STATE OF CONNECTICUT.

# ANNUAL REPORT

OF

# The Connecticut Agricultural

# EXPERIMENT STATION

For 1878.

PRINTED BY ORDER OF THE LEGISLATURE.

NEW HAVEN:
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1879.

# OFFICERS

OF

# The Connecticut Agricultural Experiment Station,

1878.

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## STATE BOARD OF CONTROL.

| | | |
|---|---|---|
| | HIS EXC. R. D. HUBBARD, Hartford, *President.* | *Ex-officio.* |
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| | W. H. BREWER, New Haven, *Sec'y and Treas.* | " 1881. |
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*Chemists.*

E. H. JENKINS, B.A.
H. P. ARMSBY, PH.B.
H. L. WELLS, PH.B.

His Exc. CHARLES B. ANDREWS, of Litchfield, is President of the Board of Control for 1879. The other Officers are as above.

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# ANNOUNCEMENT.

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THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION was established in accordance with an Act of the General Assembly, approved March 21, 1877, "for the purpose of promoting Agriculture by scientific investigation and experiment."

The Station is prepared to analyze and test fertilizers, cattle-food, seeds, soils, waters, milk, and other agricultural materials and products, to identify grasses, weeds, and useful or injurious insects, and to give information on the various subjects of Agricultural Science, for the use and advantage of the citizens of Connecticut.

All chemical analyses, seed examinations, etc., proper to an Experiment Station, that can be used for the public benefit, will be made without charge. Work done for the use of individuals will be charged for at moderate rates. The Station will undertake no work, the results of which are not at its disposal to use or publish, if deemed advisable for the public good.

Samples of Commercial Fertilizers, Seeds, etc., will be examined in the order of their coming; but when many samples of one brand or kind are sent in, the Station will make a selection for analysis. In taking samples of Commercial Fertilizers and Seeds for examination, the Station's "Instructions for Sampling" must be strictly followed, and its blank "Forms for Description of Samples" must be filled out and sent with the samples.

The results of each analysis or examination will be promptly communicated to the party sending the sample. Results that are of general interest will be sent simultaneously to all the newspapers of the State for publication.

The officers of the Station will take pains to obtain for analysis, samples of all the commercial fertilizers sold in Connecticut; but the organized coöperation of the farmers is essential for the full and timely protection of their interests. Farmers' Clubs and like Associations can efficiently work with the Station for this purpose, by sending in samples early during each season of trade.

It is the wish of the Board of Control to make the Station as widely useful as its resources will admit. Every Connecticut citizen who is concerned in agriculture, whether farmer, manufacturer, or dealer, has the right to apply to the Station for any assistance that comes within its province to render, and the Station will respond to all applications as far as lies in its power.

☞ Instructions and Forms for taking samples, and Terms for testing Fertilizers, Seeds, etc., for private parties, sent on application.

☞ Parcels by Express, to receive attention, should be prepaid, and all communications should be directed to

AGRICULTURAL EXPERIMENT STATION,
NEW HAVEN, CONN.

**Laboratory and Office, in East Wing of Sheffield Hall, Grove St., head of College St.**

# CONTENTS.

# REPORT OF THE BOARD OF CONTROL.

*To the General Assembly of the State of Connecticut:*

The Board of Control of The Connecticut Agricultural Experiment Station has the honor to submit the following Report.

For a history of the Experiment Station in Connecticut, an institution so indispensable to the progress of our agriculture and the welfare of the manufacture and commerce in fertilizers, we refer your honorable body to our last Report, and to the Reports of the State Board of Agriculture.

During the year 1878, the work of the Station, under the direction of Professor S. W. Johnson, has gone on without any interruption whatever. He has been assisted the whole year by Messrs. E. H. Jenkins and H. P. Armsby, and by Mr. H. L. Wells for six months. In an investigation of supposed poisoning of animals, he was also assisted for a time by Mr. Wm. T. Sedgwick.

The apparatus of the Station and other facilities for work have been much extended during the year just closed.

The term of office of Messrs. Webb and Brewer, as members of the Board, expired in the year; the former was re-appointed by the Governor of the State, the latter by the Governing Board of the Sheffield Scientific School.

The Executive Committee has held twelve meetings in the year, one in each month, and the full Board has held one meeting. For the expenses and operations of the Station we refer your honorable body to the appended Reports of the Treasurer and Director, presented to this Board at its Annual meeting held in Hartford, Jan. 21st, 1879.

By order of the Board.

CHARLES B. ANDREWS,
*President.*

WILLIAM H. BREWER,
*Secretary.*

# REPORT OF THE TREASURER.

Wm. H. Brewer, *in account with The Connecticut Agricultural Experiment Station.*

| | | |
|---|---|---|
| **Received.** | | |
| Balance from old account, | $301.41 | |
| For Chemical Analyses and Bulletins, | 442.99 | |
| From State Treasurer, | 5,000.00 | |
| | | $5,744.40 |
| **Paid Out.** | | |
| Salaries, | $3,900.00 | |
| Traveling Expenses of Board of Control, | 23.65 | |
| Stationery, Printing, and Postage, | 172.69 | |
| Fuel and Gas, | 101.38 | |
| Other Laboratory Expenses, | 989.00 | |
| Furniture, | 43.23 | |
| Miscellaneous, | 51.17 | |
| | 5,281.12 | |
| Balance on hand, | 463.28 | |
| | | $5,744.40 |

There is now due the Station, eighty-three (83) dollars for analyses; and the bills outstanding against the Station amount to about five hundred and forty (540) dollars.

WM. H. BREWER, *Treasurer.*

New Haven, Conn., January 20th, 1879.

# REPORT OF THE DIRECTOR.

The (1st) Report of this Station, printed in the early part of 1878, gave an account of the organization and operations of the Station from the date of its beginning, July 1st, 1877, until the close of that year.

The present (2d) Report covers the doings of the Station for the twelve-month ending Dec. 31st, 1878, during which time its work has been going on actively and without interruption.

The Objects and Uses of the Station, and the Privileges which it offers to the citizens of Connecticut, are concisely set forth in the Announcement which is to be found on page 3.

The most important subjects which have engaged attention at the Station during the year 1878, are briefly stated in the paragraphs that immediately follow. Reference to the Table of Contents will direct to their details and show what other topics are considered in this Report.

*Summary of Station Work.*—During the year 1878 the Station has been chiefly occupied with the chemical examination of the *Fertilizers* which are found in our markets in increasing quantity and variety. The number of samples analyzed has been one hundred and seventy-one (171). Many of these have required the separation and determination of five or more distinct ingredients, and as it is the rule of the Station to duplicate the analyses, in order, as far as possible, to remove all chance of error, the number of analytical determinations executed on fertilizers alone during the year has been one thousand and one hundred (1100), viz: of phosphoric acid, three hundred and twenty-six (326); of nitrogen, five hundred (500); of potash, ninety-eight (98); of water, eighty-eight (88), etc.

We have not been able to accomplish as much in the study of *Feeding Stuffs* as was hoped, because of the pressure of fertilizer-work. As an unfortunate result, some samples of feeding stuffs collected for analysis have spoiled on our hands, and others are possibly so altered as make their examination of doubtful value. We have, notwithstanding, found time to complete thirty-one (31) analyses, involving three hundred (300) determinations, which are reported in the following pages.

Other chemical work has been expended upon six samples of sugar beet, three of well-water, one of Paris green, one of white hellebore, one of "red rock," and upon two supposed cases of poisoning. In one of these cases, a well-known fertilizer was suspected of occasioning the loss of human life; in the other, the cause of the death of several horses was the point of investigation.

The study of the methods of determining the proportions of nitrogen and of phosphoric acid in fertilizers, etc., has been assiduously prosecuted during the year, and some results very valuable to the agricultural chemist, and not less so to all who make, sell or use fertilizers and feeding stuffs, have been reached. In studying the processes for estimating nitrogen, ninety-five (95) determinations of that substance have been made, for the purpose of testing every suggestion that could be gathered from the statements of other chemists, or from our own extensive experience. This investigation has cost much time and labor. Its full details are too technical for these pages, and may most appropriately appear in a scientific journal. The investigation itself will enable us in the future to do our work more correctly and more rapidly than heretofore, and to be far more certain in our conclusions. We have also reason to believe that the results will be of essential benefit to all chemists who deal with the elements in question.

The total number of quantitative analytical determinations made in the Laboratory during 1878 has been not less than fifteen hundred and fifty (1550).

But a single *Seed-Examination* has been called for during the year.

The study of the *Relations of Soils to Water* has been continued experimentally as far as time and the very insufficient means at command have permitted.

*Station Bulletins.*—The results of such analyses as were of general interest have been published in seventeen Bulletins issued as occasion required. These have been distributed to the Agricultural Societies, Farmers' Clubs, and newspapers of the State, as well as to the leading agricultural periodicals of the country. A lively interest has been manifested in these Bulletins, not only among our own citizens, but also among farmers and manufacturers in other States. In most cases they have been prepared in just sufficient number to supply societies and newspapers with a single copy each, by means of the Edison Electric Pen and Duplicating Press. This instrument only allows the issue of a small sheet, which is not always easily legible, especially after one or two hundred copies have been worked off; and its circulation ultimately depends upon the reproduction of its matter in the daily or weekly press. In order to reach the public with an ampler measure of our results, Bulletin No. 19, of seven pages like those of this Report, was printed in September last, in an edition of four thousand copies. These were distributed at the State Fair and at most of the County and Town Exhibitions, or otherwise, chiefly through the ready and enthusiastic coöperation of the officers of our Agricultural Societies and Farmers' Clubs.

This Bulletin gave report of the composition and valuation of fourteen fertilizers with forty-nine distinct analytical determinations. Some errors, mostly unimportant, found their way into Bulletin No. 19, which required for their correction more space than our usual Bulletins afforded, and accordingly Bulletin No. 20 was also printed.

The advantages of the printed Bulletin are so obvious and so great, that it is to be hoped the funds of the Station may warrant their more frequent employment.

*The Correspondence* of the Station that has passed the hands of the Director during the year has involved the exchange of some six hundred and fifty letters, including reports of analyses, answers to inquiries, etc.; many of them indeed brief, but many, also, requiring considerable time and care in their preparation.

