nitrogen.

In view of such considerations as these, the costs of nitrogen and phosphoric acid in the following table have been calculated on the basis of ratios as follows:

In Fish, Slaughter-house Refuse, and Castor Pomace—Nitrogen : Phosphoric acid :: 2½ : 1.

In Bone—Nitrogen : Phosphoric acid :: 2 : 1.

In Superphosphates the costs of the ingredients are calculated on a basis of ratios as per the valuations used in the last report of the Station, to-wit: Nitrogen, 25; Phosphoric acid, Soluble in water, 15; Soluble in ammonium citrate, 10; Insoluble, 6.

In Peruvian guanos the same rates are adopted as for the superphosphates, the additional ingredient, potash, being rated at 8.

The arithmetical computations are made as described elsewhere.* The prices are those at which the articles have been sold, or offered to farmers during the year at the places of sale; the lower rates in large quantities, lots of a ton or more, for cash; the higher one for smaller lots, or on time.

For a further discussion of some of these articles, particularly fish, bone, superphosphates, and Peruvian guano, see the corresponding parts of *Report on Commercial Fertilizers.*

* In article on *Methods of Calculating Costs of Valuable Ingredients of Fertilizers, &c.*

TABLE I.—VALUABLE INGREDIENTS.

FERTILIZING MATERIALS.	Number.	PERCENTAGES. Nitrogen.	Phosphoric Acid. Available. Soluble.	Reverted.	Insoluble.	Total.	Potash.	Retail price per ton.	COST PER POUND IN CENTS. Nitrogen.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total.	Potash.
		pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct.	$ cts.	cts.	cts.	cts.	cts.	cts.	cts.
NITROGEN.														
Nitrate of Soda, 95 per ct.,	I	15.65						70.00	22.4					
" " "	I	15.65						75.00	24.0					
" " "	I	15.65						80.00	25.6					
" " "	I	15.65						85.00	27.2					
" " 97.31 per ct.,	I	15.65						90.00	27.8					
" " "	163	16.02						75.00	23.4					
" " "	163	16.00						80.00	25.0					
" " "	163	16.00						85.00	26.6					
	163	16.00						90.00	28.1					
Sulphate of Ammonia, 24.29 per ct. Ammonia,	II	20.00												
" " " " "	II	20.00						90.00	22.5					
" " " " "	II	20.00						95.00	23.8					
" " " " "	II	20.00						100.00	25.0					
" " 24.90 " "	3	20.53						110.00	27.5					
" " 24.92 " "	161	20.51						97.50	23.8					
" " " " "	161	20.50						90.00	22.0					
" " " " "	161	20.50						95.00	23.1					
" " " " "	161	20.50						100.00	24.4					
" " " " "	161	20.50						105.00	25.6					
	161	20.50						110.00	26.8					
Dried Blood, (counting phosphoric acid,)	160	11.48				1.35		45.00	18.7				7.5	
" (not counting phosphoric acid,)	160	11.48						45.00	19.6					
" " "	160	11.50						50.00	21.7					
" @ $3.50 per unit for ammonia,	III								21.3					
" @ $4.50 " " "	III								24.28					
PHOSPHORIC ACID—SOLUBLE.														
Dissolved Bone-Black,	IV		15.00					33.00		11.0				
" "	IV		15.00					35.00		11.7				
" "	IV		15.00					36.00		12.0				
Superphosphate, from South Carolina Phosphate,	V		16.50					36.00		10.9				
" " Canada Apatite,	VI		10.50	4.30				30.00		10.5	7.0			
" " Philadelphia,	VII		13.50					30.00		11.1				
English Superphosphate,	VIII		31.00					65.00		10.5				
	53		23.28		8.67			61.00		11.5		4.6		
PHOSPHORIC ACID—INSOLUBLE.														
South Carolina Rock Phosphate,	IX					26.00		20.00					3.8	
Navassa Phosphate,	45					20.45		20.00					4.9	
Caribbean Sea Guano, Orchilla,	125					27.18		25.00					4.6	
Spent Bone-Black,	X					32.00		26.00					4.1	
" "	X					32.00		30.00					4.7	
POTASH (POTASSA). GERMAN POTASH SALTS.														
Sulphate, 65 per cent,	XI						35.15	55.00						7.8
" 65 "	XI						35.15	60.00						8.5
" 70 "	XII						37.86	60.00						7.9
" 70 "	XII						37.86	65.00						8.6
" 80 "	XIII						43.26	65.00						7.5
" 80 "	XIII						43.26	70.00						7.8
" 80 "	XIII						43.26	75.00						8.1
" 59.72 "	162						43.26	80.00						8.4
" 75.19 "	184						31.72	60.00						9.5
							40.66	65.00						8.0
Chloride, (Muriate,) 80 per cent.,	XIV						50.54	45.00						4.4
" " 80 "	XIV						50.54	50.00						4.9
" " 80 "	XIV						50.54	55.00						5.4
" " 84 "	XIV						50.54	60.00						5.9
" " 84 "	XV						53.06	50.00						4.7
" " 84 "	XV						53.06	55.00						5.2
" " 80.08 "	XV						53.06	60.00						5.7
	33						50.64	60.00						5.9
NITROGEN AND PHOSPHORIC ACID. FISH MANURES.														
Dry Ground Fish, Allen's,	24	8.80				6.17		40.00	17.7				7.1	
" " "	185	7.88				7.90		40.00	18.1				7.2	
Average of two samples, Allen's,		8.34				7.03		40.00	17.9				7.2	

TABLE I.—VALUABLE INGREDIENTS—CONTINUED.

FERTILIZING MATERIALS.	Number.	PERCENTAGES. Nitrogen.	Phosphoric Acid. Available. Soluble.	Reverted.	Insoluble.	Total.	Potash.	Retail price per ton.	COST PER POUND IN CENTS. Nitrogen.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Total.	Potash.
		pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct.	$ cts.	cts.	cts.	cts.	cts.	cts.	cts.
NITROGEN AND PHOSPHORIC ACID.														
FISH MANURES.														
Dry Ground Fish, Quinnipiac F. Co.,	100	7.50	.....	.....	.....	6.67	.....	45.00	22.1	.....	.....	.....	8.8	...
" " " "	140	7.38	.....	.....	.....	7.21	.....	45.00	21.9	.....	.....	.....	8.8	....
" " " "	172	7.96	.....	.....	.....	7.55	.....	45.00	20.5	.....	.....	.....	8.2	....
Average of three samples, Quinnipiac F. Co.,		7.61	.....	.....	.....	7.14	.....	45.00	21.5	.....	.....	.....	8.6	....
Dry Fish, Unground, Green Bros.,	179	8.60	.....	.....	.....	10.51	.....	28.00	10.9	.....	.....	.....	4.4	....
Half Dry Fish Scrap,	103	5.33	.....	.....	.....	6.23	.....	16.00	10.2	.....	.....	.....	4.1	....
"	131	5.49	.....	.....	.....	7.49	.....	16.00	9.4	.....	.....	.....	3.8	....
NITROGENOUS SUPERPHOSPHATES.*														
Ammoniated Bone Superphosphate, Russell Coe,	128	2.24	11.67	0.92	0.20	.....	.....	40.00	21.0	12.5	8.3	5.0	.....	....
" " " "	135	2.94	12.05	0.34	0.57	.....	.....	40.00	19.1	11.5	7.7	4.6	.....	....
" " " "	168	2.04	12.53	0.46	.....	.....	.....	40.00	20.5	12.3	8.2	.....	.....	....
" " " "	170	3.84	11.05	1.08	.....	.....	.....	40.00	18.3	11.0	7.3	.....	.....	....
Average of four samples above,		.....	.....	.....	.....	.....	.....	.....	19.7	11.8	7.9	4.8	.....	....
Soluble Nitrogenous Phosphate, Quinnipiac F. Co.,	101	4.41	7.24	.....	0.46	.....	.....	40.00	22.7	13.6	.....	5.4	.....	....
" " " "	146	3.33	8.16	3.39	2.55	.....	.....	40.00	19.6	11.8	7.8	4.7	.....	....
" " " "	171	2.49	7.65	2.29	1.91	.....	.....	40.00	23.6	14.2	9.5	5.7	.....	....
Average of three samples above,		.....	.....	.....	.....	.....	.....	.....	22.0	13.2	8.6	3.3	.....	....
Pine Island Guano, Quinnipiac F. Co.,	99	5.64	4.95	2.32	1.93	.....	.....	45.00	22.5	13.5	9.0	5.4	.....	....
" " "	173	6.25	4.93	0.96	0.84	.....	.....	45.00	23.0	13.8	9.2	5.5	.....	....
Average of two samples above,		.....	.....	.....	.....	.....	.....	.....	22.7	13.6	9.1	5.4	.....	....

* Articles which, among those sold under supervision of Station, furnished valuable ingredients at lowest rates.

NITROGEN, PHOSPHORIC ACID, AND POTASH.														
NO. 1 PERUVIAN GUANO.														
Ten per cent. Ammonia Standard,	47	11.33	4.14	8.81	2.42	.....	2.33	60.00	16.0	9.6	6.4	3.8	.....	5.1
" " "	108	8.56	5.25	9.79	2.86	.....	3.24	60.00	17.3	10.4	6.9	4.2	.....	5.5
" " "	137	7.76	5.27	6.24	4.01	.....	4.36	58.50	18.5	11.1	7.4	4.5	.....	5.9
" " "	164	7.52	6.05	5.59	1.39	.....	4.61	57.00	18.9	11.3	7.6	4.5	.....	6.0
Average of five samples above,	191	7.88	5.11	7.10	5.04	.....	3.54	58.00	18.0	10.8	7.2	4.3	.....	5.7
		.....	.....	.....	.....	.....	.....	.....	17.7	10.6	7.1	4.3	.....	5.6
Guaranteed, Cargo A,	186	5.87	4.55	4.35	7.10	.....	3.45	56.00	21.3	12.9	8.5	5.1	.....	6.8
"	187	5.79	4.50	5.11	7.49	.....	3.36	56.00	20.9	12.5	8.4	5.0	.....	6.7
Average of two samples above,		.....	.....	.....	.....	.....	.....	.....	21.1	12.7	8.45	5.55	.....	6.75
Rectified,	57	9.15	10.67	.....	1.71	.....	2.43	60.00	17.9	10.8	....	4.3	.....	5.7
"	136	7.82	10.02	2.82	.....	.....	4.34	65.00	19.9	11.9	8.0	.....	.....	6.4
Average of two samples above,		.....	.....	.....	.....	.....	.....	.....	18.9	11.35	8.0	4.3	.....	6.05
SLAUGHTER HOUSE REFUSE.														
Meat Scrap, Brighton Abattoir,	151	8.63	.....	.....	.....	3.46	.....	35.00	17.4	.....	.....	.....	7.0	....
Brighton Animal Fertilizer,	153	6.53	.....	.....	.....	11.90	.....	40.00	17.7	.....	.....	.....	7.1	....
" " " Acidulated,*	31	5.33	6.37	.....	1.11	.....	.....	40.00	20.9	12.5	.....	5.0	.....	....
Dried Blood, Meat Scrap and Bone, Strong, Barnes, Hart & Co.,	154	7.60	7.85	0.59	.....	.....	.....	45.00	17.9	10.8	7.1	.....	.....	....
" " " " " "	102	8.08	.....	.....	.....	5.20	.....	40.00	19.7	.....	.....	.....	7.9	....
" " " " " "	102	8.08	.....	.....	.....	5.20	.....	30.00	14.8	.....	.....	.....	5.9	....
" " " " " "	142	9.72	.....	.....	.....	3.83	.....	40.00	17.8	.....	.....	.....	7.1	....
" " " " " "	142	9.73	.....	.....	.....	3.83	.....	30.00	13.3	.....	.....	.....	5.3	....
VEGETABLE REFUSE.														
Castor Pomace,	35	4.80	.....	.....	.....	2.11	.....	25.00	22.1	.....	.....	.....	8.8	....
" "	59	4.89	.....	.....	.....	1.91	.....	19.00	16.8	.....	.....	.....	6.7	....
" "	105	5.29	.....	.....	.....	2.42	.....	19.00	15.2	.....	.....	.....	6.1	....
BONE MANURES.	Grade of fineness.													
Ground Bone, J. Lister,	I,	91	3.63	.....	.....	.....	22.85	.....	35.00	11.6	.....	.....	.....	5.8	....
Pure Ground Bone, L. B. Darling & Co.,	I,	175	3.61	.....	.....	.....	22.16	.....	40.00	13.6	.....	.....	.....	6.8	....
Bone Sawings, Granby Mfg. Co.,	I,	193	3.69	.....	.....	.....	26.05	.....	40.00	12.0	.....	.....	.....	6.0	....
Ground Bone, Thompson & Edwards,	II,	181	2.67	.....	.....	.....	26.08	.....	35.00	11.2	.....	.....	.....	5.6	....
" " H. J. Baker & Bro.,	II,	94	3.88	.....	.....	.....	23.61	.....	33.00	10.5	.....	.....	.....	5.2	....
Bone Flour, P. W. Bennett,	III,	92	3.91	.....	.....	.....	22.05	.....	36.00	12.0	.....	.....	.....	6.0	....
Fine Ground Bone, G. W. Miller,	III,	93	3.88	.....	.....	.....	21.95	.....	36.00	12.0	.....	.....	.....	6.0	....
Ground Bone, Peck Bros.,	IV,	58	4.03	.....	.....	.....	19.79	.....	38.00	13.6	.....	.....	.....	6.8	....
Coarse Ground Bone, P. W. Bennett,	IV,	92a	3.91	.....	.....	.....	22.05	.....	30.00	10.0	.....	.....	.....	5.0	....
Coarse Ground Bone, G. W. Miller,	VI,	93a	3.88	.....	.....	.....	21.95	.....	30.00	10.1	.....	.....	.....	5.0	....

* Sample sold in 1875.

VI. On Methods of Calculating the Commercial Values and Costs of Valuable Ingredients of Fertilizers.

Inquiries like the following are frequently received at the Station.

Will you please tell me what a fertilizer of composition as per analysis herewith is worth?

How are the commercial values of fertilizers estimated?

Please explain how the costs of the valuable ingredients of fertilizers are calculated.

How much a given fertilizer will be worth to the user in a given case, in other words, its agricultural value, depends upon so many different and varying circumstances that it can be told only by actual trial. The commercial value, as based upon the values of its active fertilizing ingredients, admits of more accurate computation.

It is customary to estimate the values of commercial fertilizers by attributing a certain value to each pound of the valuable ingredients. That is to say, each pound of nitrogen, phosphoric acid, and potash is rated at a certain price, and the value of a ton of the fertilizer calculated on this basis, just as a grocer would make out a bill for a lot of tea, coffee, sugar, by charging a certain price per pound for each, and adding the products to make the amount of the bill. It will be remembered that each per cent. or pound in 100 pounds will be equal to 20 pounds in a ton of 2,000 pounds. This is illustrated below in an analysis and valuation upon which a fertilizer was sold in this State last spring:

Analysis.

Ingredients.	Per cent.
Moisture,	19.16
Phosphoric acid, soluble,	10.22
" " reverted,	2.83
" " insoluble,	1.66
Nitrogen,	2.53

Commercial Valuation, per Ton of 2,000 lbs.

	Per cent.	Lbs. in ton.	@Cts. per lb.	Valuation.
Phosphoric acid, soluble,	10.22	204.4	15	$30.66
" " reverted,	2.83	56.6	10	5.66
" " insoluble,	1.66	33.2	6	1.99
Nitrogen,	2.53	50.6	25	12.65
				$50.96

Instead of calculating the commercial values by pounds, the "units" of valuable ingredients are often used. Nitrogenous fertilizers are commonly bought and sold by dealers by "units" of ammonia. The unit is one per cent., or 20 pounds to the ton. If one pound of soluble phosphoric acid is worth 15 cents a unit, 20 pounds will be worth 20 × 15 cents = $3. If, in the above case, the calculation be made by units instead of pounds, it will stand:

	Per cent. (units.)	@Valuation Per unit.	Valuation.
Phosphoric acid, soluble,	10.22	$3.00	$30.66
" " reverted,	2.83	2.00	5.66
" " insoluble,	1.66	1.20	1.99
Nitrogen,	2.53	5.00	12.65
			$50.96

HOW TO ESTIMATE THE RELATIVE VALUES OF FERTILIZERS FROM ANALYSES.

The statements and tables in the following article will supply sufficient data for judging the values of nitrogen, phosphoric acid, and potash in different forms in which they are most commonly obtained in the markets. The commercial value of a fertilizer of which the analysis is given, may be calculated by the following rule:

I. *Multiply the per cent. of each valuable ingredient by* 20 *to get the number of pounds in a ton of* 2,000 *pounds. Multiply the number (thus found) of pounds of each ingredient by its assumed value per pound; the sum of these products will be the estimated commercial value of a ton of the fertilizer. Or,*

II. *Multiply the number of "units" (per cent.) of each ingredient by the assumed value per unit, and add the products. The sum will be the estimated value per ton.*

What will be fair valuations will depend upon the material by which they are furnished, their market value at the time, the amounts purchased, time of payment, distance from market, etc. For the common superphosphates, bought in ton lots for cash, in our larger cities, the following figures will not be far out of the way:

	Per pound.	Per unit.
Nitrogen,	21 cents.	$4.20
Phosphoric acid, soluble,	12½ "	2.50
" " reverted,	9 "	1.80
" " ins., from bones, meat, or fish,	6 "	1.20
" " " from bone-black,	5 "	1.00
" " " from fossil and mineral phosphates,	3½ "	.65

It must be remembered however that the values thus calculated are not agricultural values.*

* See article "On the Money Valuations of Commercial Fertilizers."

METHODS OF CALCULATING COSTS OF VALUABLE INGREDIENTS.

In the place of the above-mentioned method for the valuation of fertilizers, another was suggested by the Station at the beginning of its work, and has been adopted in the present as in previous reports. It consists in comparing different fertilizers by the costs per pound of the valuable ingredients at the prices at which the articles are sold.