*Chemical Exhibit.*—In July last the Executive Committee instructed the Director to prepare a systematic Collection of those Chemical Elements and Compounds which enter into the composition of Soils, Fertilizers, Feeding Stuffs, and whatever is of most direct interest to the Farmer, and to display the same, suitably cased and labeled, at the Fair of the State Agricultural Society. Two cases, each six feet by four, filled with specimens, mostly contained in glass-stoppered bottles, were accordingly got ready for the State Fair, and afterwards were shown at the Fair of the New Haven County Agricultural Society.

On these occasions the Exhibit excited a deep interest among practical men, many of whom had, by its means, their first opportunity to see in a state admitting of identification, the chemical substances, which, until lately unknown, even by name, except to men of science, are rapidly becoming familiar as household words in the homesteads of our State. The officers of the two Societies named, accorded every courtesy and facility to the Station that could have been desired, and the State Agricultural Society appointed a Special Committee to report upon it. This Collection will be henceforth on view at the Office of the Station. Further account of it will be found on subsequent pages.

## COMMERCIAL FERTILIZERS.

The Station makes analyses of fertilizers and fertilizing materials; firstly, for the benefit of farmers, gardeners, and the public generally; secondly, for the private use of manufacturers and dealers. Analyses of the first class are made gratuitously, and the results are published as speedily and widely as possible, for the guidance of purchasers and consumers. Those of the second class are charged for at moderate rates, and their results are not published in a way to interfere with their legitimate private use. The Station, however, distinctly reserves the liberty to use at discretion all results obtained in its Laboratory for the public benefit, and in no case will enter into any privacy that can work against the public good.

During 1878, one hundred and seventy-one (171) samples of fertilizers have been analyzed. Of these, fifty-four (54) were examined for private parties, and the remainder, one hundred and seventeen (117), for the general use of the citizens of the State.

The samples analyzed for the public benefit have been sent in from all quarters of the State, in most instances by actual purchasers and consumers. In a few instances, dealers or agents have sent in samples, and in a few cases the Officers of the Station have sampled fertilizers on the docks at New Haven.

All the analyses of the first class are made on samples understood to have been taken in accordance with the printed Instructions which the Station supplies to all applicants. Here follows a copy of them.

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### INSTRUCTIONS FOR SAMPLING COMMERCIAL FERTILIZERS.

The *Commercial Value* of a high priced Fertilizer can be estimated, if the percentages of its principal fertilizing elements are known. Chemical analysis of a small sample, so taken as to

fairly represent a large lot, will show the composition of the lot. The subjoined instructions, if faithfully followed, will insure a fair sample. Especial care should be observed that the sample neither gains nor loses *moisture* during the sampling or sending, as may easily happen in extremes of weather, or from even a short exposure to sun and wind, or from keeping in a poorly closed vessel.

1. Provide a tea cup, some large papers, and for each sample a glass fruit can or tin box, holding about one quart, that can be tightly closed, all to be clean and dry.

2. Weigh separately at least three (3) average packages (barrels or bags) of the fertilizer, and enter these *actual weights* in the "Form for Description of Sample."

3. Open the packages that have been weighed, and mix well together the contents of each, down to one-half its depth, emptying out upon a clean floor if needful, and crushing any soft, moist lumps in order to facilitate mixture, but leaving hard, dry lumps unbroken, so that the sample shall exhibit the texture and mechanical condition of the fertilizer.

4. Take out five (5) equal cupfuls from different parts of the mixed portions of each package. Pour them (15 in all) one over another upon a paper, intermix again thoroughly but quickly to avoid loss or gain of moisture, fill a can or box from this mixture, close tightly, *label plainly*, and send, charges prepaid, to

*The Conn. Agricultural Experiment Station, New Haven, Conn.*

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The above Instructions may be over-nice in some cases, but they are not intended to take the place of good sense on the part of those who are interested in learning the true composition of a fertilizer. Any mode of operating that will yield *a fair sample* is good enough.

In case of a fine, uniform and moist or coherent article, a butter-tryer or a tin tube, like a dipper handle, put well down into the packages in a good number of places will give a fair sample with great ease. With dry, coarse articles, such as ground bone, there is likely to be a separation of coarse and fine parts on handling. Moist articles put up in bags or common barrels may become dry on the outside. It is in these cases absolutely necessary to mix thoroughly the coarse and fine, the dry and the moist portions before sampling. Otherwise the analysis will certainly misrepresent the article whose value it is intended to fix.

The quantity sent should not be too small. When the material is fine and uniform, and has been carefully sampled, a pint may be enough, but otherwise and especially in case of ground bone, which must be mechanically analyzed, the sample should not be less than one quart.

With the Instructions for Sampling, the Station furnishes a blank Form for Description of Samples, a copy of which is here given.

### FORM FOR DESCRIPTION OF SAMPLE.

Station No. Rec'd at Station, 18

Each sample of Fertilizer sent for analysis must be accompanied by one of these Forms, with the blanks *below* filled out fully and legibly.

The filled out Form, if wrapped up with the sample, will serve as a label.

Send with each sample a specimen of any printed circular, pamphlet, analysis, or statement that accompanies the fertilizer or is used in its sale.

Brand of Fertilizer,

Name and address of Manufacturer,

Name and address of Dealer from whose stock this sample is taken,

Date of taking this Sample,

Selling price per ton or hundred, bag or barrel,

Selling weight claimed for each package weighed,

Actual weights of packages opened,

Here write a copy of any analysis or guaranteed composition that is fixed to the packages.

Signature and P. O. address of person taking and sending the sample.

On receipt of any sample of fertilizer from the open market, the filled out "Form for Description," which accompanies it, is filed in the Station's Record of Analyses and remains there as a voucher for the authenticity of the sample and for the fact that it has been taken fairly, or, at least, under suitable instructions. It is thus sought to insure that manufacturers and dealers shall not suffer from the publication of analyses made on material that does not correctly represent what they have put upon the market.

The "Form for Description" when properly filled out also contains all the data of cost, weight, &c., of a fertilizer which are necessary for estimating, with help of the analysis, the commercial value of its fertilizing elements, and the fairness of its selling price. Neglect to give full particulars occasions the Station much trouble, and it is evident that want of accuracy in writing up the Description may work injustice to Manufacturers or Dealers as well as mislead consumers. It is especially important that the *Brand* of a fertilizer and its *Selling price* should be correctly given. The price should be that actually charged by the dealer of whom it is bought, and if the article be purchased in New York or other distant market, the cost at the nearest point to the consumer, on rail or boat, should be also stated.

In all cases *ton-prices* should be given, and if the sale of an article is only by smaller quantities, that fact should be distinctly stated.

When a sample of fertilizer has been analyzed, the results are entered on a printed form, which is filed in the Station Record of Analyses, facing the "Description of Sample" that was received with the fertilizer to which it pertains, and there remains for future reference.

A copy of the analysis is also immediately reported to the party that furnished the sample, the report being entered on one page of another printed form and facing a second printed page of "Explanations" intended to embody the principles and data upon which the valuation of Fertilizers is based.

These Explanations are essential to a correct understanding of the analyses that are given on subsequent pages and are therefore reproduced here.

### EXPLANATIONS OF FERTILIZER–ANALYSIS AND VALUATION.

*Nitrogen* is commercially the most valuable fertilizing element. It occurs in various forms or states. *Organic nitrogen* is the nitrogen of animal and vegetable matters generally, existing in the albumin and fibrin of meat and blood, in the uric acid of bird dung, in the urea and hippuric acid of urine, and in a number of other substances. Some forms of organic nitrogen, as that of blood and meat, are highly active as fertilizers; others, as that of hair and leather, are comparatively slow in their effect on vegetation, unless these matters are reduced to a fine powder or chemically disintegrated. *Ammonia* and *nitric acid* are results of the decay of *organic nitrogen* in the soil and manure heap, and are the most active forms of Nitrogen. They occur in commerce—the former in sulphate of ammonia, the latter in nitrate of soda. 17 parts of ammonia contain 14 parts of nitrogen.

*Soluble Phosphoric acid* implies phosphoric acid or phosphates that are freely soluble in water. It is the characteristic ingredient of Superphosphates, in which it is produced by acting on "insoluble" or "reverted" phosphates with oil of vitriol. It is not only readily taken up by plants, but is distributed through the soil by rains. Once well incorporated with soil it shortly becomes reverted phosphoric acid.

*Reverted* (*reduced or precipitated*) *Phosphoric acid*, means strictly, phosphoric acid that was once freely soluble in water, but from chemical change has become insoluble in that liquid. It is freely taken up by a strong solution of ammonium citrate, which is therefore used in analysis to determine its quantity. "Reverted phosphoric acid" implies phosphates that are readily assimilated by crops, but have less value than soluble phosphoric acid, because they do not distribute freely by rain.

*Insoluble Phosphoric acid* implies various phosphates not freely soluble in water or ammonium citrate. In some cases the phosphoric acid is too insoluble to be readily available as plant food. This is true of the South Carolina rock phosphate, of Navassa phosphate, and especially of Canada apatite. The phosphate of raw bones is nearly insoluble in this sense, because of the animal matter of the bone which envelopes it, but when the latter decays in the soil, the phosphate remains in essentially the "reverted" form.

*Potash* signifies the substance known in chemistry as potassium oxide, which is the valuable fertilizing ingredient of "potashes" and "potash salts." It is most costly in the form of sulphate, and less so in the shape of muriate or chloride.

*The Valuation of a Fertilizer* signifies estimating its worth in money, or its trade-value, a value which it should be remembered is not *necessarily* proportional to its fertilizing effects in any special case.

Plaster, lime, stable manure and nearly all of the less expensive fertilizers have variable prices, which bear no close relation to their chemical composition, but guanos, superphosphates and other fertilizers, for which $30 to $80 per ton are paid, depend chiefly for their trade-value on the three substances, *nitrogen*, *phosphoric acid* and *potash*, which are comparatively costly and steady in price. The money-value per pound of these ingredients is easily estimated from the market prices of the standard articles which furnish them to commerce.

*The average Trade-values* or cost in market, per pound, of the ordinarily occurring forms of nitrogen, phosphoric acid and potash, as recently found in the Connecticut and New York markets, and employed by the Station during 1878, are as follows:

TRADE-VALUES FOR 1878.

*See page* 19.

| | Cents per pound. |
|---|---|
| Nitrogen in ammonia and nitrates, | 24 |
| " in Peruvian Guano, fine steamed bone, dried and fine ground blood, meat and fish, | 20 |
| " in fine ground bone, horn and wool dust, | 18 |
| " in medium bone, | 16½ |
| " in coarse bone, horn shavings and fish scrap, | 15 |
| Phosphoric acid soluble in water, | 12½ |
| " " "reverted" and in Peruvian Guano, | 9 |
| " " insoluble, in fine bone and fish guano. | 7 |
| " " " in medium bone, | 6 |
| " " " in coarse bone, bone ash and bone black, | 5 |
| " " " in fine ground rock phosphate, | 3½ |
| Potash in high grade sulphate, | 7½ |
| " in low grade sulphate and kainite, | 6 |
| " in muriate, or potassium chloride, | 4½ |

*These "estimated values" of the elements of fertilizers* are not fixed, but vary with the state of the market, and are from time to time subject to revision. They are not exact to the cent or its fractions, because the same article sells cheaper at commercial or manufacturing centers than in country towns, cheaper in large lots than in small, cheaper for cash than on time. These values are high enough to do no injustice to the dealer, and accurate enough to serve the object of the consumer.

*To Estimate the Value of a fertilizer* we multiply the per cent. of Nitrogen, &c., by the trade-value per pound, and that product by 20, we thus get the values per ton of the several ingredients, and adding them together we obtain the total estimated value per ton.

*The uses of the "Valuation"* are, 1st, to show whether a given lot or brand of fertilizer is worth as a commodity of trade what it costs. If the selling price is no higher than the estimated value, the purchaser may be quite sure that the price is reasonable. If the selling price is but $2 to $3 per ton more than the estimated value it may still be a fair price, but if the cost per ton is $5 or more over the estimated value, it would be well to look further. 2d, Comparisons of the estimated values, and selling prices of a number of fertilizers, will generally indicate fairly which is the best for the money. But the "estimated value" is not to be too literally construed, for analysis cannot always decide accurately what is the *form* of nitrogen, &c., while the mechanical condition of a fertilizer is an item whose influence cannot always be rightly expressed or appreciated.

*The Agricultural value* of a fertilizer is measured by the benefit received from its use, and depends upon its fertilizing effect, or crop-producing power. As a broad, general rule, it is true that Peruvian guano, superphosphates, fish-scraps, dried blood, potash salts, plaster, &c., have a high agricultural value which is related to their trade-value, and to a degree determines the latter value. But the rule has many exceptions, and in particular instances the trade-value cannot always be expected to fix or even to indicate the agricultural value. Fertilizing effect depends largely upon soil, crop and weather, and as these vary from place to place and from year to year, it cannot be foretold or estimated except by the results of past experience, and then only in a general and probable manner.

For the above first-named purpose of valuation the trade-values of the fertilizing elements which are employed in the computations, should be as exact as possible and should be frequently corrected to follow the changes of the market. For the second-named use of valuation frequent changes of the trade-values are disadvantageous, because two fertilizers cannot be compared as to their relative money-worth, when their valuations are estimated from different data. The greatest good of the greatest number is best served, in an Annual Report, by a middle course, especially since, in such a document, the fluctuations in trade-value that may occur within the year, cannot be accurately followed, and the comparisons of estimated values are mostly in retrospect.

Further remarks upon Valuation will be found in subsequent pages, setting forth the considerations for modifying the trade-values of certain elements of fertilizers, to suit the present condition of the market, or to give more precision to the estimates of the Station.

For the year 1879, or until good reasons arise for further change, the following estimated values of the active ingredients will be used by the Station in comparing fertilizers.

### TRADE-VALUES FOR 1879.

*See page* 17.

| | Cents per pound. |
|---|---|
| Nitrogen in nitrates | 26 |
| " in ammonia salts, | 22½ |
| " in Peruvian Guano, fine steamed bone, dried and fine ground blood, meat and fish, | 20 |
| " in fine ground bone, horn and wool dust, | 18 |
| " in fine-medium bone,* | 17¼ |
| " in medium bone, | 16½ |
| " in coarse-medium bone, | 15¾ |
| " in coarse bone, horn shavings and fish scrap, | 15 |
| Phosphoric acid soluble in water, | 12½ |
| " " "reverted" and in Peruvian Guano, | 9 |
| " " insoluble, in fine bone and fish guano, | 7 |
| " " " in fine-medium bone, | 6½ |
| " " " in medium bone, | 6 |
| " " " in coarse-medium bone, | 5½ |
| " " " in coarse bone, bone ash and bone black, | 5 |
| " " " in fine ground rock phosphate, | 3½ |
| Potash in high grade sulphate, | 7½ |
| " in low grade sulphate and kainite, | 6 |
| " in muriate, or potassium chloride, | 4½ |

### ANALYSES AND VALUATION OF FERTILIZERS.

The fertilizers analyzed in the Station Laboratory during the year 1878 are as follows, viz:

39 superphosphates.
15 guanos.
26 bone manures.
31 fish fertilizers.
19 samples of dried blood and animal matters.
9 samples of potash salts.
1 sample of nitrate of soda.
3 samples of ground gypsum or plaster.
1 sample of brick kiln ashes.
1 sample of leached ashes.
1 sample of bone ash.
1 sample of South Carolina phosphate.
1 sample of tobacco stems.
1 sample of castor pomace.
1 sample of vegetable ivory dust.
1 sample of carbon sediment.

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* See p. 27.

3 composts of bone and ashes.
2 composts of peat and leather.
1 sample of leather.
1 sample of peat or swamp muck.
1 sample of poudrette.
12 samples of "special manures" or "formulas" for particular crops.

171 total.

Here follow the details of those analyses which have any general interest, together with such remarks as may be useful in explanation.

### SUPERPHOSPHATES.

Of the thirty-nine samples of this class of fertilizers, ten were analyzed for the private use of manufacturers or dealers. The composition of the remaining twenty-nine superphosphates is given in the following tabular statement.

Here follows the full name or brand of each superphosphate, so far as the Station is informed, and also the names of the parties from whom the samples were received.

*Superphosphates.*

| | Name or Brand. | Sampled by |
|---|---|---|
| **126** | New Haven Chemical Co's Acid Phosphate. | J. J. Webb, Hamden. |
| **54** | " " Ammoniated Superphosphate. | " " |
| **96** | | " " |
| **63** | Wheeler's Ammoniated Bone Phosphate. | G. H. Tomlinson, Stratford. |
| **81** | Hubbell's Ammoniated Superphos. of Lime. | Albert Wilcoxson, " |
| **82** | E. Frank Coe's Ammoniated Bone Superphosphate. | J. B. Barstow & Co., Norwich. |
| **107** | | " " |
| **109** | | Albert Day, W. Killingly. |
| **125** | | E. Stiles & Son, Willimantic. |
| **135** | | M. S. Baldwin, Naugatuck. |
| **139** | | J. B. Barstow & Co., Norwich. |
| **173** | | P. M. Augur, Middlefield. |
| **88** | Quinnipiac Fertilizer Co's Nitrogenous Superphosphate. | H. P. Armsby, N. Haven. |
| **130** | | " " |
| **104** | Russel Coe's Ammoniated Bone Superphosphate. | Albert Day, W. Killingly. |
| **129** | | R. S. Hubbard, Middletown. |
| **192** | | J. J. Webb, Hamden. |
| **106** | Quinnipiac Co's Phosphate. | F. W. Isham, Cheshire. |
| **108** | H. B. King's Pure Dissolved Bone. | L. H. Gager, Quarryville. |
| **110** | Mitchell's Superphosphate. | Albert Day, W. Killingly. |
| **111** | Lombard & Matthewson's Pure Bone Superphosphate. | J. D. Gaylord, Ashford. |
| **122** | G. B. F. | L. S. Wells, New Britain. |
| **127**<br>**158**<br>**159** | Upton's Superphosphate. | E. Stiles & Son, Willimantic. |
| **148** | Americus Ammoniated Superphosphate. | J. J. Webb, Hamden. |
| **222** | | R. Martin, Green's Farms. |
| **163** | Bradley's Superphosphate of Lime. | M. S. Baldwin, Naugatuck. |
| **225** | Excelsior Ammoniated Bone Superphosphate. | H. R. Merwin, Woodbridge. |