The way in which these computations are made here, may be explained as follows:

Take first a simple case, a sulphate of ammonia containing 20 per cent. of nitrogen, and sold at $100 per ton. 20 per cent. is equivalent to 400 pounds in a ton of 2,000 pounds. These 400 pounds of nitrogen cost $100. One pound will therefore cost $100 ÷ 400 = 25 cents.

Now, a more complicated case. Suppose a superphosphate to contain valuable ingredients (and that, for convenience, we indicate the latter by abbreviations,) as below:

Soluble phosphoric acid,	(Sol.)	10 per cent. =	200 pounds in ton,
Insoluble " "	(Ins.)	2.5 per cent. =	50 " " "
Nitrogen,	(N.)	3 per cent. =	60 " " "

that it be sold at $40 per ton, and that the values of the ingredients are in the ratios of Sol., 15; Ins., 6, and N., 25 cents per pound. The problem will be to find a series of values in the ratios 15 : 6 : 25, which, multiplied by the respective numbers of pounds of Sol., Ins., and N. in a ton, will give three products, whose sum will be $40. The method employed here for solving the problem is as follows: The assumed rate for Ins. was 6 cents that for Sol., 15 cents, or $2\frac{1}{2}$ times as much, and that for N. 25 cents, or $4\frac{1}{6}$ times as much. Multiply the number of pounds of Sol. in a ton by $2\frac{1}{2}$, and that of N. by $4\frac{1}{6}$, and add the products to the number of pounds of Ins., and the sum will be the number of pounds of Ins. which would have the same value as the Sol., Ins., and N. actually presents taken together. Divide the whole cost by this sum and the quotient will be the cost of one pound of Ins. This multiplied by $2\frac{1}{2}$ will give the cost of one pound of Sol., and by $4\frac{1}{6}$ will give the cost of one pound of N. The calculations for the above case will be:

Sol.,	-	-	200 pounds	× $2\frac{1}{2}$ =	500 pounds	Ins.
Ins.,	-	-	50 "	× 1 =	50 "	"
N.	-	-	60 "	× $4\frac{1}{6}$ =	250 "	"
					800 "	"

The price per ton, $40, divided by 800, gives 5 cents, the cost of 1 pound of Ins., 5 × $2\frac{1}{2}$ = $12\frac{1}{2}$ cents cost of pound of Sol., and 5 × $4\frac{1}{6}$ = $20\frac{1}{6}$, cost of 1 pound of N.

The proof of the correctness of these figures is plain:

Soluble phos. acid,	200 lbs.	@$12\frac{1}{2}$	cents	would cost	$25.00
Insoluble " "	50 lbs.	@ 5	"	" "	2.50
Nitrogen, - -	60 lbs.	@$20\frac{5}{6}$	"	" "	12.50
Total valuable ingredients in ton would cost,					$40.00

Another method for calculating the costs of ingredients, which consists in estimating the value of one at an assumed rate per pound, subtracting its total value, as thus computed, from the whole cost and dividing the remainder by the number of pounds of the other ingredients to get the cost of the latter, is too simple to require further explanation here.

VII. Report of Analyses and Valuations of Commercial Fertilizers.

Before proceeding to the specific subject of this article some general observations will be in place.

There are times when it is best to call a spade a spade, I think this is one. We hear a great deal of complaint of the sale of poor fertilizers at large prices, and of cheats, humbugs, and frauds. For these there is only too much ground. The loss that has fallen upon the farmers of Connecticut from such sources has doubtless amounted to many hundreds of thousands of dollars. But the blame does not all rest on the shoulders of dishonest dealers. A goodly share of it lies at the farmers' doors.

It is a fact, as common as it is deplorable, that a great many farmers will pay twenty-five dollars a ton for an article that is not worth fifteen rather than to buy one for forty or fifty that is worth the price. If they were careful to learn the quality of the goods they buy and to select the ones that furnish the valuable fertilizing ingredients they need, at the lowest rates, they would save money, and sometimes a goodly amount of it. As long as they will tempt dishonest men to cheat them by buying without heed to quality, they must be content to take the consequences.

Nor is this all. The best fertilizers often fail in consequence of drought or because they are used where they are

not needed, or are wrongly applied. To use phosphates alone where phosphoric acid is plenty and potash is lacking, is the worst kind of wastefulness. Very often, large portions of concentrated fertilizers are left in small spaces and the seed laid so close to them that the young plants are injured, when, if the manure had been uniformly mixed with the soil, so that the largest possible number of roots might have fed on it and none have been injured, a good crop would have resulted. In a great many such cases the evil that comes from the farmer's carelessness is charged to honest manufacturers or dealers whose wares were good and well worth what was charged for them.

There are a few facts too, which it would be well for some manufacturers to ponder. There was a time when bone mixed with oyster shells, plaster, and salt cake, could be sold for pure bone; phosphates adulterated with muck, marl, and sand, without detection; and materials palmed off as dissolved bone or superphosphate which had not been treated with acid and contained no soluble phosphoric acid at all. But farmers are learning better than to buy such goods, and they are leaving the market for want of sale.

It should be the object of the manufacturer to make his fertilizers of uniform quality and high grade. This can be done. At least some manufacturers do it. Abundant experience in this country and in Europe, proves that the manufacture of high grade fertilizers is, on the long run, the most profitable. Such wares are gradually and surely superseding the inferior ones in our markets just as they have already done in the best markets of Europe. It is true that by shrewd business management, judicious and plentiful advertising, easy credits, and heavy commissions to agents, lower grade goods may be sold in large quantities and at large profits. But, as farmers get educated,—and they are learning very fast—they let such fertilizers go, and buy the better ones. The time for nitrogenous superphosphates, one half of whose phosphoric acid is insoluble is past. The time for those with eight or ten per cent. or more of soluble phosphoric acid is come.

The chief defects of the artificial fertilizers in our markets are the small quantity of soluble phosphoric acid in the superphosphates, the rather small content of nitrogen in the nitrogenous superphosphates, and, in many cases, the lack of fineness of pulverization. With a little more acid applied in the making of superphosphates, to render the phosphates soluble, a little more nitrogen, sometimes a little finer grinding, and in the case of bone-dust a thorough steaming of the bones, and omitting a reasonable portion of the ballast of water, sand, and plaster, which they contain, our fertilizers would compare favorably with the best foreign articles. The improvement in our fertilizer market within the last eight years is enormous, but there is room for more.

Some dealers are adopting the method of selling their wares at prices based upon the guaranteed composition, charging each pound of nitrogen, phosphoric acid, and potash, at a certain rate, and making the price of the whole quantity accordingly. The more farmers encourage this method of sale by their patronage the better it will be for them.

I venture a few words of practical advice to Connecticut farmers who purchase commercial fertilizers.

1st. Buy none that are not accompanied by statements of composition as the State law directs, and guaranteed equal to the analyses. Give preference to those placed under the supervision of the Station. If you are in doubt as to whether an article is equal to the guarantee, select a sample in accordance with the directions given by the Station, and send it to the Station for analysis.

2d. Of those so guaranteed, select the ones that furnish, in the best forms and at the lowest cost, the ingredients that your crops need and your soils fail to supply.

3d. As to the best forms, remember that nitrogen is in its most readily available forms in sulphate of ammonia and nitrate of soda, that it becomes quickly useful to the plant in Peruvian guano, more slowly so in dried blood, meat scraps, and fish, and is very long in becoming available in leather scraps, hoof and horn shavings, hair, and the like. Soluble phosphoric acid is ready for use at once. The insoluble

phosphoric acid of fish, meat, finely steamed bones, acts more or less quickly, but in coarse pieces of bone and in bone-black its action is very slow. In the South Carolina, Navassa, Canada, and other mineral and fossil phosphates, it is of comparatively little value. When slow action will suffice, consider whether you cannot get the less readily available materials enough cheaper to make them the most profitable.

4th. To find how much nitrogen, phosphoric acid, or other valuable plant-food a fertilizer contains, look at the analysis and remember that each per cent., or one pound in one hundred makes 20 pounds in a ton of 2,000 pounds. To find how much each ingredient costs per pound, compare the composition and price in accordance with the explanations and tabular statements given in this report.

5th. The deficiencies of plant-food in a given soil can be best learned from actual trial. "The proof of the pudding is the eating." Where bone does best, there it is in order, where potash salts will bring up failing crops, there is the place to use them. If you have not your own experience or that of others in like circumstances to guide you, try experiments on a small scale with different materials on some such plan as recommended by the Station,* find what materials are most economical, use them, and let others go.

ESTIMATED COMMERCIAL VALUES.

The "estimated commercial values," are omitted from the tabular statements of analyses and valuations of fertilizers in the present report. This is a departure from the common practice in this country. The reasons for it are simple.

A good many farmers and other people are in the habit of taking up such reports as these, overlooking or only glancing at the analyses and judging the articles mainly or entirely by the estimated values. This is natural. They understand dollars and cents better than nitrogen and phosphoric acid. But it is not right nor best. Because one fertilizer "analyzes," $45.00 and another $40.00 a ton, it does not follow that the former will in every case, show the best results in use. As a

* See Article VIII, on Farm Experiments with Fertilizers.

class those that show the highest commercial values will, certainly, on the average bring the best crops. But a fertilizer that "analyzes" $30.00 may in a given case, furnish just the materials the crop needs and the soil fails to supply, while one that "analyzes" $40.00 does not.

What is wanted is to know what the fertilizers contain and to select those that furnish the needed ingredients in the best forms and at the lowest cost. To facilitate this we have taken a good deal of pains to calculate the costs of the nitrogen, phosphoric acid, and potash, and give the results in the tables along with the analyses. To these we invite especial and careful attention.

In the valuation of fertilizers it is important to distinguish between the *agricultural values*, which are measured by their effect when used, and the *commercial values*, which are based upon the market values of their ingredients.

The agricultural value of the same ingredient in different fertilizers is affected by a variety of circumstances. For instance, the nitrogen of a majority of the superphosphates in our markets comes from fish, dried blood, and meat. In some, castor pomace, leather scraps, and other cheaper materials are used. The fish and blood are worth a great deal more than the leather scraps, both agriculturally and commercially. So likewise the insoluble phosphoric acid is supplied by different ingredients, by steamed bone, meat, and fish, in which it becomes more or less quickly available to the plant, by bone black, in which its action is very slow, and by fossil and mineral phosphates in which its agricultural value is very small indeed.

Again, a pound of nitrogen or phosphoric acid is worth a great deal more in a fertilizer that is fine and dry, than in one that is wet and lumpy. The value of a fertilizer for a given case depends, too, upon the proportions of its ingredients; upon the character of the soil; upon the climate, whether dry or wet, warm or cold; upon the method of application and culture; and upon the ways the crop makes use of the food placed at its disposal. These conditions are so varied, that the value of a given fertilizer to the user, its agricultural

value, cannot be estimated accurately from the percentages of its valuable ingredients.

The commercial values of fertilizers are also influenced by conditions, which, though far less variable than those which affect the agricultural values, are still too much so to allow always of accurate computation. Among these, are the kinds of and proportions of the raw materials which are used in making the fertilizers and which cannot always be determined with satisfactory accuracy in the laboratory, and the variations in the market price, amounts purchased, time of payment, and cost of freight.

In brief, the agricultural values of fertilizers are subject to variations dependent upon the proportions and forms of combination of the valuable ingredients, the mechanical condition, the circumstances of soil, application, culture, climate, and crop. These are so different in individual cases that accurate estimates of the agricultural value from the composition are impracticable.

The commercial values, though admitting of more accurate calculation, are yet subject to variations dependent upon the sources of the ingredients, the fluctuations of the markets, the conditions of purchase, and costs of transportation. These are not so great as justly to prevent their use as the most forcible means of illustrating frauds, or as the first step of a process of education o farmers and manufacturers. For such purposes, they are in the highest degree proper and useful. But the time ought sooner or later to come, when the attention of farmers can be directed to a more thorough study of the nature of the fertilizers themselves. In the belief that that time is already near in Connecticut, and in the hope of hastening its arrival, the estimated values have been omitted from the following tables of analyses and valuations of fertilizers. In some cases, however, they have, as a matter of interest, been given in other places.

The next step in advance in the publication of analyses of fertilizers should be, I think, the omission of the money valuations entirely and the simple statement, side by side, of the percentages of valuable ingredients as guaranteed by the sellers and found in the analysis. This method, already in general use in Germany, is illustrated in the accounts of Table X in the present report. Such comparative statements would have been employed more extensively here, had it not been for the fact that so few of the articles were accompanied by clear statements of analysis, as to render the practical carrying out of the plan quite difficult.

As a further improvement in the methods of stating analyses, the omission of the percentages of insoluble phosphoric acid in superphosphates, except, perhaps, that which comes from well-prepared vegetable or animal refuse other than bone-black, would be advisable.

I desire again to urge and to insist strongly upon the propriety of giving percentages of nitrogen, instead of ammonia, and of phosphoric acid instead of bone phosphate, in the analyses which accompany packages of fertilizers offered for sale. The reasons for this have been explained in article IV.

REPORT OF ANALYSES AND VALUATION OF FERTILIZERS.

The narrow limits within which this report is by necessity confined prohibit as full descriptions as might be desired and would otherwise be given of individual articles, and compels us to condense the statements as far as possible into tabular forms.

The majority of the analyses reported herewith were made of samples furnished by consumers, a number were selected by the officers of the Station at places where they were on sale, others were furnished by manufacturers or sellers who desired to know the composition of their articles and have consented to the publication of the results. A list of names of manufacturers, sellers, and parties furnishing the samples precedes the tables. The prices per ton are those given by parties from whom the samples were received. They are believed to be correct for the places where the individual

articles were obtained, though subject to variations dependent upon freights, time of payment, quantity purchased, etc., etc. No dealer is bound by any price given here.

The classification adopted in the following report is given herewith:

A. Fertilizers whose chief valuable ingredient is Nitrogen.

CHEMICAL PRODUCTS:

NITRATE OF SODA, SULPHATE OF AMMONIA.

ANIMAL REFUSE (SLAUGHTER-HOUSE PRODUCTS, &c.):

DRIED BLOOD, MEAT SCRAP, OTHER ANIMAL REFUSE.

VEGETABLE REFUSE:

CASTOR POMACE.

FISH MANURES:

DRY GROUND FISH, DRIED FISH SCRAP, HALF DRY FISH SCRAP.

PERUVIAN GUANOS:

STANDARD (GUANAPE), GUARANTEED, RECTIFIED.

B. Fertilizers whose chief valuable ingredient is Phosphoric Acid.

a. With Nitrogen.

NITROGENOUS PHOSPHATES AND SUPERPHOSPHATES:

BONE MANURES:

PURE BONE, IMPURE BONE.

b. Without Nitrogen.

SUPERPHOSPHATES (ACID PHOSPHATES):

PHOSPHATES (not acidified):

C. Fertilizers whose chief valuable ingredient is Potash.

GERMAN POTASH SALTS:

SULPHATES (BETTER), CHLORIDE (MURIATE), PREPARED KAINIT,
SULPHATES (POORER), LEOPOLDSHALL KAINIT.

REFUSE PRODUCTS:

D. Fertilizers prepared for special crops.

MATFIELD FERTILIZERS:

STOCKBRIDGE FERTILIZERS:

E. Miscellaneous.

F. Inferior Articles.

List of names of Manufacturers or Importers of Fertilizers of following tables, with names of Dealers by whom they were offered for sale, and of Parties by whom the Samples were furnished.

Station Number.	Manufactured or Imported by	Offered for Sale by	Sample Furnished by
3.	H. J. Baker & Bro., New York,	H. J. Baker & Bro.,	Chester Sage.
4.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Chester Sage.
5.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Chester Sage.
6.	Birchall & Chapman, Port Morris, N. Y.,	I. N. Leonard, General Agent,	E. J. Bradley.
8.	Birchall & Chapman, Port Morris,	H. B. Knapp, Sub Agent,	David Hall.
10.	G. W. Miles, Milford, Conn.,	G. W. Miles,	Middlefield Farmers' Club.
11.	G. W. Miles,	Southmayd & Gardiner, Middletown,	Middlefield Farmers' Club.
12.	Russell Coe, Linden, N. J.,	Southmayd & Gardiner,	Middlefield Farmers' Club.
14.	Thompson & Edwards, Chicago,	Southmayd & Gardiner,	Middlefield Farmers' Club.
15.	Preston & Sons, Greenpoint, L. I.,	Southmayd & Gardiner,	Middlefield Farmers' Club.
16.	Agents of Peruvian Government,	Southmayd & Gardiner,	Middlefield Farmers' Club.
17.	Bridgeport Sulphuric Acid Co.,	Southmayd & Gardiner,	Middlefield Farmers' Club.
18.	Thompson & Edwards, Chicago,	Southmayd & Gardiner,	Middlefield Farmers' Club.
19.	Lodi Manufacturing Co.,	A. G. & R. A. Pease, Middletown,	Middlefield Farmers' Club.
20.	Manhattan Co., N. Y.,	Southmayd & Gardiner,	Middlefield Farmers' Club.
21.		A. G. & R. A. Pease,	Rev. W. Clift.
23.	Manhattan Co., N. Y.,	G. S. Allyn & Co.,	M. W. Terrill.
24.	G. S. Allyn & Co., Mystic River, Conn.,	Thompson & Edwards,	M. W. Terrill.
25.	Thompson & Edwards,	Thompson & Edwards,	M. W. Terrill.
26.	Thompson & Edwards,	G. W. Miles,	M. W. Terrill.
27.	G. W. Miles,	G. W. Miles,	M. W. Terrill.
28.	G. W. Miles,	C. H. Marble & Co., Boston,	J. M. Hubbard.
29.		J. J. H. Gregory, Marblehead, Mass.,	J. M. Hubbard.
30.	Riverside Phosphate Works,	Jacksons & Bowker, Boston,	J. M. Hubbard.
31.	Brighton Abattoir,	Jacksons & Bowker, Boston,	J. M. Hubbard.
32.		Jacksons & Bowker, Boston,	J. M. Hubbard.
33.			

List of names of Manufacturers or Importers of Fertilizers of following tables, with names of Dealers by whom they were offered for sale, and of Parties by whom the Samples were furnished.