*Analyses of Superphosphates.*

| Stat'n No. | Manufacturer. | Nitrogen. | Soluble Phos. Acid. | Revert. Phos. Acid. | Insol. Phos. Acid. | Potash. | Estim. Value per ton. | Cost per ton. | Dealer. |
|---|---|---|---|---|---|---|---|---|---|
| **126** | New Haven Chemical Co., | --- | 7.27 | 1.06 | 8.26 | --- | $25.87 | $30.00 | New Haven Chemical Co. |
| **54** | " " " | 1.87 | 5.21 | 1.57 | 1.80 | 2.62 | 29.00 | 40.00 | " " |
| **96** | " " " | 2.81 | 6.27 | 2.80 | 2.58 | 3.42 | 40.68 | 40.00 | " " |
| **63** | W. E. Wheeler, Stratford, | 2.12 | 10.34 | 0.00 | 0.99 | --- | 35.32 | 45.00 | W. E. Wheeler, Stratford. |
| **81** | L. S. Hubbell & Son, Stratford, | 2.80 | 8.38 | 0.81 | 1.23 | 0.30 | 35.29 | 45.00 | L. S. Hubbell & Son, Stratford. |
| **82** | E. Frank Coe, Brooklyn, L. I., | 2.09 | 8.94 | 1.25 | 2.50 | 0.10 | 36.61 | 40.00 | John B. Barstow & Co., Norwich. |
| **107** | " " | 2.41 | 8.58 | 0.31 | 3.30 | --- | 36.27 | 38.00 | " " |
| **109** | " " | 2.17 | 7.00 | 0.95 | 4.92 | --- | 34.78 | 37.00 | James Brothers, Danielsonville. |
| **125** | " " | 2.68 | 8.72 | 0.51 | 2.48 | --- | 36.91 | 38.00 | E. Stiles & Son, Willimantic. |
| **135** | " " | 2.66 | 8.96 | 0.21 | 4.04 | --- | 39.08 | 45.00 | Osborne & Tolles, Naugatuck. |
| **139** | " " | 2.35 | 8.60 | 0.76 | 1.91 | --- | 34.94 | 38.00 | J. B. Barstow & Co., Norwich. |
| **173** | " " | 2.16 | 6.92 | 1.18 | 1.42 | --- | 35.05 | 40.00 | |
| **88** | Quinnipiac Fertilizer Co., New Haven, | 3.03 | 5.64 | 1.15 | 2.46 | 1.82 | 33.38 | 40.00 | Quinnipiac Fertilizer Co. |
| **130** | " " | 3.08 | 6.27 | 1.35 | 2.82 | 2.66 | 38.37 | 40.00 | " " |
| **104** | Russell Coe, Linden, N. J., | 1.98 | 2.90 | 3.76 | 9.08 | --- | 34.65 | 35.00 | Chas. Phillips, Danielsonville. |
| **129** | " " | 1.69 | 2.06 | 5.20 | 11.18 | --- | 32.45 | 38.00 | Southmayd & Gardiner, Middletown. |
| **192** | " " | 1.92 | 4.72 | 0.82 | 6.11 | --- | 29.51 | 38.00 | Olds & Whipple, Hartford. |
| **106** | Quinnipiac Co., Wallingford, | 5.47 | 3.38 | 3.71 | 1.58 | --- | 39.22 | 45.00 | Burr Hall, Ag't, Wallingford. |
| **108** | H. B. King, Rockville, | 2.48 | 2.14 | 9.40 | 3.13 | --- | 36.57 | 45.00 | H. B. King, Rockville. |
| **110** | McKinley & Heines, Linden, N. J. | 1.73 | 0.97 | 2.99 | 5.45 | --- | 22.36 | 35.00 | Chas. Phillips, Ag't, Danielsonville. |
| **111** | Lombard & Matthewson, Warrenville, | 1.59 | 5.88 | 1.57 | 0.90 | --- | 25.15 | 43.90 | Lombard & Matthewson. |
| **122** | Imported by H. J. Baker & Bro., | --- | 14.96 | 0.19 | 0.07 | --- | 29.09 | 29.00* | H. J. Baker & Bro., New York. |
| **127** | George Upton, Boston, Mass., | 1.82 | 2.20 | 5.62 | 0.80 | --- | 24.02 | 38.00 | E. Stiles & Son, Willimantic. |
| **158** | " " | 2.01 | 1.49 | 7.34 | 1.05 | --- | 26.45 | 38.00 | " " |
| **159** | " " | 2.81 | 1.05 | 6.70 | 1.42 | --- | 27.92 | 38.00 | " " |
| **148** | Rafferty & Williams, New York, | 2.16 | 5.12 | 1.40 | 3.49 | 2.01 | 31.87 | 38.00 | Rodney Kellogg, Hartford. |
| **222** | " " | 1.96 | 6.78 | 1.44 | 2.49 | 1.74 | 32.44 | 30.00 | Rafferty & Williams, New York. |
| **163** | Bradley Fertilizer Co., Boston, Mass., | 2.51† | 6.68 | 0.54 | 3.43 | --- | 32.98 | 45.00 | W. F. Sackett, Beacon Falls. |
| **225** | Lake Erie Drier Co., Cleveland, Ohio, | 3.50 | 3.45 | 2.41 | 0.80 | --- | 28.09 | 35.00 | |

* Price in New York.

† Contains 0.59 % of nitrogen in form of ammonia.

Of the above, **126** and **122** are superphosphates without nitrogen, the others are all nitrogenous or "ammoniated" superphosphates. **108** bears the trade name "Dissolved Bone." Articles of the same brand are placed together in the table for convenience of comparison.

With regard to **111** the Station is credibly informed that the manufacturers offered it in good faith at what they supposed was a fair price. On learning its actual composition they withdrew it from the market.

**163** represented to contain 10 per cent. of sulphate of ammonia equal to 2.1 per cent. nitrogen in form of ammonia, really contained 0.59 per cent. of ammonia, corresponding to but 2.3 per cent. sulphate of ammonia.

Manufacturers of superphosphates during the last year have had difficulty in keeping up the quality of their goods because of the disturbance of the sugar business, which has closed up a large number of refineries, and greatly diminished the supply of waste "bone black," which has hitherto been the best source of soluble phosphoric acid.

The imported (English?) superphosphate **122** shows by the exact agreement of its actual and calculated values that the Station valuation for soluble phosphoric acid, viz: 12½ cents, is not too low.

The estimated values of some of the superphosphates containing potash, above given, are slightly but not materially higher than would result from the reduced valuation of potash adopted in the later Bulletins for 1878 and otherwise used in this Report.

### *Guanos.*

Of the fifteen articles analyzed under the trade-name of guanos two were examined for private parties, the composition of the other thirteen is tabulated below.

GUANOS.

| No. | Name. | Manufacturer. | Dealer. | Sampled by |
|---|---|---|---|---|
| **90** | Pine Island | Quinnipiac Fertilizer Co. | Manufacturer, | H. P. Armsby. |
| **132** | " " | " " | " | E. H. Jenkins. |
| **174** | Abbatoir | E. Frank Coe, | " | P. M. Augur, Middlefield. |
| **100** | Soluble Pacific | Pacific Guano Co., | J. H. Dickerman, Mount Carmel, | J. J. Webb, Hamden. |
| **165** | " " | " " | Rodney Kellogg, Hartford. | J. J. Webb, Hamden. |

GUANOS—continued.

| No. | Name. | Manufacturer. | Dealer. | Sampled by |
|---|---|---|---|---|
| **105** | Blood | Manhattan Fertilizer Co. | Manufacturer, | T. B. Wakeman, Green's Farms. |
| **113** | " | " " | Downs & Mallory, Sou. Norwalk. | T. B. Wakeman, Green's Farms. |
| **155** | " | " " | A. C. Sternberg, Hartford. | J. J. Webb, Hamden. |
| **120** | Peruvian, No. 1 | Imported by Hobson, Hurtado & Co., New York, Agents of the Peruvian Gove'ment, | Chapman & Van Wyck. N. York. | T. N. Bishop, Plainville. |
| **141** | " " | | Olds & Whipple, Hartford. | Andrews Bros., Southington. |
| **156** | " " | | R. B. Bradley & Co., N. Haven. | J. J. Webb, Hamden. |
| **179** | " " | | Olds & Whipple, Hartford. | J. J. Webb. Hamden. |
| **211** | " (Lobos) | | Chapman & Van Wyck, N. York. | G. M. Barber, New Britain. |

The comparison between cost and estimated value in case of the Peruvian Guano, is highly satisfactory for the consumers of this standard fertilizer. The guarantees now offered by the importers are such that no fear of getting an inferior article need be entertained if the purchase be made of the agents of the Peruvian Government directly, or of firms of established integrity, since each cargo is carefully sampled and analyzed, the composition and value of each lot is well ascertained, and the price is graded accordingly. It is impossible to analyze each bag, and the purchaser of a small quantity may get a ton, worth much more than the cost like **120**, or costing nearly what it is worth like **156**. In no case that has yet come to the knowledge of the Station, has the cost exceeded the valuation.

| Station Number. | | Nitrogen. | Soluble Phos. Acid. | Reverted Phos. Acid. | Insoluble Phos. Acid. | Potash. | Estimated Value per ton. | Cost per ton. |
|---|---|---|---|---|---|---|---|---|
| **90** | Pine Island Guano | 5.00% | 1.53% | 2.92% | 3.54% | 2.74% | $35.36 | $42.50 |
| **132** | " " | 4.85 | 1.98 | 1.65 | 1.25 | 3.29 | 34.01 | |
| **174** | Abbatoir Guano | 2.49 | 8.56 | 0.58 | 1.37 | 3.76 | 39.96 | 40.00 |
| **100** | Soluble Pacific Guano | 1.97 | 6.00 | 0.90 | 4.17 | 4.40 | 36.94 | 45.00 |
| **165** | " " | 2.39 | 5.67 | 1.84 | 3.77 | 4.05 | 38.41 | 45.00 |
| **105** | Blood Guano | 2.56 | 7.70 | 0.26 | 3.70 | 0.57 | 35.99 | 47.50 |
| **113** | " " | 2.61 | 7.91 | 0.82 | 1.37 | 0.28 | 34.04 | 47.50 |
| **155** | " " | 2.58 | 7.79 | 1.40 | 2.83 | 0.62 | 37.21 | 47.50 (?) |
| **120** | Peruvian Guano, No. 1 | 8 56 | 5.62 | 5.01 | 2.98 | 2.91 | 67.04 | 50.00 |
| **141** | " " | 8.55 | 5.37 | 4.57 | 3.40 | 3.14 | 63.29 | 54.50 |
| **156** | " " | 8.02 | 5.82 | 4.03 | 3.77 | 3.40 | 61.47 | 60.00 |
| **179** | " " | 7.69 | 5.85 | 3.58 | 3.47 | 2.86 | 59.26 | 56.00 |
| **216** | " (Lobos) | 5.14 | 5.19 | 5.73 | 8.69 | 3.75 | 59.40 | 51.00 |

## BONE MANURES.

The analyses of twenty-six samples of Bone Manures are given in the table below.

| Station No. | Name or Brand. | Phos. Acid. | Nitrogen. | Finer than $\frac{1}{50}$ in. | Finer than $\frac{1}{25}$ in. | Finer than $\frac{1}{12}$ in. | Finer than $\frac{1}{6}$ in. | Coarser than $\frac{1}{6}$ in. | Estimated value per ton. | Cost per ton. |
|---|---|---|---|---|---|---|---|---|---|---|
| **74** | Geo. W. Baker's Fine Bone Manure, No. 1 | 13.74 | 3.48 | 40 | 11 | 14 | 11 | 24 | $31.39 | $30.00 |
| **75** | G. W. B's Fine Bone Manure, No. 2. | 8.07 | 2.93 | 45 | 9 | 15 | 13 | 18 | 21.85 | 27.00 |
| **76** | G. W. B's Bone Meal. | 18.71 | 4.11 | 25 | 8 | 16 | 13 | 38 | 31.04 | 35.00 |
| **77** | G.W. B's Bone Flour. | 28.76 | 1.05 | 75 | 11 | 11 | 3 | 0 | 43.88 | 40.00 |
| **143** | G.W.B's Bone M'nure. | 11.85 | 3.26 | 32 | 21 | 23 | 24 | 0 | 28.33 | *25.00 |
| **145** | G. W. B's Rotted Bone Manure. | 2.43 | 2.05 | ---- | ---- | ---- | ---- | ---- | 10.78 | 10.00 |
| **92** | Gilbert Bros.' Raw Bone. | 20.56 | 3.63 | 26 | 23 | 27 | 24 | 0 | 36.65 | 40.00 |
| **93** | Lister's Ground Bone. | 18.48 | 3.48 | 28 | 19 | 19 | 17 | 17 | 33.66 | 35.00 |
| **101** | " " | 14.99 | 2.90 | 35 | 19 | 18 | 19 | 9 | 27.56 | 30.00 |
| **199** | " " | 12.92 | 3.02 | 38 | 21 | 16 | 14 | 11 | 28.96 | †35.00 |
| **95** | N. Haven Chem'l Co's Pure Ground Bone. | 21.60 | 3.11 | 33 | 14 | 14 | 29 | 10 | 36.18 | 36.00 |
| **121** | Pulverized Bone. | 2.34 | 0.06 | ---- | ---- | ---- | ---- | ---- | 10.85 | 20.00 |
| **123** | Peter Cooper's Pure Ground Bone. | 29.84 | 1.21 | Fine | ---- | ---- | ---- | ---- | 46.14 | 40.00 |
| **140** | Peter Cooper's Pure Bone Dust. | 26.10 | 1.41 | 35 | 11 | 14 | 27 | 13 | 41.62 | 30.00 |
| **124** | E. Frank Coe's Gro'nd Bone. | 10.64 | 2.95 | 46 | 19 | 13 | 10 | 12 | 25.51 | 35.00 |
| **136** | Ivory Saw-dust.‡ | 12.43 | 1.37 | --- | ---- | ---- | ---- | ---- | 22.33 | ---- |
| **147** | Rafferty & Williams' "Americus" Bone Meal. | 22.65 | 3.05 | 35 | 21 | 25 | 17 | 2 | 42.69 | 38.00 |
| **167** | | 15.63 | 1.55 | 46 | 20 | 18 | 11 | 5 | 27.46 | 25.00 |
| **200** | | 23.04 | 3.38 | 44 | 22 | 22 | 11 | 1 | 44.43 | §35.00 |
| **223** | | 21.90 | 3.24 | 56 | 18 | 17 | 6 | 3 | 42.32 | 28.00 |
| **176** | G. W. Miller's Fine Bone. | 23.46 | 2.90 | 16 | 18 | 28 | 33 | 5 | 37.72 | 35.00 |
| **177** | G. W. Miller's Coarse Bone. | 21.69 | 3.20 | 3 | 6 | 10 | 14 | 67 | 31.29 | 32.00 |
| **188** | "Bridgeport Bone." | 16.26 | 1.95 | 18 | 20 | 22 | 22 | 18 | 29.78 | 30.00 |
| **189** | H. J. Baker & Bros' Strictly Pure Bone. | 22.15 | 3.42 | 30 | 23 | 29 | 18 | 0 | 43.32 | 38.00 |
| **208** | Rogers & Hubbard Co's Ground Bone. | 24.13 | 4.00 | 18 | 25 | 32 | 25 | 0 | 36.13 | 30.00 |
| **209** | Bone Sawings. | 26.97 | 3.02 | 100 | 0 | 0 | 0 | 0 | 48.63 | 30.00 |

* Wholesale (in New York?)

‡ Pasty mass containing 60.64 per cent. of water.

† Price at Rockville.

§ Price in Hartford.

The following table exhibits the sources whence the bone manures were obtained, and also the rates used in estimating their value:

| Number. | Manufacturer. | Dealer. | Sent by | Estimated value per pound of P. Acid. | Estimated value per pound of Nitrogen. |
|---|---|---|---|---|---|
| **74** | Geo. W. Baker, E. Williamsburg, L. I. | N. Alvord, Green's Farms. | N. Alvord, Green's Farms. | 7 cents. | 18 cents. |
| **75** | | | | 7 " | 18 " |
| **76** | | | | 5 " | 15 |
| **77** | | | | 7 " | 18 " |
| **143** | | George W. Baker. | S. M. Wells, Wethersfield. | 7 " | 18 " |
| **145** | | ? | " | 7 " | 18 " |
| **92** | Stepney Bone Mills, Monroe. | Mix Gilbert. | R. S. Hinman, Birmingham. | 6 " | 16½ " |
| **93** | Lister Bros., Newark, N. J. | F. Hallock & Co., Birmingham. | | 6 " | 16½ " |
| **101** | " | R. B. Bradley & Co., New Haven. | J. J. Webb, Hamden. | 6 " | 16½ " |
| **199** | " | Wills & Treat, Rockville. | A. H. Pomeroy, Coventry. | 7 " | 18 " |
| **95** | New Haven Chemical Company. | New Haven Chemical Co. | J. J. Webb, Hamden. | 6 " | 16½ " |
| **121** | ? | Lombard & Matthewson, Warrenville. | J. D. Gaylord, Ashford. | See | p. 26. |
| **123** | Peter Cooper, New York. | F. Hallock & Co. Birmingham. | R. S. Hinman, Birmingham. | 7 cents. | 18 cents. |
| **140** | " | G. H. Glover, No. Branford. | Farmers' Club, Killingworth. | 7 " | 18 " |
| **124** | E. Frank Coe, Williamsburg, L. I. | E. Stiles & Son, Willimantic. | E. Stiles & Son. | 7 " | 18 " |
| **136** | Ivory Factories, Deep River. | Manufacturer. | L. F. Platts. Deep River. | 7 " | 18 " |
| **147** | Rafferty & Williams, N. York. | Rodney Kellogg, Hartford. | J. J. Webb, Hamden. | 7 " | 18 " |
| **167** | | | | 7 " | 18 " |
| **200** | | | A. Kingsbury, Coventry. | 7 " | 18 " |
| **223** | | Manufacturers. | R. Martin, Green's Farms. | 7 " | 18 " |
| **176** | G. W. Miller, Middlefield. | G. W. Miller, | P. M. Augur, Middlefield. | 6 " | 16½ " |
| **177** | " | " | " | 5 " | 15 " |
| **188** | Manhattan Fertilizer Co., Bridgeport. | F. C. Stickney, Bridgeport. | F. C. Stickney, Bridgeport. | 7 " | 18 " |
| **189** | H. J. Baker & Bro., New York. | Olds & Whipple, Hartford. | J. J. Webb, Hamden. | 7 " | 18 " |
| **208** | The Rogers & Hubbard Co., Middletown. | Manufacturers. | Chas. Fairchild, Middletown. | 5 " | 15 " |
| **209** | | | | 7 " | 18 " |

A more detailed analysis of **121** gave the following composition, upon which the valuation in the table is based:

| | | Valuable Ingredients. | |
|---|---|---|---|
| Water | 16.88 | Nitrogen | 0.06 % |
| Sulphate of Lime | 75.59 | Soluble Phosphoric Acid | 0.01 |
| Bone Phosphate of Lime | 5.11 | Reverted " | 0.80 |
| Insoluble in Acids | 1.57 | Insoluble " | 1.53 |
| Undetermined | 0.85 | Gypsum | 95.61 |
| | 100.00 | | |

The article consists almost entirely of gypsum (plaster). Allowing to this a value of $7 per ton, and to the other ingredients the values assigned to them in superphosphates, we get a total valuation of $10.85 per ton.

**121** is a waste product from the manufacture (in Rhode Island) of a "Baking Powder," in which superphosphate of lime is used as a substitute for bitartrate of potash (cream of tartar). Mr. J. D. Gaylord informs the Station that Messrs. Lombard & Matthewson, on learning its true character, have withdrawn it from the market.

**136** is the result of sawing ivory in water. No selling price was named, but the material "is considered worth half as much as bone dust."

On the whole, the bone manures are very satisfactory in quality, judged from the comparison of their estimated value and cost. Excluding **145**, **121** and **136**, the average estimated value is $35.50 and the average cost is $33.

The proper valuation of Bone Manures has, however, some difficulties. The prices customarily allowed for nitrogen are 15 cents per pound in coarse and 18 cents per pound in fine bone; the prices for phosphoric acid are 5 cents in coarse and 7 cents in fine bone. These prices are certainly not far from correct in the gross, as the above agreement between average valuation and average cost demonstrates. In many individual cases, however, they are not satisfactory. The fact whether bone is fine or coarse is determined by sifting through sieves of appropriate mesh. When 50 per cent. of the bone passes holes of $\frac{1}{25}$ inch, we call the sample fine; when fifty per cent. is larger than $\frac{1}{25}$ inch, we call the sample coarse. It may thus happen that two samples, which differ but two or three per cent. in the proportion of fine bone which they contain, are valued, one at 5 and 15 cents per pound for phosphoric acid and nitrogen respectively, and the other at 7 and 18 cents. This difference in allowed price may make a difference of from $5 to $10 in the valuation, according to the quantities and proportions of phosphoric acid and nitrogen. I have, therefore, latterly adopted for medium bone the medium prices of 6 and 16½ cents for these two elements. This leaves the valuation hardly exact enough, especially since difficulty may often arise in deciding from the results of sifting to which of the three grades a sample should belong.