Station Number.	Manufactured or Imported by	Offered for Sale by	Sample Furnished by
34.	Lodi Manufacturing Co., N. Y.,	Southmayd & Gardiner,	J. M. Hubbard.
35.		Southmayd & Gardiner,	J. M. Hubbard.
36.	Thompson & Edwards,	Southmayd & Gardiner,	Middlefield Farmers' Club.
38.		C. L. Willard, Hartford,	S. M. Wells.
39.		H. J. Baker & Bro.,	S. M. Wells.
41.	H. V. Davis, New Bedford, Mass.,	G. E. White, N. Y.,	M. W. Wilcox.
42.	E. F. Coe, Williamsburgh, L. I.,	D. B. Warner & Son, E. Haddam,	D. B. Warner & Son.
43.	Joseph Lister, Chicago,	Joseph Barry, Middletown,	M. W. Wilcox.
44.			M. W. Wilcox.
45.	Navassa Phosphate Co.,	J. Reed, New York,	M. W. Wilcox.
46.			M. W. Wilcox.
47.	Agents for Peruvian Government,	Southmayd & Gardiner, Middletown,	M. W. Wilcox.
48.			M. W. Wilcox.
49.	Kearney Chemical Works, N. Y.,	John Reed, New York,	M. W. Wilcox.
51.		Southmayd & Gardiner, Middletown,	M. W. Wilcox.
53.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Chas. Hubbard.
54.	Geo. W. Baker, N. Y.,	Nelson Alvord, Southport,	H. J. Baker & Brother.
55.	Geo. W. Baker,	Nelson Alvord,	Rev. E. L. Wells.
56.	Bridgeport Sulphuric Acid Co.,	T. B. Wakeman,	Rev. E. L. Wells.
57.	Hobson, Hurtado & Co., New York,	Hobson, Hurtado & Co.,	Rev. E. L. Wells.
58.	Peck Brothers, Northfield,	Peck Brothers,	W. M. Habirshaw, F. C. S.
59.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Mr. Peck.
60.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Geo. B. Forrester.
61.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Geo. B. Forrester.
62.	Peter Cooper, N. Y.,	Peter Cooper,	Geo. B. Forrester.
63.	J. O. & E. Smith, South Canterbury,	J. O. & E. Smith,	T. S. Gold.
75.	Jas. A. Byrnes, Springfield, Mass.,	Jas. A. Byrnes,	J. O. & E. Smith.
76.	Jas. A. Byrnes,	Jas. A. Byrnes,	L. F. Mellen.
77.	Jas. A. Byrnes,	Jas. A. Byrnes,	L. F. Mellen.
79.	G. W. Miles,	G. W. Miles,	G. W. Miles.
80.	G. W. Miles,	G. W. Miles,	G. W. Miles.
81.			S. M. Wells.
91.	J. Lister,	P. W. Bennett,	Martin Loveland.
92.	P. W. Bennett, Middlefield.	G. W. Miller & Son,	M. W. Terrill.
93.	Geo. W. Miller & Son, Middlefield,	H. J. Baker & Bro.,	M. W. Terrill.
94.	H. J. Baker & Bro.,	Lister Brothers,	T. B. Wakeman.
95.	Lister Brothers, Newark, N. J.,	Wm. Meeker & Son, Southport,	Rev. E. L. Wells.
96.	Lister Brothers,	Wm. Meeker & Son,	Rev. E. L. Wells.
97.	Lister Brothers,	Horace Staples, Westport,	Rev. E. L. Wells.
98.	Lister Brothers,	Quinnipiac Fertilizer Co.,	A. C. Taylor.
99.	Quinnipiac Fertilizer Co., New Haven,	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.
100.	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.
101.	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.
102.	Strong, Barnes, Hart & Co., New Haven,	Strong, Barnes, Hart & Co.,	Strong, Barnes, Hart & Co.
105.	R. B. Brown & Co., St. Louis,		R. B. Brown & Co.,
108.	Agents of Peruvian Government,	C. L. Willard, Hartford,	Andrews Brothers.
109.	Charter Oak Fertilizer Co., Hartford,	Charter Oak Fertilizer Co.,	G. W. Williams.
110.	Charter Oak Fertilizer Co.,	Charter Oak Fertilizer Co.,	G. W. Williams.
111.	Matfield Fertilizer Co., Boston,	Matfield Fertilizer Co.,	Matfield Fertilizer Co.
112.	Matfield Fertilizer Co.,	Matfield Fertilizer Co.,	Matfield Fertilizer Co.
113.	Matfield Fertilizer Co.,	Matfield Fertilizer Co.,	Matfield Fertilizer Co.
114.	Matfield Fertilizer Co.,	Matfield Fertilizer Co.,	Matfield Fertilizer Co.
115.	Matfield Fertilizer Co.,	Matfield Fertilizer Co.,	Matfield Fertilizer Co.
116.	Pacific Guano Co., Boston,	Pacific Guano Co.,	Pacific Guano Co.
117.	E. F. Coe, Williamsburg, N. Y.,	J. P. Barstow & Co., Norwich,	J. P. Barstow & Co.
120.	Sternfels Bone Fertilizing Co., N. Y.,	Sternfels Bone Fertilizing Co.,	Arnold Rudd.
121.	Lombard & Matthewson, Warrenville, Ct.,	Lombard & Matthewson,	John D. Gaylord.
122.	Lombard & Matthewson,	Lombard & Matthewson,	John D. Gaylord.
125.	W. H. Bowker & Co., Boston,	W. H. Bowker & Co.,	Dr. J. W. Alsop, Jr.
126.	R. H. Allen & Co., N. Y.,		Southmayd & Gardiner.
127.	E. F. Coe, Williamsburgh, L. I.,	J. P. Barstow & Co.,	J. P. Barstow & Co.
128.	Russell Coe, Linden, N. J.,	J. P. Barstow & Co.,	J. P. Barstow & Co.

List of names of Manufacturers or Importers of Fertilizers of following tables, with names of Dealers by whom they were offered for sale, and of Parties by whom the Samples were furnished.

Station Number.	Manufactured or Imported by	Offered for Sale by	Sample Furnished by
129.	Lister Brothers, Newark, N. J.,		J. P. Barstow & Co.
130.	Thompson & Edwards, Chicago,	J. A. Lewis, Willimantic,	A. B. Fuller.
131.	Wm. Raynor, Greenpoint, L. I.,	Mr. Hulburt, Westfield,	Dr. J. W. Alsop, Jr.
132.	J. O. & E. Smith, South Canterbury,		J. P. Barstow & Co.
133.	Rumford Chemical Works, Providence, R. I.,		J. P. Barstow & Co.
134.	Preston & Sons, Greenpoint,	Southmayd & Gardiner, Middletown,	W. Balentine.
135.	Russell Coe,	Southmayd & Gardiner,	W. Balentine.
136.	Agents for Peruvian Government,	Southmayd & Gardiner,	W. Balentine.
137.	Agents for Peruvian Government,	Southmayd & Gardiner,	W. Balentine.
138.	J. Lister, Chicago,	Southmayd & Gardiner,	W. Balentine.
139.	Thompson & Edwards,		F. Ellsworth.
142.	Strong, Barnes, Hart & Co., New Haven,	Strong, Barnes, Hart & Co.,	J. M. Hubbard.
143.		Wm. H. Bowker & Co.,	W. H. Bowker & Co.
145.		J. C. Hendrickson, Jamaica, L. I.,	J. C. Hendrickson.
146.	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.
147.	Matfield Fertilizer Co.,	Southmayd & Gardiner,	W. O. Atwater.
148.			S. M. Wells.
149.	Wm. H. Bowker & Co.,	Wm. H. Bowker & Co.,	M. W. Wilcox.
150.	Brighton Abattoir,	N. Jackson & Sons,	W. O. Atwater.
151.	Brighton Abattoir,	N. Jackson & Sons,	W. O. Atwater.
152.	Brighton Abattoir,	N. Jackson & Sons,	W. O. Atwater.
153.	Brighton Abattoir,	N. Jackson & Sons,	W. O. Atwater.
154.	Brighton Abattoir,	N. Jackson & Sons,	W. O. Atwater.
157.	W. H. Bowker & Co.,		Dr. J. W. Alsop.
159.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Dr. J. W. Alsop.
160.		W. H. Bowker & Co.,	Dr. J. W. Alsop.
161.		W. H. Bowker & Co.,	Dr. J. W. Alsop.
162.	W. H. Bowker & Co.,	W. H. Bowker & Co.,	Dr. J. W. Alsop.

163.	H. J. Baker & Bro.,	H. J. Baker & Bro.,	Dr. J. W. Alsop.
164.	Agents of Peruvian Government,	F. Ellsworth, Hartford,	W. Balentine.
165.	Thompson & Edwards,	F. Ellsworth,	W. Balentine.
166.	Agents of Peruvian Government,	Rodney Kellogg, Hartford,	W. Balentine.
167.	Pacific Guano Co.,	Rodney Kellogg,	W. Balentine.
168.	Russell Coe, Linden, N. J.,	Rodney Kellogg,	W. Balentine.
169.	W. E Wheeler, Stratford, Conn.,	L. B. Bishop, New Haven,	W. Balentine.
170.	Russell Coe, Linden, N. J.,	L. B. Bishop, New Haven,	W. Balentine.
171.	Quinnipiac Fertilizer Co., New Haven,	R. B. Bradley & Co., New Haven,	W. O. Atwater.
172.	Quinnipiac Fertilizer Co.,	R. B. Bradley & Co.,	W. O. Atwater.
173.	Quinnipiac Fertilizer Co.,	R. B. Bradley & Co.,	W. O. Atwater.
174.	J. A. Byrnes, Springfield, Mass.,	Rodney Kellogg,	W. Balentine.
175.	L. B. Darling & Co., Pawtucket,	Rodney Kellogg,	W. Balentine.
177.	Atlantic & Virginia Fertilizer Co.,	Atlantic & Virginia Fertilizer Co.,	S. M. Wells.
179.	Green Brothers,	J. B. Smith, E. Hartford,	J. B. Smith.
181.	Thompson & Edwards, Chicago,	Southmayd & Gardiner,	
182.	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.,	Quinnipiac Fertilizer Co.
184.	H. J. Baker & Bro , N. Y.,	H. J. Baker & Bro.,	J. B. Smith.
185.	G. S. Allyn & Co., Mystic River,	G. S. Allyn & Co.,	Rev. Wm. Clift.
186.	Agents of Peruvian Government,	C. V. Mapes, N. Y.,	C. V. Mapes.
187.	Agents of Peruvian Government,	C. V. Mapes,	S. M. Wells.
191.	Agents of Peruvian Government,	C. V. Mapes,	C. V. Mapes.
192.	C. V. Mapes, N. Y.,	C. V. Mapes,	C. V. Mapes.
193.	Granby Manufacturing Co., Granby,	Granby Manufacturing Co.,	N. Eggleston.
194.	Mr. Salmon, Westport, Conn.,		S. B. Sherwood.
195.	Davis & Smith, Boston,		

TABLE II.

Nitrogenous Fertilizers.

NAME OF FERTILIZER.	Station Number.	ANALYSES. Moisture.	Phosphoric Acid.	Nitrogen.	Ammonia equivalent to Nitrogen.	Retail price per ton.	COSTS PER POUND. Nitrogen.	Phosphoric Acid.
CHEMICAL PRODUCTS:		Per ct.	Per ct.	Per ct.	Per ct.		Cents.	Cents.
Sulphate of Ammonia, H. J. Baker & Brother,	3	.....	.....	20.53	24.92	$97.50	23.7	——
Sulphate of Ammonia, W. H. Bowker & Co.,	161	0.44	.....	20.51	24.90	90.00	21.9	——
Nitrate of Soda, H. J. Baker & Brother,	163	1.18	.....	16.02	19.45	80.00	24.9	——
ANIMAL REFUSE:								
DRIED BLOOD:								
Dried Blood,	119	.....	——	10.87	13.19	——	——	——
Dried Blood,	141	8.96	——	8.92	10.82	——	——	——
Dried Blood, Brighton Abattoir,	150	20.03	2.72	10.49	12.73	——	——	——
Dried Blood,	160	15.83	1.35	11.48	13.98	45.00	18.7	7.5
MEAT SCRAP:								
Meat Scrap, Brighton Abattoir,	151	10.48	3.46	8.63	10.47	35.00	——	——
Long Island Fertilizer,	145	8.83	3.77	8.73	10.60	40.00	19.5	7.8
Tallow Scrap,	198	55.30	——	3.53	4.29	——	——	——
Azotin,	118	.....	——	11.71	14.21	——	——	——
OTHER ANIMAL REFUSE:								
Animal Dust	29	14.45	6.06	7.32	8.89	50.00	25.7	10.3
Azotin,	49	12.56	6.92	7.33	8.89	50.00	24.8	9.9
Dried Blood, Meat Scrap and Bone, Strong, Barnes, Hart & Co.,	102	12.26	5.20	8.08	9.80	40.00	19.7	7.9
Dried Blood, Meat Scrap and Bone, Strong, Barnes, Hart & Co.,	142	11.75	3.83	9.72	11.80	40.00	17.8	7.1
Peter Cooper's Hair Manure,	62	——	1.74	5.75	6.98	12.00	9.3	3.7
Hoof Shavings	194	——	——	11.84	14.38	——	——	——
VEGETABLE REFUSE:								
Castor Pomace,	35	6.83	2.11	4.80	5.83	25.00	22.1	8.8
Castor Pomace, H. J. Baker and Bro.	59	7.21	1.91	4.89	5.94	19.00	16.8	6.7
Castor Pomace, R. B. Brown & Co.,	105	19.13	2.42	5.29	6.42	19.00	15.2	6.1

TABLE III.

Fish Manures.

NAME OF FERTILIZER.	Station Number.	ANALYSES. Moisture.	Sand, etc.	Phosphoric Acid.	Nitrogen.	Ammonia equivalent to Nitrogen.	Retail price per ton.	COSTS PER POUND. Nitrogen.	Phosphoric Acid.
DRY GROUND FISH:		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		Cents.	Cents.
Ground Fish, G. W. Miles,	10	18.74	.....	7.65	8.06	9.78	$45.00	20.2	8.1
Fish Guano, G. W. Miles,	28	21.96	2.70	8.66	6.07	7.36	40.00	20.9	8.4
C. Island Guano, G. W. Miles,	80	8.63	1.43	7.74	8.84	10.73	——	——	——
Allyn's Fertilizer,	24	.....	.....	6.17	8.80	10.68	40.00	17.7	7.1
Allyn's Fertilizer,	185	6.34	.....	7.90	7.88	9.56	40.00	18.1	7.2
Dry Ground Fish, Quinnipiac Fertilizer Co.,	100	14.64	.....	6.67	7.50	9.11	45.00	22.1	8.8
Dry Ground Fish, Quinnipiac Fertilizer Co.,	140	10.85	.....	7.21	7.38	8.97	45.00	21.9	8.8
Dry Ground Fish, Quinnipiac Fertilizer Co.,	172	13.45	.....	7.55	7.96	9.66	45.00	20.5	8.2
DRIED FISH SCRAP:									
"Dry Fish," Green Brothers,	179	11.04	.....	10.51	8.60	10.44	28.00	10.9	4.4
"Dried Fish,"	182	9.37	.....	——	8.13	9.86	——	——	——
"Dry Fish,"	189	11.00	.....	——	7.46	9.05	——	——	——
"Fish Scrap,"	190	7.74	.....	——	7.10	8.61	——	——	——
"Dry Fish,"	196	7.59	.....	——	7.79	9.46	——	——	——
"Dry Fish,"	199	.....	.....	——	7.65	9.28	——	——	——
HALF DRY FISH SCRAP:									
Fish Scrap, "Half Dry,"	103	40.95	.....	6.23	5.33	6.47	16.00	10.2	4.1
Fish Scrap, "Half Dry,"	131	25.10	2.52	7.49	5.49	6.66	16.00	9.4	3.8
Fish Scrap, "Half Dry,"	197	56.83	.....	——	3.63	4.41	——	——	——

Fertilizers whose Chief Valuable Ingredient is Nitrogen.

We give, first, analyses* of nitrogenous fertilizers, commencing with chemical products and animal and vegetable refuse, as shown in Table II, and following with fish manures, in Table III, and Peruvian guano, in Table IV. As previously stated, the names of manufacturers, or importers, sellers, and parties who furnished the samples may be found, with the corresponding Station numbers, in the list on pages 57–61. Other explanations, of chemical composition, prices, etc., have been previously made. In lack of the space that would be required for extended descriptions of the individual articles, we simply call attention to the fact that in sulphate of ammonia and nitrate of soda the whole of the nitrogen is in forms fit for immediate use by the plant. Dried blood, meat scrap, fish and castor pomace, furnish nitrogen in forms not so immediately available as in the chemical products, and phosphoric acid in combinations which are slower in their action than that soluble in water. The value of these ingredients varies with the quality of the articles, being, of course, higher in those which are fine and dry, and lower in those which are wet and lumpy. All the samples of animal refuse except Nos. 62 and 194 were in very good mechanical condition.

It will be noticed that in the chemical products the nitrogen costs from 20 to 25 cents per pound, in the animal refuse it varies from 18 to 25 cents. In the fish guano it ranges a little lower, from 18 to 20 cents, while in the fish scrap it comes to only about 10 cents per pound. The latter is, taking into account quality and price, the cheapest fertilizer we have met with.

For reasons elsewhere explained, the estimated values per ton are not given here.

* The methods followed in executing the analyses herewith reported are, in general, such as have been adopted in the German agricultural experiment stations. Soluble phosphoric acid has been extracted on the filter with the aid of the Bunsen pump. That soluble in ammonium citrate has been estimated by the method of Fresenius, Neubauer, and Luck. *Zeitschrift für analytische Chemie*, X, 154 & 157. The determinations of phosphoric acid have been made uniformly by the molybdenum method, which, though somewhat more tedious than others commonly employed, we have preferred because of its reliability.

Peruvian Guanos.

The samples of Peruvian guano of which analyses are given in Table IV, herewith, are of three classes, designated in the table as No. 1 Standard, Guaranteed, and Rectified.