I therefore propose in the future (1879) to distinguish for the purposes of valuation five grades of ground bone, each with the dimensions and price below specified, viz:

| Grade. | Dimensions. | Estimated value per pound<br>Nitrogen. | Phos. acid. |
|---|---|---|---|
| Fine, | smaller than $\frac{1}{50}$ inch, | 18 cts. | 7 cts. |
| Fine-medium, | between $\frac{1}{50}$ and $\frac{1}{25}$ inch, | 17¼ " | 6½ " |
| Medium, | " $\frac{1}{25}$ and $\frac{1}{12}$ inch, | 16½ " | 6 " |
| Coarse-medium, | " $\frac{1}{12}$ and $\frac{1}{6}$ inch, | 15¾ " | 5½ " |
| Coarse, | larger than $\frac{1}{6}$ inch, | 15 " | 5 " |

The chemical and mechanical analysis of a sample of ground bone being before us, we separately compute the nitrogen value of each grade of bone which the sample contains, by multiplying the pounds of nitrogen per ton in the sample by the per cent. of each grade, taking $\frac{1}{100}$th of that product, multiplying it by the estimated value per pound of nitrogen in that grade, and taking this final product as the result in cents. Summing up the separate values of each grade, thus obtained, together with the values of each grade for phosphoric acid, similarly computed, the total is the estimated value of the sample of bone.

As an example of the valuation of a bone manure by this method the following may serve. **92**, raw bone, from Stepney Bone Mills, Monroe, contains phosphoric acid 20.56 *per cent.* or 411.2 pounds per ton, and nitrogen 3.63 *per cent.* or 72.6 pounds per ton. By the mechanical analysis it showed:

| | | |
|---|---|---|
| 26 | per cent. | fine. |
| 23 | " | fine-medium. |
| 27 | " | medium. |
| 24 | " | coarse-medium. |
| 0 | " | coarse. |

The calculations are as follows:

$$72.6 \times 26 \div 100 \times 18 = \$3.40$$
$$72.6 \times 23 \div 100 \times 17\tfrac{1}{4} = 2.88$$
$$72.6 \times 27 \div 100 \times 16\tfrac{1}{2} = 3.23$$
$$72.6 \times 24 \div 100 \times 15\tfrac{3}{4} = 2.74$$

Estimated value of nitrogen = $12.25

$$411.2 \times 26 \div 100 \times 7 = \$7.48$$
$$411.2 \times 23 \div 100 \times 6\tfrac{1}{2} = 6.15$$
$$411.2 \times 27 \div 100 \times 6 = 6.66$$
$$411.2 \times 24 \div 100 \times 5\tfrac{1}{2} = 5.43$$

Estimated value of phosphoric acid= $25.72
Total estimated value=$37.97

This result is $1.32 higher than the valuation ($36.65) given in the table on p. 24, and agrees within $2.00 with the cost ($40.00).

When the sample of bone contains foreign matters introduced as preservatives, dryers, or adulterants, such as salt, salt-cake, niter-cake, ground oyster-shells, spent lime, plaster, or soil, these must be taken account of in the mechanical analysis, especially since they would be likely on sifting to pass chiefly or entirely into the finer grades. Lister's Bone usually contains a considerable, sometimes a large percentage of salt-cake; of sample **101**, 54 per cent. passed the finest sieve, but the sample yields to water 14 per cent. of salt cake, which mostly passes the finest sieve. In such cases the several grades, as obtained by sifting, must be separately examined and the amounts of foreign matter which they contain must be suitably taken into the account.

In some instances a further source of error in valuation might arise from the fact that the proportions of nitrogen and phosphoric acid are not the same in the finer and coarser portions of a sample, which contains no adulterants, properly speaking, but partly consists of meat, tendon, etc., as is especially the case in certain kinds of "tankings."

There is, however, a limit beyond which it is useless to attempt to refine the processes of valuation. When they become too complicated or costly they defeat the object which they should serve. It is sufficient when the errors of valuation are no greater than those which arise from unavoidable variations in different portions of the same lot of fertilizer, or in different lots of the same brand. A difference of two or three dollars between cost and estimated value cannot ordinarily demonstrate that either is out of the way.

## FISH SCRAP OR FISH GUANO.

Twenty-eight samples have been examined, all but three of them for private parties. The results of all the analyses are given below, and serve to show the range in composition and the average as compared with previous years.

| Station No. | | Moisture. | Phos. Acid. | Nitrogen. | In water-free fish. | |
|---|---|---|---|---|---|---|
| | | | | | Nitrogen. | Oil. |
| **84** | Fish by Goodale's Process | 10.19 | ---- | ---- | ---- | 1.61 |
| **98** | " " " | 10.45 | ---- | ---- | ---- | 1.40 |
| **83** | " 1875 | 6.18 | ---- | ---- | ---- | 18.61 |
| **86** | Half-dry Scrap | 47.88 | 4.88 | 4.32 | 8.29 | ---- |
| **87** | Dry Ground Fish Scrap | 22.98 | 6.22 | 6.85 | 8.89 | ---- |
| **133** | Fish Guano | ---- | 5.02 | 3.47 | ---- | ---- |
| **62** | Dry Fish Scrap | 9.47 | ---- | 7.61 | 8.41 | ---- |
| **65** | " " | 8.48 | ---- | 8.11 | 8.86 | ---- |
| **149** | " " | 11.11 | ---- | 8.75 | 9.84 | ---- |
| **150** | " " | 12.47 | ---- | 8.15 | 9.31 | ---- |
| **160** | " " | 17.67 | ---- | 6.74 | 8.18 | ---- |
| **162** | " " | 16.59 | ---- | 6.77 | 8.12 | ---- |
| **164** | " " | 10.67 | ---- | 8.50 | 9.52 | ---- |
| **169** | " " | 13.08 | ---- | 7.05 | 8.13 | ---- |
| **170** | " " | ---- | ---- | 8.70 | ---- | ---- |
| **171** | " " | ---- | ---- | 8.65 | ---- | ---- |
| **180** | " " | ---- | ---- | 8.13 | ---- | ---- |
| **185** | " " | ---- | ---- | 6.68 | ---- | ---- |
| **186** | " " | ---- | ---- | 7.52 | ---- | ---- |
| **190** | " " | ---- | ---- | 7.45 | ---- | ---- |
| **202** | " " | ---- | ---- | 8.28 | ---- | ---- |
| **203** | " " | 13.04 | ---- | 8.83 | 10.15 | ---- |
| **204** | " " | 17.89 | ---- | 8.02 | 9.77 | ---- |
| **212** | " " | 15.33 | ---- | 8.66 | 10.23 | ---- |
| **213** | " " | 17.75 | ---- | 8.69 | 10.56 | ---- |
| **214** | " " | 19.56 | ---- | 7.66 | 9.52 | ---- |
| **219** | " " | 12.60 | ---- | 8.13 | 9.30 | ---- |
| **220** | " " | 19.77 | ---- | 6.24 | 7.78 | ---- |
| | Average (excluding **83, 84, 86** and **98**) | 14.90 | ---- | 7.65 | 7.91 | ---- |
| | Average for 1877 | 13.66 | ---- | 8.24 | 9.36 | ---- |
| | " " 1875 and 1876 | 11.78 | ---- | 7.80 | ---- | ---- |

The first three samples are from Hon. S. L. Goodale, of Maine, and show the effect of his simple process for removing oil from fish scrap, to which allusion was made in Report for 1877, p. 41. All the other samples are of Connecticut manufacture. **86** and **87** were manufactured and sold by the Quinnipiac Fertilizer Co., New Haven, and sampled by H. P. Armsby, in New Haven. Their estimated values were respectively $19.79 and $37.01 per ton, and their cost $20.00 and $42.50.

**133** was manufactured by H. Preston & Sons, and sold by Southmayd & Gardiner, of Middletown. The sample was sent by R. S. Hubbard, of Middletown. Estimated value $20.91, cost $38.00.

### FISH AND POTASH.

Manufactured by the Quinnipiac Fertilizer Co., and sampled by H. P. Armsby.

| Station Number. | Nitrogen. | Soluble Phos. Acid. | Reverted Phos. Acid. | Insoluble Phos. Acid. | Potash. | Estimated val. per T. | Cost per Ton. |
|---|---|---|---|---|---|---|---|
| 89 | 3.64 | 1.20 | 2.04 | 1.58 | 3.07 | $28.05 | $35.00 |

### BLOOD, HAIR, AND HORN MANURES.

Of nineteen samples of this class of materials analyzed, fourteen were examined for private parties. The composition of the others follows:—

| Station Number. | | Moisture. | Nitrogen. | Phos. Acid. | Estimated value per T. | Cost per Ton. |
|---|---|---|---|---|---|---|
| 112 | Baugh's Blood & Meat | ---- | 10.02 | 3.07 | $44.38 | $40.00 |
| 78 | Pure Hair | ---- | 4.80 | 1.72 | 16.12 | 11.00 |
| 168 | Hair Manure | 39.43 | 3.43 | 0.26 | 12.71 | ? |
| 66 | Slaughter House Refuse | 53.91 | 2.23 | 8.20 | 14.89 | ? |
| 72 | Hoof Shavings | ---- | 12.37 | ---- | 37.00 | ? |

The following table shows the sources whence the above samples were obtained.

| Station Number. | Manufacturer. | Dealer. | Sent by |
|---|---|---|---|
| 112 | ------------------------ | New Haven Chemical Co., New Haven. | J. J. Webb, Hamden. |
| 78 | Geo. W. Baker, East Williamsburg, L. I. | N. Alvord, Green's Farms. | N. Alvord, Green's Farms. |
| 168 | Peter Cooper, New York. | ------------------ | G. H. Glover, North Branford. |
| 66 | King & Day, Lima, Ohio. | ------------------ | N. N. King, Suffield. |
| 72 | ------------------------ | ------------------ | Wm. H. Burr, Redding Ridge. |

**112** fairly represents the better class of dried blood and meat manures, including the so-called Azotin.

The hair manure is quite variable in composition, as might be expected. A sample examined in 1877 containing 24.6 per cent. moisture, 7.9 per cent. nitrogen, and 2.23 per cent. phosphoric acid, was valued at $25.93. The samples above reported contain more water and correspondingly less of fertilizing elements, and their valuation more nearly approaches the cost.

**66** is a sample of slaughter refuse, too much ballasted with worthless matters, probably, to be worth transportation from Ohio.

The hoof-shavings, **72**, have quite the same content of nitrogen as was found in the horn-shavings analyzed last year, viz: 12.32 per cent.