Those of the first class were designated by the retail dealers and buyers from whom the samples were obtained, by the terms "*No.* 1, 10 *per cent. Ammonia Standard*," *Guanape, and Raw Peruvian Guano.* They are all understood to be Guanape, and of the class to which the general appellation "Standard" is now given, and which are guaranteed to yield, on the average, 10 per cent. ammonia. The average amount of nitrogen is 8.45 per cent., corresponding to 10.26 per cent. ammonia. Sample No. 166 falls quite appreciably below the standard in nitrogen. It should be said, however, that it is, we believe, a rare exception, and even this sample is so rich in phosphoric acid and potash as to be, at the price at which it was sold, a very cheap article.

TABLE IV.

Peruvian Guanos.

NAME OF FERTILIZER.	Station Number.	ANALYSES.											VALUATIONS.					
		Moisture.	Sand, etc.	Phosphoric Acid.				Potash.	Nitrogen.	Ammonia equivalent to Nitrogen.	Retail price per ton.	Cost of one pound each, of valuable ingredients, at prices stated.					
				Available.		Insoluble.	Total.					Nitrogen.	Phosphoric Acid.			Potash.
				Soluble in water.	Soluble in ammonium citrate.								Soluble in water.	Soluble in ammonium citrate.	Insoluble.	
		Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.		Cts.	Cts.	Cts.	Cts.	Cts.
No. 1, Peruvian Guano—"Standard,"	16	16.60	2.10	5.75	8.81	11.69	17.44	*2.33	9.97	11.97	$60.00	15.6	9.3	6.7	4.5	6.0
No. 1, Peruvian Guano—"Standard,"	47	11.40	2.10	4.14	8.81	2.49	15.37	2.33	11.33	13.75	60.00	16.7	9.9	7.2	4.8	6.4
No. 1, Peruvian Guano—"Standard,"	105	21.57	....	5.25	9.82	2.50	17.90	3.24	8.56	10.39	58.50	17.8	10.6	7.6	5.1	7.0
No. 1, Peruvian Guano—"Standard,"	137	13.06	....	5.27	6.24	4.01	15.52	4.36	7.76	9.42	57.00	18.2	10.8	7.8	5.2	6.9
No. 1, Peruvian Guano—"Standard,"	164	15.30	....	6.05	5.59	1.39	13.03	4.60	7.52	9.12	57.00	19.3	11.5	8.3	5.5	7.4
No. 1, Peruvian Guano—"Standard,"	166	12.63	....	5.55	3.44	5.15	14.14	4.06	6.95	8.43	57.00	17.3	10.3	7.4	4.9	6.6
No. 1, Peruvian Guano—"Standard,"	191	14.88	....	5.11	7.10	5.04	17.25	3.54	7.88	9.57	†58.00	17.3	10.1	7.3	4.9	6.5
Average of above seven samples,	....	15.06	....	5.30	6.83	3.43	15.80	3.69	8.45	10.26	†58.00	17.				
No. 1, Peruvian Guano—Guaranteed (Cargo A),	186	13.11	11.39	4.55	4.35	7.10	16.00	3.45	5.87	7.12	56.00	20.1	12.1	8.7	5.8	7.7
No. 1, Peruvian Guano—Guaranteed (Cargo A),	187	12.54	11.36	4.50	5.11	7.49	17.10	3.36	5.79	7.03	56.00	19.9	11.8	8.5	5.7	7.6
No. 1, Peruvian Guano—Rectified,	57	12.61	1.80	10.67	None.	1.71	12.38	2.43	9.15	11.10	60.00	17.7	10.5	.....	5.1	6.7
No. 1, Peruvian Guano—Rectified,	136	14.90	....	10.02	2.89	None.	12.81	4.34	7.62	9.49	65.00	19.5	11.6	8.3	.....	7.4

* Not determined. The insoluble, 11.69, includes that soluble in ammonium citrate. † Assumed price. Nos. 16 and 47 were bought in 1876.

As a matter of interest, the amounts of phosphoric acid, soluble in water, and in ammonium citrate have been determined in all the samples (except No. 16) of this, as of the other classes. The average percentages in the seven samples of Standard are, nitrogen, 8.45, corresponding to ammonia, 10.26; phosphoric acid, soluble in water, 5.30, soluble in ammonium citrate, 6.83; insoluble, 3.48, total, 15.80, and potash, 3.69.

The two samples of "Guaranteed," were from "Cargo A." and guaranteed to contain, ammonia, 6.80, (corresponding to nitrogen, 5.60), phosphoric acid, soluble, 3.80, reverted, 11.50, insoluble, 3.00, and potash, 3.70. They proved equal or superior to the guarantees in all respects, except the so-called "reverted" phosphoric acid which fell somewhat short of the statements. This was probably due to a difference in the analytical methods followed.* For practical purposes, however, this is a matter of minor consequence, since all of the phosphoric acid of Peruvian guano is in comparatively available forms.

Of the samples of Rectified, No. 57 was guaranteed to contain 10 per cent. each of ammonia and soluble phosphoric acid, and 2 per cent. potash. The guarantees of No. 136 were 9½ per cent. each of ammonia and soluble phosphoric acid, and 2 per cent. potash. Both were equal or superior to the guarantees.

The costs of the valuable ingredients as shown in the above table are worthy of especial attention. The nitrogen averages from 17 to 20 cents per pound, and the phosphoric acid and potash are correspondingly low. It should be noted also,

* The methods employed by different chemists in this country, for determining the so-called "reverted," "reduced," or "precipitated" phosphoric acid, are, unfortunately, somewhat varied. That used here, (digesting the substance, after previous extraction with water, in a neutral solution of ammonium citrate of sp. gr. 109, for one-half hour at a temperature of 30°—40° C.) in the one which has been recommended by Fresenius, and adopted by the German experiment stations, and, as it seems to us, should be preferred, until some more satisfactory one is found in which chemists generally can join. The only ground for making these determinations in Peruvian guano, is for the sake of comparison with superphosphates, in which it has become a custom to estimate the phosphoric acid soluble in ammonium citrate, and designate it as "reverted."

that these ingredients in Peruvian guano are in very readily available and, consequently, valuable forms. Of over two hundred samples of fertilizers analyzed at the Station, leaving out a few articles of mere local importance like crude fish-scrap, no others have been found which, as a class, taking into account both quality and price, furnish the valuable ingredients of plant-food so cheaply as Peruvian guano.

The figures in column A below, show what would be the estimated values of the samples above described, when computed on the schedule used for nitrogenous superphosphates, nitrogen, 21 cents; phos. acid, soluble in water, 12½ cents; soluble in ammonium citrate, 9 cents; insoluble, 6 cents; potash, 8 cents per pound. The calculations of column B are on the same basis, except that the total phosphoric acid is reckoned at 9 cents per pound:

Brand.	Station Number.	Estimated Commercial Values per ton. A	B
No. 1, Standard,	47	$80.42	$75.24
" "	108	75.37	73.35
" "	137	68.89	67.50
" "	164	65.79	62.39
" "	166	61.92	61.14
" "	191	70.36	69.81
Average of 6 samples Standard,		70.46	68.24
No. 1, Guaranteed, Cargo A,	186	57.90	58.97
" " "	187	59.13	60.47
Average of 2 samples Guaranteed,		58.51	59.72
No. 1, Rectified,	57	71.04	64.60
" "	136	69.91	62.90
Average of 2 samples, Rectified,		70.47	63.75

Any detailed description here of the different brands of Peruvian guano in the market has been rendered unnecessary by the timely pamphlet on "Peruvian Guano, Its Qualities, Brands under Which It Is Sold, and Brief Directions for Using It," issued by authority of MM. Hobson, Hurtado & Co., Agents of the Peruvian government, No. 63 Pine st., New York. There are, however, a few points to which it seems proper to refer, as can be conveniently done by extracts, as follows:

Brands of Guano.

The following are the brands or designations under which Guano is placed on the market:

No. 1.—Peruvian Guano.
No. 1.—Peruvian Guano—Lobos.
No. 1.—Peruvian Guano—Guaranteed.
No. 1.—Peruvian Guano—Rectified.
No. 2.—Peruvian Guano.

* * * * *

Peruvian Guano Guaranteed.

By this brand is designated Guano that has been overhauled after being discharged from the vessel, the lumps crushed, the stones or petrified Guano (if any) and all other impurities removed by screening:—the Guano, in this shape is, therefore, in purer condition than when first imported.

In Guano sold under this brand, every condition that could interest the farmer is guaranteed; hence, its name.

It is warranted to be genuine Peruvian Guano.

It is warranted free from damage by sea-water and to be in dry, powdery condition, fit for immediate use in the drill.

The analysis of contents of each bag, is also warranted, and printed in full on one side; and, to guard, as far as practicable, against adulteration, the extremities of the twine with which the mouth of the bag is sewn, are secured by lead seals, on which the monogram of the trade mark * * is stamped. * * *.

Below this, is printed the analysis, stating the percentage of Ammonia, Phosphoric Acid in its different forms, and Potassa. Beneath the analysis is marked the retail price per ton of 2,000 lbs. to serve as a guide to the purchaser.

The manner in which the price of this Guano is fixed, forms one of its principal features. It is determined according to the analysis, allowing for the quantity of fertilizing ingredients contained in a ton of Guano, at the following rates:

For Ammonia,	- - - -	17½c. per lb.
" Soluble Phosphoric Acid,	- -	10c. "
" Reverted, " "	- -	8c. "
" Insoluble, " "	- -	2c. "
" Potassa, " "	- -	7½c. "

The sum of the several items, is taken as the price per ton.

No. 1. Peruvian Guano Rectified.

As we have said before, this brand consists of pure Guano, mixed with Sulphuric Acid. * * * *

"Rectified Guano," like the "Guaranteed," does not represent any particular grade. It may contain only 4 per cent. Ammonia, or it may hold 10 per cent. or even more; but whatever it may contain will appear in the analysis on the bag, and the price is regulated accordingly after the following rates:

For Ammonia,	-	-	-	20	cts. per lb.
" Soluble Phosphoric Acid,			-	10	" "
" Reverted "	"	-	-	8	" "
" Insoluble "	"	-	-	nil.	"
" Potassa,			-	7½	" "

In making the above citations we desire to call attention to the ways in which the Rectified and Guaranteed brands are prepared and sold. They are both finely ground and uniformly mixed, so as to render their composition uniform and their application easy, and the Rectified is further treated with sulphuric acid which fixes the ammonia and renders the phosphoric acid soluble. From our standpoint, however, in which not only the intrinsic propriety of these methods of preparation and sale, but also their beneficial effect upon the fertilizer market are more particularly considered, a still greater merit rests in the plain guarantee of composition and the fixing of the whole price per ton upon the guaranteed amounts of valuable ingredients. This amounts to selling plant-food by the pound, rather than an indefinite mixture of materials by the ton. It enables the buyer to buy just what he wants, and know what he is paying for it.

Had the Station been called upon to suggest methods for the sale of guano, I do not know how it could have proposed plans which, in respect to either the mode of preparation, form of guarantee, or price, would be fairer, more favorable to the buyer, or more useful in educating the public and elevating the tone of the trade, than those above described.*

Nitrogenous Phosphates and Superphosphates.

Table V gives analyses and valuations of these articles. The prices are those given with the samples, and in nearly

* Except that it would be better to use the term nitrogen, instead of ammonia, though the latter is more excusable for guano than for most other fertilizers, since much of its nitrogen exists as ready formed ammonia.

every case are as stated by the retail seller. We can, of course, do nothing else than give the prices, as thus stated to us, though the charges for a given brand by different sellers may differ from each other, and from that at which the manufacturer expects it to be sold. For instance, the figures for Nos. 128, 168, and 170, all of the same brand, are, respectively, $40.00, $45.00, and $50.00, which are as given to us by the dealers, from whose stocks they were taken. The samples of numbers below 47 were bought in 1875. In this table, as in the others, we invite special attention to the calculated costs of the valuable ingredients.

It will be seen, for instance, that the nitrogen varies from 19 to 41½ cts. per pound, and the other ingredients in like proportions. A careful study of these figures will show that the highest grade articles are almost uniformly the cheapest, and the lower grades the dearest.

TABLE V.

Nitrogenous Phosphates and Superphosphates.

NAME OF FERTILIZER.	Station Number.	ANALYSES. Moisture.	Sand, etc.	Phosphoric Acid. Available. Soluble.	Reverted.	Insoluble.	Total.	Potash.	Nitrogen.	Ammonia equivalent to Nitrogen.	VALUATIONS. Retail price per ton.	Cost of one pound each, of valuable ingredients, at prices stated. Nitrogen.	Phosphoric Acid. Soluble.	Reverted.	Insoluble.	Potash.
												Cents.	Cents.	Cents.	Cts.	Cents.
Dissolved Bone, Thompson & Edwards,..	14	9.02	3.77	1.31	.....	11.43	12.74	.....	3.65	4.44	$48.00	31.2	18.5	.....	8 9	.....
Dissolved Bone, Thompson & Edwards,..	25	8.71	.....	None.	.....	12.77	12.77	.....	4.25	5.15	48.00	30.3	.....	.....	8.6	.....
Dissolved Bone, Thompson & Edwards,..	107	12.37	.....	None.	.....	12.38	12.38	.....	3.99	4.84	47.50	31.5	.....	.....	9.0	.....
Dissolved Meat and Bone, Thompson & Edwards,	165	13.51	.....	None.	6 67	7.41	14.08	.....	5.20	6.31	50.00	24.5	.....	10.5	7.0	.....
Ammoniated Bone Superphosphate, Thompson & Edwards,	18	15.95	.90	None.	.....	8.31	8.31	.....	3.40	4.12	48.00	41.5	.....	.....	11.9	.....
Ammoniated Bone Superphosphate, Thompson & Edwards,	26	14.84	.....	None.	.....	13.78	13.78	.....	4.16	5.05	48.00	29.6	.....	.....	8.4	.....
Ammoniated Bone Superphosphate, Thompson & Edwards,	139	19.31	2.27	1.70	8.60	3.22	13.52	.....	2.99	3.62	50.00	29.0	17.2	12.4	8.3	.....
"Pure Bone"	81	7.54	.....	.....	.....	15.22	15.22	.....	5.46	6.62	45.00	22.9	.....	.....	6.5	.....
Riverside Phosphate,	30	20.16	.....	.....	.....	20.44	20.44	.....	4.18	5.07	45.00	22.4	.....	.....	6.4	.....
Ammoniated Bone Superphosphate, G. W. Miles,	11	19.37	2.60	9.91	0.16	0.80	10.87	.....	2.75	3.33	48.00	26.8	15.9	11.4	7.7	.....
Ammoniated Bone Superphosphate, G. W. Miles,	27	18.50	.....	4.92	.....	4.64	9.56	.....	2.98	3.62	.....	.....	.....	.....	.....	.....

Bone Superphosphate, G. W. Miles,	79	24.15	3.40	9.28	2.61	0.91	12.80	.....	2.57	3.12	45.00	23.7	14.1	10.1	6.8	.....
Ammoniated Bone Superphosphate, Russell Coe,	12	18.47	0.35	6.24	1.28	6.39	13.91	.....	1.92	2.33	42.50	26.5	15.8	11.4	7.6	.....
Ammoniated Bone Superphosphate, Russell Coe,	135	20.16	.....	12.05	0.34	0.57	12.96	.....	2.94	3.56	40.00	19.2	11.4	8.2	5.5	.....
Ammoniated Bone Superphosphate, Russell Coe,	128	21.01	.....	11.67	0.92	0.20	12.79	.....	2.24	2.71	40.00	20.7	12.3	8.9	5.9	.....
Ammoniated Bone Superphosphate, Russell Coe,	168	19.35	.....	12.53	0.46	.....	12.99	.....	2.04	2.47	45.00	23.2	13.8	9.9	.....	.....
Ammoniated Bone Superphosphate, Russell Coe,	170	22.27	.....	11.05	1.08	.....	12.13	.....	3.84	4.66	50.00	22.9	13.7	9.8	.....	.....
Ammoniated Bone Superphosphate, Preston & Sons,	15	21.75	3.60	9.94	.....	4.10	14.04	.....	1.67	2.03	42.50	24.2	14.4	.....	6.9	.....
Ammoniated Bone Superphosphate, Preston & Sons,	134	24.97	.....	7.86	1.32	1.78	10.96	.....	2.87	3.48	40.00	23.1	13.8	9.9	6.6	.....
Superphosphate, Bridgeport Sulphuric Acid Co.,	17	23.33	6.90	2.82	8.23	1.89	12.94	.....	0.88	1.06	45.00	33.9	20.2	14.5	9.7	.....
Superphosphate, Bridgeport Sulphuric Acid Co.,	56	9.37	8.41	3.67	.....	7.43	11.10	.....	1.14	1.38	.....	.....	.....	.....	.....	.....
Superphosphate, Lister Bros.,	95	19.09	.....	10.29	2.12	1.38	13.79	.....	2.65	3.21	45.00	22.3	13.3	9.5	6.4	.....
Superphosphate, Lombard & Matthewson,	122	4.29	4.78	5.75	6.38	2.89	15.02	.....	2.92	3.54	50.00	25.2	15.0	10.8	7.2	.....
Superphosphate, J. O. & E. Smith,	63	12.35	1.45	5.06	.....	12.84	17.90	.....	2.83	3.43	.....	.....	.....	.....	.....	.....
Superphosphate, J. O. & E. Smith,	132	19.53	2.50	5.71	4.94	0.27	10.92	.....	2.67	3.24	40.00	24.2	14.4	10.4	6.9	.....
Superphosphate, Wilson's,	133	19.70	2.62	5.84	1.19	1.04	8.07	.....	2.39	2.90	40.00	29.9	17.8	12.8	8.6	.....
Superphosphate, Stagg's,	169	13.52	.....	11.22	0.44	1.75	13.41	.....	2.65	3.21	55.00	27.4	16.3	11.7	7.8	.....
Phosphatic Blood Guano, Manhattan,	20	21.56	2.20	6.75	3.40	0.71	10.86	.....	2.99	3.63	53.00	30.5	18.2	13.1	8.7	.....
Phosphatic Blood Guano, Manhattan,	23	21.83	0.93	7.83	1.75	2.08	11.66	.....	2.90	3.52	.....	.....	.....	.....	.....	.....
Abattoir Guano, E. F. Coe,	42	16.24	1.59	7.39	4.11	.....	11.50	3.92	3.32	4.02	50.00	22.8	13.6	9.8	.....	8.7
Abattoir Guano, E. F. Coe,	127	17.61	1.63	8.91	1.69	1.23	11.83	3.99	3.39	4.11	50.00	22.1	13.2	9.5	6.3	8.4
Ammoniated Superphosphate, E. F. Coe,	117	19.16	1.25	10.22	2.80	1.66	14.68	.....	2.54	3.08	42.00	20.4	12.1	8.7	5.8	.....
Soluble Nitrogenous Phosphate, Quinnipiac Fertilizer Co.,	101	19.27	.....	7.24	.....	0.46	7.70	.....	4.41	5.35	40.00	22.6	13.4	.....	6.5	.....
Soluble Nitrogenous Phosphate, Quinnipiac Fertilizer Co.,	146	16.15	.....	8.16	3.39	2.55	14.10	.....	3.33	4.00	40.00	19.3	11.4	8.3	5.5	.....
Soluble Nitrogenous Phosphate, Quinnipiac Fertilizer Co.,	171	17.72	.....	7.65	2.29	1.91	11.85	.....	2.49	3.02	45.00	26.2	15.6	11.3	7.5	.....
Pine Island Guano, Quinnipiac Fertilizer Co.,	99	15.93	.....	4.95	2.32	1.93	9.20	.....	5.64	6.84	45.00	22.1	13.2	9.5	6.3	.....
Pine Island Guano, Quinnipiac Fertilizer Co.,	173	18.12	.....	4.93	0.96	0.84	6.73	.....	6.25	7.58	45.00	22.7	13.6	9.8	6.5	.....
Charter Oak Fertilizer,	110	13.45	8.64	8.57	.....	9.07	17.64	.....	1.77	2.14	.....	.....	.....	.....	.....	.....
Pacific Soluble Guano,	116	10.29	.....	5.06	1.50	7.23	13.79	4.62	2.42	2.93	45.00	24.4	14.5	10.4	4.6	9.3
Pacific Soluble Guano,	167	21.87	.....	3.46	1.39	7.13	11.98	1.80	2.48	3.01	45.00	31.3	18.6	13.4	6.0	11.9
Sternfel's Ammoniated Dissolved Bones,	120	16.83	5.83	2.64	2.31	0.44	5.39	.....	2.09	2.53	40.00	41.9	24.9	17.9	12.0	.....

TABLE V—Continued.

NAME OF FERTILIZER.	Station Number.	ANALYSES.								VALUATIONS.					
		Moisture.	Sand, etc.	Phosphoric Acid.				Potash.	Nitrogen.	Amount equivalent to Nitrogen.	Retail price, per ton.	Cost of one pound each, of valuable ingredients, at prices stated.			
				Available.			Total.					Nitrogen.	Phosphoric Acid.		Potash.
				Soluble.	Reverted.	Insoluble.							Soluble.	Reverted.	Insoluble.	
												Cents.	Cents.	Cents.	Cts.	Cents.
Orient Ammoniated Bone Superphosphate,	177	17.69	.....	5.96	1.55	8.05	15.56	.....	2.02	2.45	$45.00	27.6	16.4	11.8	6.6	.....
Bradley's Sea Fowl Guano,	148	13.69	.....	5.68	1.79	5.28	12.75	.....	2.37	2.87	55.00	36.5	21.8	15.7	7.0	.....
SLAUGHTER HOUSE PRODUCTS:*																
Animal Fertilizer, Brighton Abattoir,	153	9.92	.....	.....	.....	.....	11.90	....	6.53	7.92	40.00	20.1	.....	.....	5.8	.....
Acidulated Animal Fertilizer, Brighton Abattoir,	31	17.59	. ...	6.37	.....	1.11	7.48	.....	5.33	6.47	40.00	21.2	12.6	.....	6.1	.....
Acidulated Animal Fertilizer, Brighton Abattoir,	154	17.26	.....	7.85	0.59	.....	8.44	.....	7.60	9.32	45.00	17.9	10.7	7.7	.....	.....
HOME-MADE SUPERPHOSPHATES:																
By adding Sulphuric Acid to Ground Bone, No. 43,	44	9.65	.....	1.27	.....	17.73	19.00	.....	2.70	3.27	42.00	24.6	14.7	.....	7.0	.....
By adding Sulphuric Acid to Navassa Phosphate, No. 45,	46	15.85	.....	7.96	.....	11.56	19.52	.....	.....	.....	28.00	.....	10.3	.....	5.0	.....
By adding Sulphuric Acid to Guanape Guano, No. 47,	48	16.01	.....	9.05	.....	3.77	12.82	1.62	7.69	9.33	57.40	19.4	11.6	.....	5.6	7.4

* See, also, Nos. 29, 49, 102, and 142, under Animal Refuse, Table II.

As a matter of interest to some persons, we have calculated the "commercial values" per ton, using as a schedule of valuations Nitrogen, 21 cts.; Phosphoric Acid, Soluble, 12½ cts.; Reverted, 9 cts.; Insoluble, 6 cts., and Potash 8 cts. per lb. In the articles containing more than 5 per cent. of insoluble phosphoric acid, however, the latter, when not evidently from animal matters, is taken at 5 cts. per pound. Consultation with Prof. Goessmann, State Inspector of Fertilizers for Massachusetts, indicates that his experience coincides with our own in the fairness of these rates for the present state of the market. But we can not repeat too often, nor insist too strongly that such valuations are not always just expressions of the relative values of the articles.

Estimated Commercial Values per ton of Nitrogenous Phosphates and Superphosphates of Table V:

No.	Amount.	No.	Amount.	No.	Amount.	No.	Amount.
11,	$37.57	31,	$39.64	107,	$31.61	139,	$36.15
12,	33.63	42,	46.08	110,	39.74	146,	43.55
14,	32.32	44,	35.79	116,	40.06	148,	31.60
15,	36.78	46,	33.76	117,	43.24	153,	41.70
17,	27.82	48,	62.04	120,	20.06	154,	52.60
18,	24.25	56,	22.87	122,	41.58	165,	42.73
20,	36.40	63,	39.84	127,	47.41	167,	31.57
23,	37.40	79,	39.78	128,	40.47	168,	40.71
25,	33.17	81,	41.19	132,	34.70	169,	42.07
26,	34.00	95,	42.32	133,	28.02	170,	45.69
27,	30.38	99,	42.55	134,	36.32	171,	35.99
30,	42.08	101,	37.17	135,	43.77	173,	41.31
						177,	34.22

TABLE VI.

	Ground Bone, J. Lister.	Steamed Meat and Bones, J. A. Byrnes.	Pure Fine Ground Bone, L. B. Darling & Co.	Bone Flour, C. V. Mapes.	Ground Bone, R. H. Allen & Co.	Bone Sawings, Granby Mfg. Co.	Ground Bone, Thompson & Edwards.	Fine Bone, Lombard & Mathewson.	Pure Fine Bone, C. V. Mapes.	Pure Fine Bone, C. V. Mapes.'	Fine Ground Bone, H. J. Baker & Co.
	43	174	175	A	126	193	181	121	192	B	94
MECHANICAL ANALYSIS.											
Parts in 100 by weight. Coarser Pieces	......	......	......	1.0	......	......	......	......	......	......	......
Passed holes 6 mm. diameter	......	......	......	......	......	......	4.9	0.7	1.2	0.8	......
" " 3 " "	......	2.0	......	......	......	......	7.5	4.4	15.7	24.1	28.6
" " 2 " "	2.7	5.8	......	0.2	......	......	5.0	14.8	13.4	16.0	16.0
" " 1.5 " "	11.5	9.1	8.0	0.2	......	2.0	8.9	33.8	13.8	15.0	15.2
" " 1.0 " "	9.2	8.9	7.3	......	18.0	5.4	6.4	19.1	8.2	8.0	9.4
" " 0.5 " "	76.0	72.9	84.3	96.6	82.0	91.6	66.4	27.0	46.0	32.2	31.2
Assumed Grade of Fineness	I	I	I	I	I	I	II	III	III	III	III
CHEMICAL COMPOSITION:											
Phosphoric Acid per cent	23.55	20.51	22.16	20.4*	22.94	26.05	26.08	26.72	20.43	20.4*	23.61
Nitrogen "	3.15	3.53	3.61	3.75*	3.57	3.69	2.67	3.40	3.75	3.75*	3.88
Selling Price	$35.00	45.00	40.00	43.00		40.00	45.00	45.00	40.00	40.00	33.00
COST OF INGREDIENTS PER POUND AT PRICES STATED.	Cts.	Cts.	Cts.	Cts.		Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
Nitrogen	11.7	16.3	13.6	15.5		12.0	14.3	13.4	14.3	14.3	10.5
	5.9	8.1	6.8	7.8		6.0	7.2	6.7	7.2	7.2	5.2

	Pure Ground Bone, H. J. Baker & Co.	Bone Flour, "No. 1," P. W. Bennett.	Fine Ground Bone, G. W. Miller & Son.	Coarse Ground Bone, G. W. Miller & Son.	Pure Ground Bone, Thompson & Edwards.	Ground Bone, Peck Bros.	Ground Bone, Peck Bros.	Ground Bone, "No. 2," P. W. Bennett.	Mapes' Pure Bone, Medium.	Mapes' Pure Bone, Medium.	Mapes' Pure Bone, Coarse.
	C	D	93	E	13	58	F	G	H	K	L
MECHANICAL ANALYSIS.											
Parts in 100 by weight. Coarser Pieces	......	......	......	0.5	10.2	2.2	......	......	2.8	......	8.3
Passed holes 6 mm. diameter	......	11.4	0.4	19.4	27.6	29.0	15.8	33.8	43.9	46.8	86.4
" " 3 " "	12.2	18.9	6.1	13.2	12.7	19.2	22.2	11.2	25.4	14.8	3.3
" " 2 " "	10.7	11.9	4.6	9.2	7.8	14.0	14.2	9.3	10.2	7.8	1.2
" " 1.5 " "	18.7	16.8	32.5	14.7	10.1	14.3	19.8	12.3	8.5	7.9	......
" " 1.0 " "	11.5	8.7	14.4	7.6	7.3	7.5	12.8	7.4	3.2	4.9	......
" " 0.5 " "	45.6	29.3	31.3	32.8	23.1	12.2	14.5	25.4	6.1	17.2	......
Assumed Grade of Fineness	III	III	III	IV	IV	IV	IV	IV	V	V	VI
CHEMICAL COMPOSITION:											
Phosphoric Acid per cent	23.60*	22.05*	21.95	21.95*	23.68	19.79	19.79*	22.05	20.4*	20.4*	20.4*
Nitrogen "	3.9*	3.91*	3.88	3.83*	3.44	4.03	4.03*	3.91	3.75*	3.75*	3.75*
Selling Price	33.00	36.00	36.00	30.00	48.00	38.00	38.00	33.00	37.00		40.00
COST OF INGREDIENTS PER POUND AT PRICES STATED.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.		Cts.
Nitrogen	10.5	12.1	12.1	13.5	15.7	13.8	13 8	11.0	13.5		14.3
	5.2	6.0	6.1	6.8	7.9	6.8	6.8	5.5	6.8		7.2

* Assumed Composition.

Bone Manures.

One of the most important factors of the value of ground bone is its fineness. This point has been discussed to some extent in previous reports. In continuation of what has been there said, I wish to propose a more accurate classification of bone manures by grades of fineness than has heretofore been customary.

Table VI illustrates a method for such classification which is based upon a mechanical analysis, such as has been recommended by various chemists.

For the determinations here given a set of sieves were employed such as are recommended by Dr. Nobbe, of Tharand, for sifting seeds. They are of tin, with holes circular in form and accurate as to size, and have the additional advantage of being very convenient for use. It will be remembered that one inch equals 25.4 millimeters. The holes in the largest seive are 6 millimeters, or $\frac{1}{4}$ inch in diameter, the others, 3 millimeters, 2 millimeters, and so on, as per the table, or expressed in inches, $\frac{1}{12}$, $\frac{1}{16}$, $\frac{1}{25}$, and $\frac{1}{50}$ inch in diameter, respectively. The results of the siftings appear in the tables. The coarser pieces are those which did not pass through the 6 millimeter ($\frac{1}{4}$ inch) holes, the next are those which went through these, but not through the 3 millimeter apertures, the next, such as stopped at the two 2 millimeter holes, while the last are those whose diameter was less than 0.5 millimeters ($\frac{1}{50}$ inch). Twenty-two samples were thus sifted, generally in portions of 50 grams. The figures above represent the averages of duplicate, or in some cases, triplicate determinations. The duplicates vary somewhat, of course, though not essentially.

I have preferred not to lay down any specific rule for fixing the grade of fineness from the sifting, because it seems to me that concerted action, based upon consultation between chemists interested in such work, would be preferable. I would, however, offer the following suggestions:

It might at first seem that the determination of the percentages which pass through the 0.5 millimeter holes, and which might be designated as bone dust, could be used as a basis. For instance, a ground bone with 75 per cent. or more of this fine material could be graded as I; that with between 75 and 50 per cent. of the dust as II; that with between 50 and 25 as III; and that with less than 25 as IV, coarser articles V and VI being graded by larger sieves. But the percentages of the coarser portions are extremely varied, and ought to be taken into account. A much more rational plan would be to multiply or divide each percentage by a certain factor, and fix the grade by the sum of the products thus obtained. In view of the limits of the present article, however, I refrain from further discussion of this point here, save so far as to suggest the following method for these determinations:

In the place of the six sieves used as above, I think four would suffice, with apertures of 4, 2, 1, and 0.5 millimeters, respectively. The percentages passing through these could be determined as above. The percentage passing through the smallest could be taken as it stood, and to it added certain factors of the coarser divisions, say one-half of the second, whose particles varied between one and one-half millimeters, one-third of the next coarser, one-fourth of the next, and one-fifth of the courser pieces, which failed to pass the first sieve. The sum of the figures thus obtained could be taken as a basis of classification.

If all passed the finest sieve, this percentage of fineness would be 100; if none passed the coarsest sieve it would be 20; the percentage in other cases would be between 100 and 20. In grading the samples by these figures the divisions could be made at discretion. I am inclined to recommend putting the first grade from 100 to 90, the second from 90 to 80, and so on, making nine possible grades. This would be simple, and, though the number of grades seems large, yet the differences are no less than those practically used by grinders and sellers in fixing the grades and brands of their wares. This is well illustrated by Nos. D and G, and Nos. 93 and E of the tables.

The method suggested is extremely simple, costs but little labor, and for completeness and accuracy leaves nothing to be desired. The rendering of the bone to remove the fat and make the grinding easier is, of course, far preferable to the grinding of raw bone. The steamed bone is easily ground, and almost always fine. But for some time to come, at any rate, the grinding of raw bone must continue to be, as it has been, a most important and useful industry. And since its grinding is difficult and costly in proportion to the fineness, it is clear that the latter ought to be taken into account, as well as the composition, in reports in which different articles are compared.

The grading of the table is somewhat arbitrary but it suffices to illustrate the propriety and value of such a classification.

Of the articles in the table above, those numbered with Arabic numerals were analyzed at the Station. Those designated by letters A, B, C, etc., were not analyzed. Their composition is, for the sake of comparison, assumed to be the same as the samples of corresponding brands which were analyzed. In the case of A, however, the assumed analysis is very likely too low, as this appears to be a "floated bone," *i. e.*, bone-sawings made in water and afterwards dried. It is probably from the so-called "shin-bones" of beef, and if so, its composition would be similar to that of 193.

We now proceed to the more particular consideration of the chemical composition and valuations of bone manures, as illustrated by Table VII.

TABLE VII.—BONE MANURES.

NAME OF FERTILIZER.	Station Number.	ANALYSES.								VALUATIONS.		
		Moisture.	Sand, etc.	Phosphoric Acid.			Nitrogen.	Ammonia equivalent to Nitrogen.	Grade of fineness.	Retail price per ton.	Cost of one pound, each, of valuable ingredients, at prices stated.	
				Soluble.	Insoluble.	Total.					Nitrogen.	Phosphoric Acid.
		Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.			Cents.	Cents.
PURE BONE.—*(Steamed.)*												
Ground Bone, J. Lister	43	5.69	2.81	.....	.....	23.55	3.15	3.82	I	(1) $42.00	14.0	7.0
"	89			.....	.....	23.52			I			
Ground Bone,	91	4.24	.....	.....	.....	22.85	3.63	4.40	I	32.00	10.6	5.3
"	138	5.05	.....	.....	.....	24.62	3.76	4.56	I	35.00	10.8	5.4
Pure Ground Bone, J. A. Byrnes	75	7.07	.....	.....	.....	19.68	3.79	4.60	I			
Steamed Meat and Bone, J. A. Byrnes	77	9.66	.....	.....	.....	21.32	3.38	4.11	I	48.00	17.1	8.5
Steamed Meat and Bone,	174		.....	.....	.....	20.51	3.53	4.28	I	45.00	16.3	8.1
Steamed Bone, Brighton Abattoir	152	8.81	.....	.....	.....	24.16	3.29	3.99	....	40.00	13.0	6.5
Pure Fine Ground Bone, L. B. Darling & Co.	175	7.13	.....	.....	.....	22.16	3.61	4.38	I	45.00	15.3	7.6
Average of 9 Samples of Steamed Bone	.....	.....	.....	.....	.....	22.36	3.51	4.26	.....	.....	.....	.....
Pure Ground Bone, Thompson & Edwards (3)	181	4.31	.....	.....	.....	26.08	2.61	3.24	II	33.00	10.5	5.3
PURE BONE *(Raw).*												
Pure Ground Bone, Thompson & Edwards	130	12.03	0.89	.....	.....	22.67	2.63	3.19	.....	(4) 40.00	14.3	7.1
Pure Ground Bone, "	36	8.45	1.30	.....	.....	23.68	3.44	4.17	IV	48.00	15.7	7.8
Ground Bone, Peck Bros.	58	11.88	.....	.....	.....	19.79	4.03	4.89	IV	38.00	13.8	6.8
Fine Ground Bone, P. W. Bennett	92	7.98	.....	.....	.....	22.05	3.91	4.74	III	.....	.....	.....
Fine Ground Bone, G. W. Miller & Son	93	7.87	.....	.....	.....	21.95	3.88	4.71	III	.....	.....	.....
Ground Bone, H. J. Baker & Bro.	94	7.00	.....	.....	.....	23.61	3.88	4.71	III	33.00	10.5	5.2
Fine Bone, Lombard & Matthewson	121	8.33	.....	.....	.....	26.72	3.40	4.12	III	45.00	13.4	6.7
Ground Bone, R. H. Allen & Co.	126	10.12	.45	.....	.....	20.43	3.75	4.55	I	.....	.....	.....
Pure Fine Bone, C. V. Mapes	192	7.42	9.68	.....	.....	22.94	3.57	4.33	III	.....	.....	.....
Bone Sawings, Granby Manufacturing Co (2)	193	8.38	.....	.....	.....	26.05	3.69	4.57	I	40.00	12.0	6.0
Average of 10 Samples of Raw Bone	.....	.....	.....	.....	.....	22.99	3.63	4.39	.....	.....	.....	.....
IMPURE BONE.												
Bone Flour, Lister Bros.	96	16.05	.....	0.95	.....	14.62	2.36	2.86	.....	35.00	18.0	9.0
Bone Meal, "	97	18.45	.....	1.02	13.23	14.25	2.97	2.87	.....	30.00	15.8	7.8
Celebrated Ground Bone, Lister Bros.	98	17.09	.....	1.40	9.30	10.70	3.43	4.16	.....	31.00	17.6	8.3
Ground Bone, Lister Bros.	129	14.71	3.74	1.33	11.64	12.97	2.84	3.44	.....	38.00	20.4	10.2
Raw Ground Bone, Thompson & Edwards	106	8.78	5.55	.....	.....	15.26	3.90	4.73	.....	47.50	23.7	9.5
Fine Bone, G. W. Baker	54	16.78	3.40	.....	.....	14.41	2.46	2.99	.....	.....	.....	.....
Coarse Bone, "	55	19.66	2.98	.....	.....	15.53	3.04	3.69	.....	.....	.....	.....