Other analyses of dried blood, etc., are the following, made for private parties, which serve to show how these materials vary in composition.

| Station Number. | Brand. | Moisture. | Nitrogen. | Phos. Acid. |
|---|---|---|---|---|
| 57 | Dried Blood | ------ | 10.01 | ---- |
| 59 | " | 10.20 | 10.73 | ---- |
| 71 | " | 10.30 | 10.97 | ---- |
| 73 | " | 33.65 | 5.84 | 4.89 |
| 178 | " | 18.00 | 8.72 | ---- |
| 191 | " | ------ | 8.34 | ---- |
| 194 | " | 7.51 | 13.57 | ---- |
| 198 | " | 6.72 | 7.60 | 9.62 |
| 70 | Dried Blood and Meat Scrap | 9.09 | 8.51 | 3.64 |
| 58 | Azotin | 12.04 | 10.46 | ---- |
| 151 | Tankings | ------ | 4.06 | 10.39 |
| 161 | " | ------ | 5.01 | 10.93 |

### POTASH SALTS.

Nine samples of commercial potash salts have been examined.

| Station No. | Brand. | Dealer. | Potash. | Muriate of Potash. | Sulphate of Potash. | Estimated value per ton. | Cost er ton. |
|---|---|---|---|---|---|---|---|
| 91 | German Potash Salt. | George W. White, New York. | 8.37 | ---- | 15.38 | $10.04 | $22.50 |
| 97 | Sulphate of Potash. | New Haven Chemical Co., N. Haven. | 25.31 | ---- | 46.80 | 37.96 | 35.00 |
| 119 | " " | H. J. Baker & Bro., New York. | 38.30 | ---- | 70.82 | 57.45 | 60.00 |
| 99 | Muriate of Potash. | New Haven Chemical Co., N. Haven. | 54.52 | 86.31 | ---- | 49.07 | 50.00 |
| 117 | " " | H. J. Baker & Bro., New York. | 50.36 | 79.71 | ---- | 45.32 | 41.50* |
| 131 | " " | Southmayd & Gardiner, Middletown. | 50.79 | 80.41 | ---- | 45.71 | 43.75 |
| 134 | " " | George W. Miller, Middlefield. | 43.08 | 68.20 | ---- | 38.77 | 45.00 |
| 138 | " " | Mapes Formula and Peruv. Guano Co. | 56.17 | 88.92 | ---- | 50.55 | 40.00* |
| 210 | " " | Chapman and Van Wyck, New York. | 55.01 | 87.09 | ---- | 49.51 | 40.00 |

* $38.00 in New York.

**91** was sent by Dennis Fenn of Milford, **97** and **99** by J. J. Webb of Hamden, **119** by M. S. Baldwin of Naugatuck, **117** by L. S. Wells of New Britain, **131** and **134** by R. S. Hubbard of Middletown, **138** by J. S. Kirkham of Newington, and **210** by G. M. Barber of New Britain.

In **91** (low grade sulphate) potash is valued at six cents per pound, in **97** and **119** (high grade sulphates) at seven and a half cents, and in the remainder (muriates) at four and a half cents. These estimated values of potash in the three several grades of potash-salts are essentially lower than those adopted in the Station Report for 1877, as seen in the following comparison:

| | Estimated value per pound. | |
|---|---|---|
| | In 1877. | In 1878. |
| Potash in high grade sulphate | 9 cents. | 7½ cents. |
| " low " | 7½ " | 6 " |
| " muriate | 6 " | 4½ " |

The lower estimated values of this year are the direct result of diminished market prices, and are simply deduced from the latter. Their fairness to the dealers will be seen from the fact that in case of high grade sulphate the average valuation is $47.70, and the average cost $47.50; in case of the muriates the average valuation is $46.49, and the average cost in our markets is $43.37. Low grade sulphates are the cheapest potash-fertilizers to produce, but freight makes their potash relatively more expensive than it comes in the muriate. The proper estimated value of this grade of potash is between the high grade sulphate and the muriate, and there it is accordingly placed.

### Nitrate of Soda.

But a single sample of this excellent fertilizer has been analyzed.

**118**, sold by H. J. Baker & Bro., New York, was sampled and sent from stock purchased by the Naugatuck Farmers' Club, by M. S. Baldwin, Secretary.

| | |
|---|---|
| Nitrate of Soda (nitrogen=15.58 per cent.), | 95.50 |
| Moisture, | 3.71 |
| Other matters, | .79 |
| | 100.00 |
| Estimated value per ton (nitrogen at 24 cents), | $74.78 |
| Cost, per ton, | 80.00 |

Nitrate of soda is subject to considerable fluctuation in cost. The above estimated value is too low for the market prices that have ruled during the year 1878. The actual cost of nitrogen in **118** was nearly 26 cents per pound. As $80 per ton is now the average price of nitrate of soda, the nitrogen of nitrates will be rated at 26 cents per pound in future valuations.

### Gypsum, or Land Plaster.

Three samples of ground gypsum have been examined. As this is a standard article of trade in Connecticut, I give in the subjoined table the composition of pure gypsum, that of the three samples investigated this year, and also the analyses of two other samples that were made for the Board of Agriculture in 1875.

Pure gypsum is a hydrated calcium sulphate (sulphate of lime) which is not of uncommon occurrence, but which is more or less mixed with various impurities in "land plaster." The pure or nearly pure gypsum, when ground and calcined at a gentle heat, loses its combined water, and constitutes the burned plaster or plaster of Paris used for stucco, hard finish, making fire-proof floors, etc. Together with gypsum there often occur small quantities of the mineral *anhydrite*, which, like calcined gypsum, is simple calcium sulphate without combined water. The pure gypsum is usually white. Ground land plaster is white or light gray, when obtained from the extensive gypsum beds of Nova Scotia, but the plaster quarried in Central New York is mostly dark gray in color. The agricultural value of land plaster depends upon its content of hydrated calcium sulphate, and cannot be judged of accurately from color or appearance after grinding.

Analysis of Gypsum.

| | Pure Gypsum. | **102** | **103** | **172** | Big Rock. | Chevarie. |
|---|---|---|---|---|---|---|
| Sulphuric acid, | 46.51 | 45.12 | 42.01 | 42.34 | 44.81 | 43.05 |
| Lime, | 32.56 | 31.58 | 29.41 | 29.64 | 31.37 | 30.14 |
| Combined water, | 20.93 | 20.30 | 18.90 | 19.08 | 20.16 | 19.37 |
| Gypsum, | 100.00 | 97.00 | 90.32 | 91.06 | 96.34 | 92.56 |
| Matters insoluble in acids, | | 1.11 | 1.39 | 1.31 | 2.83 | 1.32 |
| Carbonate of lime and undet'd, | | 1.89 | 8.29 | 7.63 | .83 | 6.12 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

**102** was sold by H. J. Mattoon, **103** by H. C. Warner, of Watertown. Both were received from Hubert Scovill, Esq., of Watertown. **172** was sold by G. W. Miller, of Middlefield, and sent by P. M. Augur, Secretary of Farmers' Club of Middlefield.

All the samples were Nova Scotia plaster. **102** was reputed inferior in quality to **103**. It was, in fact, darker in color, although nearly seven per cent. richer in gypsum than **103**, and therefore superior to the latter for fertilizing purposes. The *Big Rock* and *Chevarie* samples had the appearance of Nova Scotia gypsums, but the Station has no authentic information as to their origin. They were obtained in Bridgeport in March, 1875. These five samples probably represent pretty fairly the Nova Scotia plaster as found in our markets. Their average content of pure gypsum is 93½ per cent.

## LEACHED WOOD-ASHES.

**94** represents 8,000 bushels of Canadian leached ashes, purchased by the Guilford Agricultural Society, of Breed & Allen, New York, sampled and sent to the Station by J. Seymour Benton, Secretary of the Guilford Agricultural Society. The sample was moist, cost 19 cents and weighed 55 pounds per bushel.

The analysis is given below, together with the analyses of four other samples formerly analyzed under the writer's direction, and printed in the Report of the State Board of Agriculture for 1873, p. 418. Some misprints in that report are here corrected. Several of the samples were analyzed after drying, and their analyses are calculated upon the average water-content of 35 per cent. The sixth column in the subjoined table gives an average of the five analyses, and in the last column the average composition is stated in pounds per bushel.

| Number | 1. | 2. | 3. | 4. | **94.** | Av'age | Lbs. per bu. |
|---|---|---|---|---|---|---|---|
| Water | 35.00 | 35.00 | 35.00 | 35.00 | 36.70 | 35.34 | 19.44 |
| Char | 0.80 | 3.30 | 5.00 | 18.40 | 1.46 | 11.47 | 6.31 |
| Sand, clay, etc., insol'e in acids | 5.50 | 4.30 | 10.30 | | 8.30 | | |
| Oxide of Iron | 0.80 | 1.70 | 1.50 | 2.70 | 0.82 | 1.50 | 0.82 |
| Lime | 29.70 | 28.10 | 23.20 | 21.20 | 27.77 | 25.99 | 14.30 |
| Magnesia | 3.40 | 3.30 | 2.90 | 4.10 | 2.82 | 3.30 | 1.81 |
| Potash | 0.80 | 2.30 | 0.70 | 0.90 | 0.97 | 1.27 | 0.70 |
| Soda | 0.20 | 0.00 | 0.00 | | 0.48 | | |
| Phosphoric Acid | 1.30 | 1.30 | 1.40 | 1.10 | 2.12 | 1.44 | 0.80 |
| Sulphuric Acid | 0.00 | 0.20 | 0.10 | 0.10 | 0.12 | 0.11 | 0.06 |
| Carbonic Acid | 19.90 | 18.20 | 17.10 | 13.80 | 18.44 | 17.49 | 9.61 |
| Silica (soluble) | 2.60 | 2.30 | 2.80 | 2.70 | ---- | 2.09 | 1.15 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 55.00 |

It is seen that **94** agrees, in general, quite closely with the other samples, but it contains somewhat more lime and phosphoric acid and a little less potash and magnesia than the average. As regards potash, however, **2** is manifestly exceptional, and if that be disregarded, **94** is above the usual average.