(1) In 1875, when sample was purchased. (2) Average of two closely agreeing samples. (3) This sample had evidently been rendered, but in such manner as not to make it quite as soft as the steamed bones above.

These manures are divided into two general classes, those made from pure bone and those with which other materials are mixed.

Pure Bone Manures.

Of the former class are nine samples of steamed bone, and ten of raw bone.

The fragments of bone that have been steamed at high pressure are generally quite soft, often so much so as to be easily crushed on the palm of the hand with the flat side of a knife-blade. The fragments of raw bone on the other hand, are hard, and crushed with difficulty. No. 181 ranks between the raw and the steamed in respect to texture. It has evidently been rendered to remove the fat. The large percentage of phosphoric acid and small content of nitrogen, shows that the process was such as to remove a very considerable proportion of the organic matter other than fat also. The close similarity of the composition of the steamed and the raw bone as indicated by the averages given, is worthy of notice, as are the variations in the composition of the individual articles of each class. These points deserve more extended study and comment than we now find practicable.

It will be seen at a glance that the prices of the different brands of pure bone are very irregular and in far from close relation with their quality. The same brand brings different prices in different localities. No. 175 for instance, is advertised at $40.00 per ton in some places. Sample No. 181 was not offered for sale, but another of the same brand, and similar composition as shown by analysis here, is offered in the State for $33.00 per ton. The low price of 91, $32.00, was due, in part, to sharp competition. We are informed that it was sold at considerably lower rates than even this, in ton lots, to a farmers' club. Nos. 121 and 193 had the highest percentages of valuable ingredients. No. 193 consisted of sawings of so-called "shin bones," (of cattle) used for the manufacture of knife-handles.

The percentage of phosphoric acid varied in the above samples of pure bone, from under 20 to over 26 per cent. and those of nitrogen from 2.6 to 4 per cent. Samples 75 and

58, which contained the least phosphoric acid were ordinary bones, the former from butchers' shops, the latter (as we understand), from houses. No. 130, which was the richest of all in phosphoric acid, is also stated by the manufacturers to have been made from bones gathered from place to place, in the country, "house bones." It had been wet and fermented somewhat, but not enough to affect particularly either its texture or its contents of nitrogen. The highest percentage of nitrogen was in No. 58, a raw "house bone."

The costs per pound of phosphoric acid and nitrogen which we give instead of the estimated commercial values per ton, are calculated as explained in Article VI.

In deciding between different bone manures, the farmer will do well to remember that the finer articles act quicker and bring a readier return for the capital invested. The effect of finely ground steamed bone may not be manifest during more than three or four years; while that of coarse fragments of raw bone will be much less marked but will last very much longer. Nearly all of the phosphoric acid will remain in the soil until removed by plants, but much of the nitrogen will, after a time, leach out in drainage water, or escape into the air. Unless therefore he can get the coarser articles at considerably lower cost, the finest ones are decidedly preferable. For land to be laid down to grass, the use of the medium grades may be advisable if they are not too costly. Any grades, and, more especially, the coarser ones may be fermented (by composting, or better, by treating with urine from the stables), with profit before applying. Pure fine bone, at from thirty to thirty-five dollars a ton, the prices at which a good many farmers will get it in Connecticut, this coming season, will furnish phosphoric acid in from 5 to 6 cents, and nitrogen at from 10 to 12 cents per pound. At these rates it is an extremely cheap fertilizer.

Impure Bone Manures.

We have seen that pure bone manures, including those which contain, with the bone, the small particles of meat or other animal tissues which naturally cling to them as they are

found in the slaughter-house, meat-market or kitchen, generally contain 20 per cent. or more of phosphoric acid. When a bone manure contains much less than this, it is fair to suppose that some other material has been added, as is the case with the seven articles classed as impure bone in Table VII. So far as our observation goes, the materials most commonly used for mixing with bone manures are animal matter of various kinds, salt-cake or niter-cake (an impure sulphate of soda), plaster, and oyster shells. The animal matter which comes from slaughter-houses, glue works, &c., contains considerable nitrogen, decomposes readily, and may be a valuable adjunct to the bone. That No. 106 contains some such material is evident not only from the appearance of the sample, but also from the analysis, which gives 15.3 per cent. of phosphoric acid, and 3.9 per cent. of nitrogen. The proportion of nitrogen is larger than is usual in pure bone, while that of phosphoric acid is much smaller. It is evident that some nitrogenous material has been added to this bone.

The samples of Lister Brothers' bone are noticeable for their large content of water, their low percentage of phosphoric acid and nitrogen, and the fact that small proportions of their phosphoric acid was soluble. They contained considerable quantities of material soluble in water, chiefly soda salts (salt-cake, or niter-cake); some of them, at least, appeared to contain small quantities of animal matter also. They were quite finely ground, and in excellent mechanical condition when received, but became lumpy on long standing. The solubility of the phosphoric acid may very likely be due to the acid of the salt-cake, which is doubtless of some use in this way, and also in diffusing or otherwise rendering plant-food available in the soil.

A glance at the figures in Table VII will show that the valuable ingredients are in every case much costlier in the impure than in the pure bones.

In choosing between the different grades of pure bone the buyer should give preference to the more finely ground articles, whose action will be quicker, unless he can get the nitrogen and phosphoric acid in the coarser grades at enough cheaper rates to make up for their slower action. At the present prices the finer grades of pure bone are much to be preferred. In deciding whether he shall select such articles as No. 96 or not, he has to consider not only the costs of the ingredients, but also whether or not the salt-cake, 150 to 300 pounds or so to the ton, is worth enough to him to pay for its own handling and that of the extra amount of water, say from six to twelve per cent., or 120 to 240 pounds to the ton, which they contain.

The addition of animal matter or salt-cake is, of course, perfectly legitimate, provided the composition of the article is distinctly stated, and the articles are not sold in such way as to lead the buyers to think they are pure. Every manufacturer has a right to make and sell such goods as he will, so long as he states what he sells and sells what he states. If he and his customers find that the good effect of bone is increased by adding other materials, it is perfectly proper and just that he should add them. It is the chemist's duty to point out the actual nature of the articles, and thus help the buyer to select and apply them understandingly. When this is done, the question whether their use is profitable or not will be decided not by advertisements of manufacturers, nor by the analyses, but by the intelligent experience of consumers.

TABLE VIII.

Superphosphates and Phosphates without Nitrogen.

NAME OF FERTILIZER.	Station Number.	ANALYSES.						VALUATIONS.		
		Moisture.	Sand, etc.	Phosphoric Acid.				Retail price per ton.	Cost per Pound. Phosphoric Acid.	
				Available.		Insoluble.	Total.		Soluble.	Insoluble.
				Soluble.	Reverted.					
SUPERPHOSPHATES:									Cts.	Cts.
Superphosphate,	5	17.39	6.12	10.27	.....	3.46	13.73	$33.00	13.8	6.6
Superphosphate,	53	8.55	.....	23.28	.....	8.67	31.95	61.00	11.1	5.3
Superphosphate,	60	16.36	8.18	12.19	1.31	0.70	14.20	.....	.....	.....
Superphosphate,	61	13.03	4.24	17.79	.....	1.04	18.83	.....	.....	.....
Superphosphate,	159	12.00	.....	23.81	2.24	2.27	28.32	.....	.....	.....
PHOSPHATES:										
Navassa Phosphate,	45	1.41	3.65	.....	.....	.....	20.45	20.00	.....	4.9
Caribbean Sea Guano,	125	11.90	0.51	.....	.....	.....	27.18	25.00	.....	4.6

Phosphates and Superphosphates without Nitrogen.

Table VIII gives analyses of these articles. No comment is necessary further than to suggest that here, as elsewhere, the higher grades are the cheapest. The economy of using such articles as Navassa, Charleston, or other mineral or fossil phosphates, without treatment with acid, is at any time questionable. The Caribbean Sea guano would doubtless be better. But at the present low prices for which bone can be obtained, it will doubtless be a much more economical source of insoluble phosphoric acid for our market than either of the articles just named.

Potash Salts.

For detailed descriptions of German Potash Salts I refer to the lecture on "Potash in Agriculture," in the report of the Secretary of the Connecticut Board of Agriculture for this year. Of the articles in Table IX, none were of the highest grades. Of the sulphates designated as "better," No. 184 was the best we happen to have analyzed, though there are higher grade articles in the market. No. 184 was represented to contain 80, and No. 162, 65 per cent. of sulphate of potash.

It is an unfortunate fact that the sulphates of potash in our markets have not unfrequently fallen below the standard on which they were sold, both as regards the total amount of potash and the amount of sulphate—more or less being in the form of chloride. The three articles designated as "poorer" sulphates, are cases of this sort. No. 32 was purchased as containing 40–44 per cent., and Nos. 67 and 180 as containing 50 per cent. of sulphate of potash. In each of these instances the American importer had been deceived by the representations of the agents or chemists on the other side of the Atlantic. In a number of such cases that have come under our notice, the importers, being too honest to sell the articles as sulphates, and unable to get restitution from German agents, who fell back upon German analyses, have been compelled to suffer the loss themselves. It is to be hoped that the Stassfurt manufacturers will see to it that this evil, which, in so

far as the fact of the potassium being in the form of chloride instead of sulphate is concerned, is attributable to the "*usance*" there prevalent—we have a stronger expression of it in English—of estimating, in the salts sold as sulphates, only the potassium, and calculating it as sulphate without regard to the amount of sulphuric acid actually present, is corrected. In view of the uncertainty of the composition of the German sulphates, some of our largest dealers have decided to give up the importation of the sulphates, and manufacture them themselves from the chlorides.

Of the refuse products, No. 39 appears to be, and No. 41 certainly is, a so-called "prussiate residue." No. 39 was sold by H. J. Baker & Bro. of New York as a "by-product, with 40 per cent. actual potash," and proves to be as represented, save that it is richer in potash. No. 41 was manufactured by H. V. Davis of New Bedford, Mass., and was sold by G. E. White of New York to a farmer in this vicinity as a "sulphate of potash" with 54 per cent. of actual potash. A sulphate of potash, to yield 54 per cent. actual potash, would have to be chemically pure and would contain 46 per cent. of sulphuric acid. This contained, however, 42.36 per cent. of actual potash and only 3.39 per cent. of sulphuric acid, the remainder being made up of various compounds, with the rest, some known in the laboratory as cyanides which might, if applied in sufficient quantities, prove poisonous to plants. It is only just to add, however, that this sample contained a good deal of water, which might have been taken on after it was sold, and before the sample was taken. This would have reduced the percentages of potash and sulphuric acid, of course, very materially. Without the water the sample would have contained some 53 per cent. of potash.

These "cyanide" or "prussiate" residues would doubtless be very useful for composting. They are strongly alkaline and would aid in the decomposition of the compost very materially, while the objectionable compounds would gradually become disorganized. For such purposes, if not too costly, they are to be recommended.

TABLE IX.

Potash Salts.

NAME OF FERTILIZER.	Station Number.	ANALYSES.								Retail price per ton.	Cost of one pound of actual Potash at prices stated.
		Moisture.	Sand, etc.	Sulphuric Acid.	Chlorine.	Potash.	Equivalent Sulphate of Potash.	Equivalent Chloride of Potassium.			
GERMAN POTASH SALTS:											Cents.
SULPHATES (BETTER):											
Sulphate of Potash, W. H. Bowker & Co.,	162	.....	.....	47.82	0.90	31.97	59.12	.....		$60.00	9.4
Sulphate of Potash, H. J. Baker & Bro.,	184	4.71	.....	45.25	.....	40.66	75.19	.....		65.00	8.0
SULPHATES (POORER):											
Sulphate of Potash,	32	.....	4.56	8.91	36.84	30.77	19.40	32.00		———	———
Sulphate of Potash,	67	0.93	.....	16.56	31.74	27.27	36.06	13.62		———	———
Sulphate of Potash,	180	.....	.....	15.95	31.72	27.06	34.73	14.06		———	———
Muriate of Potash, Jacksons & Bowker,	33	.....	0.12	.....	47.82	50.64	.....	80.08		60.00	5.9
Prepared Kainit, H. J. Baker & Bro.,	4	.....	2.96	16.04	———	16.29	30.12	.....		25.00	7.6
Prepared Kainit, H. J. Baker & Bro.,	38	.....	.....	17.59	31.06	14.41	26.65	.....		25.00	8.6
Leopoldshall Kainit,	21	.....	.....	19.39	———	13.97	25.83	.....		30.00	10.7
Leopoldshall Kainit,	51	.....	.....	———	———	12.18	.....	.....		30.00	12.3
Leopoldshall Kainit,	104	.....	.....	19.38	29.55	11.47	21.93	.....		———	———
REFUSE PRODUCTS:											
"Potash Salt,"	39	.....	.....	6.15	14.37	44.19	13.39	33.43		60.00	6.8
"Sulphate of Potash,"	41	20.30	.....	3.39	.....	42.36	7.38	.....		55.00	6.4

Fertilizers prepared for special crops.

Table Xa gives analysis of six samples of the Matfield fertilizers. Of these Nos. 111–115 were furnished by Mr. H. N. Hooper, manager of the Matfield Fertilizer Co., by whose courtesy we are permitted to publish the analysis. No. 147 was taken by the writer from the store of Southmayd & Gardiner of Middletown, where it was retailed at $55.00 per ton. The percentages in the columns marked G, are those guaranteed by the manufacturers. Those in the columns F, were found in analysis. The articles were, accordingly, as good or better than claimed.

TABLE X a. MATFIELD FERTILIZERS.

	Spring Grass.		Potato.		Oat.		Beet.		Fruiting Strawberry.		Tobacco.	
Station Number	No. 111.		No. 112.		No. 113.		No. 114.		No. 115.		No. 147.	
	G.	F.	G.	F.	G.	F.	G.	F.	G.	F.	G.	F.
	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.	Pr ct.
Nitrogen	4.4	5.4	4.0	5.2	5.0	6.0	1.6	2.0	2.0	2.7	3.7	3.2
Potash	6.0	5.8	7.0	6.7	3.5	3.2	12.0	11.9	5.5	6.3	6.7	7.1
Magnesia	1.0	1.6	2.0	2.2	0.5	0.6	1.2	1.3	1.0	1 3	3.0	*
Phosphoric Acid, Soluble	1.6	2.5	2.4	2.8	2.0	2.8	2.8	2.5	3.5	4.3	0.8	1.6
" " Reverted	....	1.0	.....	0.6	....	1.5	....	1.5	....	0.7	....	1.2
" " Insoluble	....	0.7	....	0.3	....	0.5	....	0.4	.....	0.5	....	....
" " Total	....	4.2	....	3.7	....	4.8	....	4.4	....	5.5	....	2.8
Sulphuric Acid	17.9	20.9	20.8	22.0	19.0	20.8	7.2	10.2	20.0	19.9	28.0	*
Soda	1.7	1.9	1.7	1.3	0.5	0.3	11.0	11.0	6.8	2.3	1.0	*
Chlorine	6.0	...	7.3	....	3.5	....	20.0	...	7.4	....	1.1	*
Lime	3.0	3.6	3.9	3.8	4.2	3.6	4.5	4.3	14.3	14.0	15.0	*
Moisture	10.0	10.0	10.0	10.4	....	11.1	10.0	10.6	10.0	11.5	10.0	13.6

*Not determined.

Table Xb gives analyses of two samples of Stockbridge fertilizers, which were furnished by farmers who used them. By comparing the guaranteed composition in the columns G, with that found by analyses in F, it will be seen that the articles were equal or superior to the representations. The Stockbridge fertilizers were not sold by the weight, but "by the acre," that is to say, a specific sum was charged for the quantity recommended for an acre, irrespective of the weight. By comparing the weight of No. 139 with the price, it was found to cost $71.05 per ton.

TABLE X b. STOCKBRIDGE FERTILIZERS.

	Corn.		Corn Fodder.	
Station Number	No. 149.		No. 157.	
	G.	F.	G.	F.
	Per cent.	Per cent.	Per cent.	Per cent.
Nitrogen	6 to 8	8.37	5.00	4.23
Potash	6 to 8	13.66	15.00	16.20
Phosphoric Acid, Soluble	2 to 4	4.01	3.00	2.85
" " Reverted	.....	1.21	.....	2.45

Miscellaneous Articles.

Under this head are classed two articles of low grade and price. They are:

No. 76, "Ammoniated Lime Fertilizer," manufactured by J. D. Byrnes, Springfield, Mass. This consists of gas lime, saturated with the waste liquid from the rendering of bones. The nitrogenous matters of the latter are retained by the lime, forming a fertilizer which, besides a large content of lime, furnished 1.21 per cent. of nitrogen.

No. 109, "Charter Oak Top-Dressing," manufactured by the Charter Oak Fertilizing Company, Hartford, Conn., yielded 3.31 per cent. potash, and 2.77 per cent nitrogen.

TABLE XI.

Inferior Articles.

NAME OF FERTILIZER.	ANALYSES.							VALUATIONS.				
	Station Number.	Moisture.	Sand, etc.	Phosphoric Acid.			Nitrogen.	Ammonia equivalent to Nitrogen.	Retail price per ton.	Estimated value per ton.	Cost of one pound each, of valuable ingredients, at prices stated.	
				Soluble.	Insoluble.	Total.					Phosphoric Acid.	Nitrogen.
											Insoluble.	Soluble.
											Cents.	Cents.
Popplein's Silicated Fertilizer for Cereals,	88	*	25.55	*	*	10.22			$25.00	$8.59	1.75	61.1
Lodi Double Refined Poudrette,	19	4.20	63.07	.....	.....	2.22	1.41	1.71	25.00	5.78	26.0	.....
Lodi Double Refined Poudrette,	34	3.85	60.71	.....	.....	1.81	0.86	1.04	25.00	13.26	21.7	91.0
Ammoniated Bone,	22	29.70	9.20	2.24	1.90	4.14	1.28	1.55	48.00	7.42	48.4	76.0
American Bone Fertilizer,	6	10.10	47.15	.....	.....	2.61	1.02	1.23	55.00	7.69	42.9	169.4
American Bone Fertilizer,	8	13.07	41.46	.....	.....	2.80	1.03	1.24	55.00	4.42	54.3	150.2
Union Fertilizer,	195	.....	10.44	.....	.....	1.16	0.72	0.87	40.00			190.2

* Not determined.

Table XI gives analyses of a number of articles of inferior grades. Of these No. 88, was Popplein's Silicated Fertilizer for cereals. An analysis of a sample of this article received from the agents for its sale, gave:

Silica and insoluble matters, .	25.55 per cent.
Phosphoric acid, . .	10.22 per cent.
Potash, . . .	0.14 per cent.

The formula by which the fertilizer for wheat is claimed to be made is given by the manufacturers as follows:

Vegetable Silica, . . .	800 lbs.
Dissolved bone, . . .	800 lbs.
Potash salts, . . .	400 lbs.

The price of the article is stated at $45.00 per ton.

It is evident that the sample analyzed could hardly have been made after this formula. Leopoldshall Kainit, which is one of the poorest and lowest-priced potash salts in our markets, may be assumed (see analyses in table IX) to contain on the average 12½ per cent. of actual potash. Had four hundred pounds of this been used in the above fertilizer it would have furnished 50 lbs. or 2½ per cent. of actual potash.

This fertilizer was accompanied by a somewhat pretentious pamphlet, bearing the title "New Ideas of Fertilization." These "new ideas" consist in part of the revival of two old ideas disproved by experiment and now discarded by agricultural chemists. The first is that an artificial supply of nitrogen is not generally needed in fertilizers designed for the production of full crops. The second is that considerable supplies of silica are required for plant-food, and that it prevents the lodging of grain.

The research and experience of later years in the laboratory and in the field have proven very conclusively that nitrogen is, generally speaking, a most important constituent of fertilizers, and that if silica is needed for plant-food at all it is required only in minute quantities, and is supplied in excess by all our ordinary soils.

Quite new on the other hand is the idea of supplying farmers with silica as is proposed in this fertilizer. The mate-

rial employed for the purpose is stated to be infusorial earth found on the shore of the Chesapeake, belonging to the well-known deposits of that region and consisting largely of the microscopic siliceous shields of the infusoria called diatoms. It was claimed that these very minute particles of silica were absorbed directly by the growing plant and thus formed a valuable source of silica for fertilizers. This remarkable theory was supported by accounts of investigations which were used in advertising the article, and which at the time attracted considerable attention in the agricultural papers, but whose incorrectness, to use a mild expression, has been so plainly shown elsewhere* as to require no further comment here. The pamphlet referred to made use also of the names and statements of numerous authorities in agricultural chemistry, in such ways as to lead persons not familiar with such subjects, to suppose that they upheld the peculiar theories, though, as agricultural chemists well know, their views and investigations lead to precisely the opposite conclusions.

In a fertilizer made by the formula above, the 800 lbs. of dissolved bone could be bought for $14.00, and the 400 lbs. of kainit for $3.50, or less, making together $17.50, the most that could be allowed for the valuable ingredients in a ton. Subtracting this from the price, $45.00, and there remains $27.50 in money, besides cost of carrying and handling to be paid for 800 lbs. of material, which, if placed in the middle of a field, would not, except possibly in some cases as a mechanical amendment to the soil, be worth the spreading. The introduction of this article into the State was, as we learn, prevented by the refusal of several leading dealers to handle it without the approval of the Station.

For comments on the poudrettes we refer to Circular 4 of the Station. As there explained, these articles contain in a ton over 1,200 lbs. of sand, fragments of brick, and coal, and other equally worthless matters, and as much of valuable fertilizing elements as could be obtained in 300 lbs. or so of

* In the American Journal of Microscopy, and other scientific Journals.

guano, or for $4.00 to $8.00 in any of the better fertilizers in the market. The "Ammoniated Bone," No. 22, was one of several samples of fertilizers received for examination before purchase by the Middlefield Farmers' Club from the manufacturers who had no idea that their chemical composition would be tested. There was nothing in the general appearance to distinguish this from the best samples. There is a slight possibility of error in the name of the manufacturer, this being the only one of a considerable number of samples not fully identified and described by the committee of the club by whom the samples were furnished. In all probability it is from a firm a number of samples of whose wares have proved by analyses here to be of low grade, but who are now endeavoring to retrieve their reputation by sending into the State fertilizers of excellent quality and at low prices. As will be noticed, the sample contains only 2.24 per cent. of soluble phosphoric acid and 1.28 per cent. of nitrogen. The nitrogen cost 76 cents per lb. The valuable materials in a ton could be had in first-class superphosphates for about $13.00. The price per ton was $48.00.

The most noteworthy examples of positive

Frauds in Fertilizers,

are in Nos. 6, 8, and 195. The samples of American bone fertilizer were referred to briefly in "Circular No. 4." Since that was published some new facts concerning the sale of the articles have been obtained, from which it appears that the article was sold in considerable quantities, in this region, during the season which preceded the establishment of the Station. Shortly after the commencement of the work of the Station, a farmer from this vicinity came into the laboratory with a sample of the fertilizer which himself and neighbors had tried the previous season, with very poor results. In due time it was analyzed, and proved to be an extremely poor article, in fact, a very evident fraud. To be more certain of its character, a second sample was obtained from a lot purchased by another farmer in the neighborhood, and analyzed with similar results. The story which the parties tell is about this: In the previous

spring an agent called on them to sell a fertilizer, showing them samples, "in little bottles, which upon opening had a strong smell of ammonia. He called it the *American Bone Fertilizer*, and said that he had sold a good deal about Hartford at $60 per ton, but as he wanted to introduce it here he would let us have it for $55. He represented it to be a first-class superphosphate. Both this man, who was 'sub-agent,' and the 'general agent,' said that it was better than Peruvian guano." One of the farmers "tried a few bags, thinking that it would neither make nor break him," another took a ton and a half, and so on. But they all had the same experience. One "could not see that it was any better than the dust from the road;" another "saw no effect from it," and they "will give their affidavits that they got no benefit from it at all."

The best superphosphates contain from 12 to over 20 per cent. of phosphoric acid, of which from 6 to 12 per cent. or more is *soluble*. This (No. 6) contained a trifle over 2½ per cent., of which no appreciable quantity was soluble. A good quality of Peruvian guano will contain 8 per cent. or more of nitrogen. This article contained 1 per cent. The best guanos and superphosphates contain from none to 8 per cent. of sand, etc. This contained 47.2 per cent., or 947 lbs. to the ton. It has the appearance of salt-marsh muck mixed with sugar-house scum, the latter a material of little agricultural value, which is sold in New York, I am informed, at $5 or thereabouts per ton. The estimated value was about $7.50 per ton. That is to say, the valuable ingredients furnished by one ton of this fertilizer could have been bought for $7.50, or less, in any of the best phosphates, bone manures, or guanos sold in the State.

The parties furnishing the samples state that Messrs. Birchall & Chapman of Port Morris, N. Y., claim to be the manufacturers, that it was sold to them by a person named W. B. Knapp, who represented himself as a sub-agent and I. N. Leonard of Elizabeth, N. J., as general agent, and that the latter person has also visited them in this capacity to recommend the article, and attend to the collection of the bills.

The truth of these statements is amply confirmed both by the character of their authors and by documents bearing the names and signatures of the manufacturers and sellers.

Upon receipt of the results of the analyses of the American Bone Fertilizer, the purchasers who had not paid for the article very justly refused to do so.

We have direct information that the person mentioned as "general agent," deposited for collection at a single banking office in one of the cities of this State, notes and bills against farmers in the region, to the amount of some twelve or fifteen hundred dollars, of which some certainly, and as it is supposed all, was for the "American Bone Fertilizer."

The next season the farmers, in whose behalf the analyses of this article were made, brought samples of bone manure offered them to the Station for analysis before buying. They united in the purchase of an article which, taking into account quality and price, was the cheapest we have yet met. It was a fine-steamed bone of high grade, and furnished nitrogen at 10 cents, and phosphoric acid at 5 cents per pound, which was about one-fifteenth the cost of the same ingredients in the "American Bone Fertilizer."

The poorest article we have analyzed was the "Union Fertilizer, No. 195." The sample was received from a person who seems to have been deceived as to its value, and took an early opportunity to send a sample to the Station for analysis. He states that a small quantity came into his hands from parties who had sold it at $40 per ton. A handbill which accompanied it gave an analysis claiming phosphoric acid soluble, 2.80 per cent.; insoluble, 4.65 per cent.; total, 7.45 per cent.; and nitrogen, 4.68 per cent. The sample yielded about 1 per cent. of total phosphoric acid, and ¾ per cent. of nitrogen. The analysis was accompanied by the address of the manufacturers, Davis & Smith, 21 and 25 India Wharf, Boston. On inquiry at that place, no such persons were found. It should be added that the sample was taken from a single barrel, and may not have fairly represented the whole lot. But any article of which a part could have such composition as this is not worthy the name of fertilizer.

VIII. Farm Experiments with Fertilizers.

"These experiments, it is true, are not easy; still they are within the power of every thinking husbandman. He who accomplishes but one, of however limited application, and takes care to report it faithfully, advances the science, and, consequently, the practice of agriculture, and acquires thereby a right to the gratitude of his fellows, and of those who come after. To make many such is beyond the power of most individuals, and cannot, therefore, be expected. The first care of all societies formed for the improvement of our science, should be to prepare the forms of such experiments, and to distribute the execution of these among their members."

ALBRECHT THAER, *Principles of Rational Agriculture.*

We are continually receiving such inquiries as the following:—

"I have a piece of old land that has been somewhat worn down by a number of years' cropping. It is such and such a kind of soil, has been treated so and so, and I want to get such a crop, and at the same time bring it into good condition. My supply of stable manure is short. Will it pay for me to try guano, or superphosphate, or potash salts?"

"Are the ——— or ——— fertilizers of enough value to farmers in —— county, to warrant their purchase these hard times?"

"Will you be kind enough to give me a proper formula for a fertilizer for a corn crop?"

It would of course be very easy to take the analysis of a given crop, and say, "this requires so many pounds of nitrogen, so many pounds of phosphoric acid, lime, potash, and so on. These will be furnished by so much sulphate of ammonia, superphosphate, and sulphate of potash or other materials." But very likely the soil would supply enough potash of itself and the sulphate of potash would not be needed. The crop may have the power of making use of the compounds of nitrogen already stored in the soil, or supplied by the atmosphere, so that at least part of the nitrogenous material will be superfluous; phosphoric acid may be already present in sufficient quantity; the application of gypsum is often an equivalent to the addition of potash, since gypsum tends to liberate this from its combinations in the soil, and thus render it available

to plants. So, likewise, lime may often be applied instead of phosphate, or other high-priced manures, with good results, and at but a fraction of the cost. The physical conditions of the soil also may be such as to very materially affect for good or ill the action of the fertilizers. For these and various other reasons, which this is not the place to discuss, and which for that matter, are, in the present state of our knowledge very imperfectly understood, the formula, however attractive in theory, might be far from the most economical, in fact.

One of the main results of the vast amount of work done in field experiments with fertilizers, is the clear demonstration that soils vary greatly in their capabilities of supplying food to crops, that different ingredients are deficient in different soils, and that the results of any given experiment are in the main applicable only to the particular kind of soil on which it is made.

The chief office of commercial fertilizers is to supply the plant-food which the crop needs and the soil fails to supply. It may be regarded as pretty well settled that the only ingredients of plant-food which we need to consider in commercial fertilizers, are *Potash*, *Lime*, *Magnesia*, *Phosphoric acid*, *Sulphuric acid*, *and Nitrogen*. Of this list the magnesia is commonly, though not always, supplied in sufficient quantities in even "worn-out" soils. Sometimes its presence in fertilizers may be of considerable importance to crops. Sulphuric acid and lime are more often deficient, and hence, one reason of the good effect so often observed from the application of lime and plaster. The remaining substances, the *Nitrogen*, *Phosphoric acid*, *and Potash*, are the most important ingredients of our common commercial fertilizers, because of both their scarcity in the soil and their high cost.

It is in supplying these that guano, phosphates, bone manures, potash salts, and most other commercial fertilizers are chiefly useful. To use them economically then, we must know what materials are deficient in the soil where they are to be applied.

It is not good economy to pay high prices for materials which our soils may themselves furnish, but it is good economy to supply the lacking ones in the cheapest way.

For farmers who have not their own experience, or that of others in like circumstances, to guide them, the most sensible method for determining what are the deficiencies of their soils, and how they will be the most economically supplied to given crops, is to try experiments on a small scale; to put the question to the soil with different fertilizing materials and obtain its reply in the crops produced.

This is no new idea. It has been urged again and again by the leading agricultural chemists in this country and in Europe. Stoeckhardt, Knop, and Wolff in Germany, Ville in France, Voelcker in England, and Johnson in this country, have all not only urged upon farmers the importance of such experiments, but given specific suggestions for conducting them.

Lack of space forbids my giving details of a number of experiments which I had intended to adduce in exemplification of the principle here urged. Its truth is so clear, however, that the illustrations might perhaps be superfluous, and I append, instead, some practical directions for conducting such experiments. They are as given by Wolff, who is, I suppose, the leading European authority on the subject of fertilizers.*

It is of the greatest importance to the farmer to find out which of the more important ingredients of plant-food his soil, in its actual condition, fails to supply in sufficient quantity for the production of the largest possible crops, and which, when directly added, would therefore exercise an especially favorable and profitable influence.

This can be done, practically, only by properly conducted fertilizing experiments. With this in view, it will be well, first, to arrange some trials in which the separate elements of plant-food are employed, each by itself alone, in the form of a definite salt as pure as possible. I propose, for this end, trials with the following articles:

1. Phosphoric acid in superphosphate, from Baker† guano, or Mejillones† guano (in lack of this, good superphosphate from phosphorite or bone-black).
2. Nitrogen in Chili saltpeter‡ (or crude sulphate of ammonia).

* Translated from his *Praktische Düngerlehre*, 1875, s. 141–147.

† A phosphatic guano without nitrogen, much used in Germany.

‡ Nitrate of soda.

3. Potash in fivefold concentrated potash salt* (or high grade sulphate of potash).
4. Magnesia, in epsom salts (crude sulphate of magnesia).
5. Plaster.
6. Burnt lime.

The trials need not, by any means, extend over very large plots. Often small plots of five and a half square rods each will suffice. But the whole ground under experiment should, by all means, be of a uniform quality, and two or three plots must always be left unmanured for comparison.

The arrangement and order of the plots, if the quality of the soil is uniform, can be planned as is most convenient, just as the lay of the land and the kind of preparation make desirable; for instance, as follows:

1. Unmanured.	2. Superphosphate.	3. Epsom salts.
4. Potash salt.	5. Unmanured.	6. Chili saltpeter.
7. Plaster.	8. Quick lime.	9. Unmanured.

The separate materials should be applied in such proportions as about correspond to an average manuring. For instance: for each five rods, 10 lbs. each of superphosphate, epsom salts, and plaster; 6 lbs. each of potash salt, Chili saltpeter, or sulphate of ammonia, and 25 lbs. of quick lime. The latter may be sown in the fine powdery condition which results from careful slacking with water, or gradual disintegration in the air. The plaster should be applied in finely ground condition. The other materials should be mixed before spreading with once or twice their bulk of good earth, rich in vegetable matter, or with tolerably moist sawdust, in order to insure more thorough and even distribution. The spreading should be done a considerable time before the planting. It will be well to even off the ground first with a light harrow, spread the fertilizers, and then work them into the soil with a strong harrow in the usual way.

It is still better to turn the fertilizers under by shallow ploughing, and then proceed with the preparation and planting of the field as usual. If the separate plots are once accurately staked off, and the fertilizers carefully distributed in their appropriate divisions, the plow and harrow may be passed freely from one plot to another, without fear of any considerable shifting of the fertilizers, especially when unmanured spaces two feet wide are left between the plots, and, after planting, left as paths.

The trials should be made on land which is exhausted, in the agricultural sense of the word, and would, in ordinary practice, have been again dressed with stable manure. They should be repeated for at least three to six years in succession, in the same manner, with the same quantity of fertilizers on the same plots, each year, only changing the crops to be raised, as the course of rotation requires.

Equally instructive for the agriculturist as a test, both of the needs of the soil, and of the height to which the yield of the harvest can be raised,

* Same as is sold in this country as "muriate of potash," of 80–84 per cent.

under existing conditions, will be a series of experiments in which the three ingredients of plant-food most important from the agricultural point of view, Phosphoric Acid, Nitrogen, and Potash, are incorporated with the soil, each by itself, two by two, and all three together. For example:

1. Unmanured. 2. Superphosphate. 3. Potash salt.
4. Chili saltpeter. 5. Superphosphate and Chili saltpeter.
6. Superphosphate and Potash salt.
7. Potash salt and Chili saltpeter.
8. Superphosphate, Potash salt, and Chili saltpeter.
9. Unmanured.

The relative proportion of fertilizing material can be the same here as has been given above, the trials likewise begun at the close of the usual period of manuring, and carried on from three to six years in succession, the materials above mentioned being employed on each crop. The results of such trials are not always applicable to manuring on a large scale, but they throw light on what is wanting in the soil, what elements of plant-food it is desirable to increase in the soil, and consequently which of these ought to have especial attention in the purchase of fertilizers for the case in hand, and in general, in the whole management of the farm.

In exactly the same way, and with more directly practical results, other commercial fertilizers may be tested with regard to their influence in the production of various crops under the actual relative conditions of soil and climate. Such fertilizers often have a more complex composition, but when taken by themselves alone, only rarely represent, in the quality and quantity of their ingredients, a complete plant-food. In this case, naturally, such articles will be first considered as can be easily and cheaply procured. It will be an excellent plan to carry out comparative trials at the same time with two or more different fertilizers on areas of equal size and adjacent to one another, one and the same crop being grown on all. For example: 1. Steamed bone meal; 2. Peruvian guano; 3. Superphosphate, or 1. Peruvian guano, 2. Superphosphate; 3. Peruvian guano and superphosphate, or 1. Bone meal; 2. Potash salt; 3. Bone meal and Potash salt, or 1. Peruvian guano superphosphate; 2. Sulphate of potash; 3. Peruvian guano superphosphate, and Sulphate of potash, etc., etc.

In every case, a small area must be left unmanured, to make it possible to confirm more accurately the working of the manures in question. The separate plots may properly be of somewhat larger area (say 17 square rods) in these trials than is necessary for those above mentioned. The proper quantity of fertilizing material may in this case, too, be reckoned according to the ordinary so-called average manuring, as, for a surface of 200 rods, about 1½ cwt. Peruvian guano; 2 cwt. of the ordinary superphosphate; 2 to 3 cwt. bone meal; 2 to 3 cwt. crude sulphate of potash; 1 to 2 cwt. of the threefold concentrated potash salt, high grade sulphate of potash, or of the refined potash-magnesia.

From a more practical point of view, the amounts of fertilizers used in

the several trials are often so arranged as to make the costs the same, and to amount to an appropriate sum per acre. In this case, however, if the low grade Stassfurt potash salts are used, the amount should be reduced to half the cost of the others, or less, since otherwise the large quantities might be injurious to the plants.

In the last named trials, at least so long as they are to be regarded as preliminary, and serving the farmer as an introductory study, it is important to carefully observe the after effect of the manures employed, during the two, or if possible, three following years. Only the entire action during a period of some three years gives a reliable measure of the practical value of the material in question under the existing conditions. So if the trials have been started on an exhausted soil, or, what is preferable in the case of the last-mentioned ones, on a soil still tolerably well manured, the crops following in rotation should be raised in the two subsequent years without further manuring of the trial plots.

Trials like those here indicated, which the farmer arranges for his own interest, really cost little trouble, and involve but small outlay of time and money. Nothing further is necessary than to choose, at a proper time before planting, a suitable place in the field whose qualities of soil are to be tested with concentrated fertilizers, divide this into plots, and then spread the weighed quantity of manure. For the rest, the arrangement and entire treatment of the field will be the same that should be adopted in any other case. Even if, at the time of the harvest, through the pressure of other business, the farmer does not succeed in accurately ascertaining the results of the trials by weighing the yield of each separate plot, he will still have abundant opportunity in the course of the summer, during the whole growth of the plants, to make interesting observations on the more or less favorable action of the manures in question, and can draw important conclusions from them for the rational conduct of his farming.

But these conclusions will of course have far more significance and reliability for himself, and for the whole neighborhood as well, if he takes the pains to ascertain, as accurately as possible, the results of harvest in quantity and quality, giving especial heed to the quality of the grain and root crops. In order to obtain reliable and clear results from comparative fertilizer trials, it is important, as has been already stated, that the soil of the whole area under experiment be of uniform quality throughout. But this is a requisite which is often difficult to fulfill in the more or less square form and net-like arrangement of plots generally adopted hitherto, even if the latter are only five square rods each. Still the disturbance from inequalities of soil can be entirely eliminated, so far as the result of the trial is concerned, as has been shown by the experiments proposed and carried out by the Experiment Station at Salzmünde, if the separate parcels are laid out side by side, in the form of very long, narrow strips. The rules which from experience in Salzmünde and elsewhere, seem to be most

important to be observed in the choice and management of trial-fields, are the following:

1. The portion of the field to be chosen should be as nearly level as possible, at least a cross section through its width should be horizontal throughout. When this is the case, it does not matter if the field rises or falls somewhat in the direction of its length.

2. The plan of experiment should be chosen, if any way possible, a year before, while the previous crop is growing. In May or June it is easy to see by the condition and appearance of the crop, in what part of a large field there is a piece of quite uniform quality, large enough for a trial-field. This piece should be staked off at once at the four corners, and accurately marked. This will give the desired area for experiment for the next year.

The length of the experimental field should be some 600 feet. The breadth will depend on the number of plots. Still the whole breadth of the area under experiment should not exceed 100 feet. The relation of length to breadth must be at least 6 : 1.

4. The most appropriate size of the plots is 16 or 17 square rods. This is suitable for all kinds of experiments, and for all classes of crops. Larger plots do not increase the value of the trial. Smaller plots than 12 rods are not advisable, because they are too narrow.

5. The plots should each be 600 feet long, and so run parallel through the whole field. In the middle of the strip of land so formed should be an unmanured plot, and, on each side, at equal distances between the middle and border furrows, should be another, making three unmanured plots altogether. These are absolutely necessary for comparative control.

6. The single plots should be separated from one another by an unoccupied space or path two or three feet wide. When these narrow plots are manured in windy weather, a high pasteboard screen, say five feet high and seven feet long, should be carried by the side of the sower, otherwise a considerable part of the powdery fertilizer might easily be thrown or blown on to the neighboring plots.

7. It will be further desirable to determine by the use of an earth-borer, or by digging holes at different points, that the soil of the whole trial area to a depth of four feet, has everywhere a tolerably uniform quality, and is similar in its strata.

8. In experiments with fertilizers the seeds should generally be put in rows or drills; in raising beets, potatoes, and other root crops, there should be an equal number of hills on each plot. With cereals there should be always the same number of rows. The seed of the legumes, too, should be planted in rows.

In order to facilitate the introduction of experiments of this sort among the farmers of Connecticut, the Station has made arrangements to furnish materials for the purpose to a limited number of persons willing to undertake the trials.

The fertilizers are put in small bags of about 20 pounds each, and accompanied by analyses, explanations, directions for using and blanks for recording observations and results. They will be furnished at prices as low as will cover the actual cost in money, to Station,* no charge being made for labor. The materials will be of the highest grades conveniently obtained. Those recommended for experiments the coming season are as below:

No.	Furnishing,	In form of	Amount.
I.	Nitrogen,	Dried Blood,	20 lbs.
II.	Phosphoric Acid,	Dissolved Bone Black,	20 lbs.
III.	Potash,	German Potash Salt (Chloride,)	20 lbs.
IV.	Nitrogen and Phosphoric Acid,	Mixture of I and II,	20 lbs.
V.	Nitrogen, Phosphoric Acid, and Potash,	Mixture of I, II, and III,	20 lbs.
VI.	Lime and Sulphuric Acid,	Plaster,	20 lbs.

Extras.

No.	Furnishing,	In form of	Amount.
Ia.	Nitrogen,	Nitrate of Soda,	15 lbs.
IIIa.	Potash,	German Potash Salt, (Sulphate)	20 lbs.
IVa.	Nitrogen & Phosphoric Acid,	Pure, Steamed Bone Dust,	20 lbs.
IVb.	Nitrogen & Phosphoric Acid,	Rectified Peruvian Guano,	20 lbs.

A considerable number of farmers have expressed a desire to make the trials and some fifty sets have been ordered. The undertaking is itself an experiment, and we prefer to say but little about it until the results of a season's experience are known. We believe, however, that the principle is sound, even if some of the details proposed do not prove the wisest. The enterprise is undertaken in the belief that it will be useful, as a means of education, at least, and in the hope that still further good may come from it.

* The Set I–VI costs $4.00, which covers expense of materials, packing, printing, &c., &c.

IX. On Investigations of Seeds.

Of the many new ways in which science has of late come to be applied to agriculture, one of the most interesting as well as most useful is in the investigation of seeds. In 1869, Dr. Nobbe, director of the Agricultural Experiment Station at Tharand, in Saxony, commenced the study of seeds in common use in Germany, and founded the first "seed-control station." How much of good has come from this may be inferred from the fact that during the seven years that have since elapsed, over 4,000 samples of seeds have been examined at Tharand; that adulterations have been discovered, most ingenious in character, harmful in effect, and remarkable in amount, so much so as to work a by no means inconsiderable injury to the agriculture of the country; and that more than twenty seed-control stations have been established in Germany, while others have been either founded or projected in Denmark, Austria, Hungary, Holland, Belgium, and Italy.

Work of this sort has commenced at the Station, in the form of an attempt toward a systematic examination of the condition of the seed market both in this State, and as far as practicable, outside the State as well.

The utility of such work is quite evident. By means of the fertilizer control system now in operation, every farmer in the State can assure himself of the genuineness and value of the fertilizers he employs. To secure the best returns for the capital he invests it is of equal importance to him that the seed sown should be pure, and capable of germination. Otherwise a part of the plant-food supplied to his crop will be wasted, or go to the support of useless or noxious weeds unwittingly sown with the seed which was bought as pure.

The question will be asked, are our farmers in any danger of getting seed which is mixed with foreign material or has lost its germinating power? We know that in late years English farmers have been greatly troubled by the presence in their markets of seed purposely adulterated. Dr. Nobbe asserts that the English, German, and Austrian, markets are supplied with the different kinds of meadow grass

seeds chiefly from dealers who have these seeds collected by women and children from the grasses growing wild in woods. A large number of analyses of samples of such articles, as they were offered in European markets, gave an average of 41 per cent. of foreign matters, including a great many foreign seeds, among which were those of worthless grasses, poisonous plants and parasites. Of the 59 per cent. of seed which corresponded to the labels under which the articles were sold, only 18.3 per cent. were capable of germination.

Prof. S. W. Johnson refers to this matter in the following language:

> There lately flourished in London, establishments where the business of "doctoring" turnip-seed was prosecuted on an extensive scale. Old and worthless seeds, or the seeds of inferior kinds of turnips, were killed and colored, and used to the estimated amount of 20,000 bushels annually for adulterating the seed of those varieties most sought for by farmers.
>
> In London, and on the Continent, hundreds of tons of the cheap yellow clover seed (*Medicago lupulina*), were, and still are, mixed in larger or smaller proportions with the red clover seed, and sold at the high price of the latter.
>
> In 1868, three tons of so-called red clover seed were sold to farmers in the Saxon city of Chemnitz alone, of which two-thirds was yellow clover.
>
> In Saxony light and inferior kinds of oats are extensively bought by seedsmen, to adulterate the heavy and prized sorts.
>
> The celebrated "Probsteir rye," is annually produced to the extent of 2,800 to 3,400 bushels; but the amount ostensibly disposed of in the seed trade is hundreds of thousands of bushels.
>
> Dr. Nobbe reports finding in a sample of tall meadow fescue grass (*Festuca elatior*), 70 per cent. of adulteration; and two samples of so-called "grass-seed," having all the external appearance of a good article, were found to consist of grass flowers only, without a ripe seed of any sort.
>
> The climax of this kind of ingenious villainy appears to have been reached in Hamburg, where there recently existed a manufactory of counterfeit clover seed, which was made from quartz sand, and with such skill as to deceive experienced judges, who have pronounced samples containing 25 per cent. of these quartz grains to be pure red clover seed.
>
> In a sample of timothy seed which had the appearance of being very pure, Dr. Nobbe found about 7 per cent. of foreign seeds, in which he identified thirty-one different kinds, mostly weeds and inferior grasses; and he calculated that upon a Saxon acre (equals 1.37 English acres), no less than 1,700,000 of these foreign seeds would be sown, or twenty-four upon

every square foot, by using the customary quantity of this pure timothy seed.

So far as we know, nothing like an extended examination of our own seed market has yet been attempted. We hear frequent complaints about the feeble germinating power of seeds, which is generally attributed to their age. It is only fair to say, that these complaints are in many cases unreasonable. Seeds often fail to come up on account of unfavorable weather immediately following the planting, or because they were improperly planted, too shallow or too deep, or sufficient pains was not taken to press down the earth covering them, and thus enable it to hold its moisture. Now and then, too, a farmer is deceived in the nature of the seed he buys, and gets a crop quite different from what he anticipated. Any such superficial examination as a purchaser can make at the dealer's before buying, is quite inadequate. We feel there is good reason for undertaking examinations of seeds in the laboratory, to determine whether we are really free from the danger of buying bad articles, and, what is equally important, to prevent such a state of things as exists in other countries. In this endeavor, we shall feel sure of the co-operation of all honest seedsmen. They will appreciate, as do dealers in fertilizers, that the Station is a defense to them as well as to farmers.

A brief outline of the method recommended by Dr. Nobbe and pursued at this Station, may be of interest. The sample for examination is taken from barrels or bags, with instruments made for the purpose, or in such other way as to secure a perfect average sample. This, when brought to the laboratory is thoroughly mixed, and a small part of it withdrawn, with very special precautions to ensure its representing the average quality of the whole. This portion, of from 2 to 50 grammes* according to the kind of seed, is next carefully weighed, and then picked over by the examiner, seed by seed, with the aid of magnifying glasses and other instruments designed for the purpose. Each seed passes under the eye, the genuine seeds, those corresponding with the label under which they were sold, are put by themselves, in one place, and all foreign matters, whether seeds, chaff, dust, or sand in another. The pure seeds are weighed by themselves, and the impurities also.

*1-15th to 1 3-4ths ounces.

In this way, we learn the per cent. of pure seed. For instance, suppose we take four grammes of seed and find after picking it over, one gramme of impurities and three grammes of pure seed. We make then the proportion, 4 : 3 : : 100 : 75. *i. e.* our sample contains 75 per cent. of pure seed and 25 per cent. of impurities. The foreign seeds are examined botanically to see if there are among them any which would produce parasitic plants, or weeds poisonous to cattle. If there are, such an article should be at once rejected by the farmer. The germinating power of the pure seeds is next ascertained, as follows: Two lots of two hundred seeds each are carefully counted out, and, after being weighed, are allowed to soak in distilled water twenty-four hours. They are then transferred, the one lot to an apparatus of porous earthen ware, where they can be kept moist and protected from dust, the other to a wrapper of bibulous paper which is also kept moist. From time to time the seeds are examined, and those which have germinated are counted and removed.

The date of the counting and the number which had germinated at the date are entered in a book kept for the purpose. At the expiration of ten days or two weeks, in most cases, the trial is concluded. The number which have sprouted, all told, is found, and to it is added one-third of the number which have remained sound during the experiment, and yet show no disposition to sprout. The sum is divided by two and the quotient taken as the number of seeds in one hundred, *i. e.* the per cent., which will sprout. The object in making two sprouting trials, is to provide a check on any possible mistake which might pass unnoticed in a single experiment.

As was said, these four hundred seeds were weighed previous to the sprouting trial. From this we calculate the weight of one thousand kernels. This a not unimportant item in judging of the good quality of the seed. Heavier seed, other things being equal, is to be preferred to light seed.

From the per cent. amount of pure seed in the sample, and the per cent. of pure seed capable of germination we calculate its "agricultural value," which expresses the percentage amount by weight of the sample which may be expected to furnish plants of the kind indicated by the label.

The report returned to the persons sending in the sample will run then as is illustrated by the following example:

The following is the result of examination of *Trifolium pratense*—RED CLOVER.

STATION NO. 22.

Received March 21, 1877, from John Smith, Middletown, Conn.

Pure Seed, - - - 94.3 per cent.
Impurities, - - - 5.7 per cent.

Consisting of chaff, broken seeds, and a little [illegible]ish clover—*T. hybridum.*

Pure seed capable of germination, 89 per cent.
Agricultural value, - - 83.9 per cent.
One thousand seeds weigh, - 1.59 grammes.
The seed is accordingly of good quality.

In selecting a sample for examination the very greatest care should be used to have it represent accurately the whole amount from which it was taken. The contents of the barrel or bag should be thoroughly mixed with the hand and arm, and the seed then removed in small quantities, from different places. This is conveniently done with a small tin spice box or a custard cup. The cup can be closed with the palm of the hand until forced down to the desired place, and there filled and removed. When a number of such samples are obtained they may be spread on a paper. From this mixture a sample may be taken, securely done up, and forwarded to the Station, by mail or express. At the same time a full description should be sent, giving the label under which the article is sold, price, name of dealer, mode of taking the sample, and, when possible, the name of the seedsmen who raised the sample. The size of the sample sent to the laboratory should vary with the kind of seed. Of the smaller seeds—red top, white clover, timothy, etc., ounces; of beets, turnips, red clover, etc., four ounces; of cereals and legumes, eight ounces will suffice.

As the test of germinating power requires some time for its completion, a report on samples sent in cannot be ordinarily expected in less than two weeks.

It is hoped that this work will meet with favor among the farmers of the State, and that its prosecution will receive from them all needed assistance.

The credit of this, the first introduction of such investigations of seeds into this country, is due to Messrs. Jenkins and Warnecke, both of whom have lately studied the methods with Dr. Nobbe at Tharand.