It is manifest that *water*, *char*, *insoluble matters*, *iron oxide*, *carbonic acid* and *silica* together, make up no less than 65.7 per cent. of the sample (or nearly 68 per cent. on the average), leaving 34.3 per cent. of really valuable fertilizing matters. These would be quite exactly supplied, except as regards *magnesia*, by a mixture of thirty pounds of fresh burned oyster-shell lime, eight pounds of kainite, costing nine cents, and ten pounds of fine bone, costing fifteen to twenty cents.

These materials would yield:

| | | |
|---|---|---|
| Lime | 28. | pounds. |
| Phosphoric acid | 2.80 | " |
| Potash | 1.00 | " |
| Soda | 1.50 | " |
| Magnesia | .66 | " |
| Sulphuric acid | 1.33 | " |
| Other matters | 12.71 | " |
| | 48.00 | |

These forty-eight pounds of lime, kainite and bone dust, would equal one hundred pounds or thirty-five cents worth of leached ashes, as regards kind and quality of fertilizing elements. If the bone were really fine, and the lime and kainite were well mixed and slacked together, the mixture would doubtless equal one hundred pounds of leached ashes in all respects as a fertilizer, for magnesia is seldom lacking in the soil.

When lime is procurable for four to six cents per bushel, as it is in many towns along the Sound, the cost of materials for the mixture would be no greater than that of the equivalent amount of leached ashes. In many localities such a mixture might doubtless be economically substituted for leached ashes, or, such of its components as experience has shown to be useful, might be employed to greater advantage than leached ashes themselves.

Such a mixture newly prepared would contain quicklime, and might be too caustic for immediate application, except in moderate doses on grass or on plow land, where it should be well harrowed in, a week or more before planting. If this mixture were made and exposed to the air some weeks before using, or if it were prepared with air-slacked lime (40 pounds) instead of quicklime, it might be applied in large quantities without fear of any ill effect.

## BRICK-KILN ASHES.

A sample of ashes, **217**, obtained in the burning of brick, was received for examination from Mr. E. H. Kelley of New Britain. It is stated that in each arch (fire-place) about two cords of hard wood are burned at each firing. The ashes are mingled with broken brick, and a good deal of fine burnt clay remains in them after screening. Each arch yields about two barrels of the mixture of ashes and calcined clay.

The ashes weighed 80 pounds per bushel, or 400 pounds per arch. They contained 1.26 per cent. of potash. Ordinary wood ashes as made in stoves contain, according to Prof. Storer's examinations, an average of eight and a half per cent. of potash. Simple calculation from these data show that the 400 pounds of brick-kiln ashes contain but about 60 pounds of pure wood-ashes.

8.50 : 1.26 : : 400 : 59.3.

The same result is reached from the estimate that a cord of oak wood (128 cubic feet) weighs 3,000 pounds, and yields one per cent. of ashes (two cords = 6,000 pounds, give 60 pounds ashes).

These brick-kiln ashes then consist, per arch, of 60 pounds wood-ashes and 340 pounds brick-dust or burned clay, or by bulk, of one and a quarter bushels wood ashes (50 pounds = 1 bushel) and three and three-quarter bushels brick dust or burned clay. Each arch yields in the wood ashes five pounds (1.26 × 4) of potash, which at the cheapest rate, viz: four and a half cents, gives a value of twenty-two and a half cents for that ingredient. The other substances present, mostly clay and carbonate of lime, are not enough to raise the value over twenty-five cents.

## TOBACCO STEMS.

The stems and midribs of tobacco leaves, which are a refuse of the cigar manufacture, have already been utilized to a considerable extent, and have a high repute as a fertilizer.

The Station received from the Secretary of the Board of Agriculture in January, 1878, a sample of such tobacco stems for analysis. The sample was purchased in New York City, and was quite moist in appearance and to the feel. The results of chemical examination were as follows:

**55**

| | Per cent. | Pounds per ton. |
|---|---|---|
| Moisture | 32.730 | 654½ |
| Organic matters* (difference) | 54.787 | 1096 |
| Sand and soil | 1.216 | 24 |
| Iron oxide | .106 | 2 |
| Lime | 3.639 | 73 |
| Magnesia | .105 | 2 |
| Potash | 5.243 | 105 |
| Soda | .211 | 4 |
| Phosphoric acid | .469 | 9½ |
| Sulphuric acid | .615 | 12 |
| Chlorine† | 1.134 | 23 |
| | 100.255 | 2005 |
| Deduct oxygen, equivalent to chlorine‡ | .255 | 5 |
| | 100. | 2000 |
| * With nitrogen, | 1.81 | 36.2 |
| † Equal to chloride of potassium, | | 48.5 |
| Value per ton, | $14.38 | |
| Cost in New York, | $8.00 | |

‡ The potassium exists in the stems mainly as potash compounds, but partly as potassium chloride. For convenience of comparison with other fertilizers, and of valuation, the potassium is all stated in the form of potash (potassium oxide). This causes the footing of the analysis to exceed 100 by a quantity of oxygen chemically equivalent to the chlorine; a quantity which is therefore deducted from the total.

The valuation above given is based upon the following trade-values: nitrogen, twenty cents; phosphoric acid, nine cents; and potash, six cents. For most purposes, however, the potash is worth but four and a half cents per pound, since one-half of it exists as muriate (potassium chloride), and on that basis the valuation is $12.81.

The higher valuation given in the Station Bulletin of March 11th, 1878, was the result of reckoning potash at nine cents per pound, a price it no longer holds.

The composition of this sample shows that tobacco stems are, as might be anticipated, a good general fertilizer, supplying all the elements of crops, and especially rich in potash and lime. They are likely to be somewhat variable in composition, particularly as regards moisture.

## SUNDRY WASTE PRODUCTS.

| Station No. | Name or Brand. | Nitr'gen. | Phos. Acid. | Carbonate of Lime. | Esti'ated value per ton. | Cost per ton. |
|---|---|---|---|---|---|---|
| **69** | Dust of Vegetable Ivory | 0.48 | ---- | ---- | $ 1.44 | ---- |
| **79** | "Carbon Sediment" | 3.22 | 0.92 | ---- | 10.58 | $10.00 |
| **142** | Castor Pomace | 4.59 | 1.50 | ---- | 21.06 | 22.00 |
| **154** | Glue Settlings | 0.67 | 0.21 | 38.91 | 3.37 | ---- |

No. **69** was from the works of the American Braid Co., West Cheshire, Ct., and sent by N. S. Platt of Cheshire. No. **79** was sold by George W. Baker, East Williamsburg, L. I., and sent by N. Alvord of Green's Farms, Ct. No. **142** was manufactured by H. J. Baker & Bro., New York, and sold by Olds & Whipple, Hartford, Ct. The sample was sent by S. M. Wells of Wethersfield, Ct. No. **154** was manufactured by Peter Cooper, New York, and sent by George H. Glover, North Branford, Ct.

The Vegetable Ivory, **69**, is the fruit of a South American tree (Phytelephas), but it consists largely of cellulose or woody tissue, and has little more fertilizing value than saw-dust.

Carbon Sediment, **79**, appears to be a refuse of the manufacture of Prussian blue or prussiate of potash. Its nitrogen is valued at fifteen cents per pound; whether it is all worth that as plant-food is perhaps doubtful, and only to be learned by trial.

Castor Pomace, **142**,—the crushed seeds of the castor-oil plant after extraction of the oil—is a long-known and well-tested fertilizer. The value of the sample closely approaches its cost.

The Glue Settlings are too watery and inconvenient to handle to warrant much cost of transportation.

### SWAMP MUCK OR PEAT.

A sample, sent by Dr. J. Hamilton Lee, Secretary of the Killingworth Farmers' Club, was examined with the subjoined results.

| | **166**<br>Fresh. | Dry. |
|---|---|---|
| Water | 73.54 | ---- |
| Organic and volatile matter* | 21.12 | 79.82 |
| Soluble ash, mostly carbonate of lime | 1.15 | 4.35 |
| Sand and insoluble ash | 4.19 | 15.83 |
| | 100.00 | 100.00 |
| Containing nitrogen | 0.06 per cent. | 0.23 per cent. |

This peat, if fairly represented by the sample, is remarkably destitute of nitrogen, and can have little direct fertilizing effect. It is, however, not unlikely that specimens taken at other points in the "meadow" would have a different composition. As an absorbent or employed as litter in the stable, the air-dried peat would be of value, but its use for this purpose would be decided by the cost of handling.

### POUDRETTE.

Manufactured by the Lake Erie Drier Company, at Cleveland, Ohio. Sampled and sent by Henry F. Merwin, Esq., of Woodbridge.

| | **224** |
|---|---|
| Nitrogen, | 0.97 |
| Soluble phosphoric acid, | 0.11 |
| Reverted " " | 1.22 |
| Insoluble " " | .34 |
| Calculated value, per ton, | $6.67 |
| Cost, | $25.00 |

The 0.97 per cent. of nitrogen is equivalent to 1.18 per cent. of ammonia, and the total phosphoric acid (1.67 per cent.), is equivalent to 3.64 per cent. of bone-phosphate or reduced phosphate of lime.

The composition printed on the tag accompanying the sample was as follows:

| | |
|---|---|
| Animal matter, | 38 to 40 |
| Bone phosphate, | 11 to 13 |
| Water, | 4 to 6 |
| Reduced phosphate of lime, | 4½ to 6 |
| Ammonia, | 3½ to 6 |
| Insoluble undetermined matter, | 30 to 38 |

### SPECIAL MANURES OR FORMULAS FOR PARTICULAR CROPS.

Special Fertilizers appear to have been first prescribed in detail by Prof. J. F. W. Johnston of Scotland. In the second edition of his Lectures on Agricultural Chemistry and Geology, Edinburgh, 1847, pages 637–647 are occupied with the principles of preparing "mixed saline manures for different crops," and the "composition of special manures for wheat, barley, oats, rye, maize, rice, potatoes, turnips, cabbages, tobacco, sugar cane, coffee and flax." Johnston's principles are three in number, as follows:

"1. The manure must contain all those inorganic or mineral substances which the crop we wish to grow carries off the soil, and in the relative proportions in which they are respectively found in the ash of the plant.

The only exception to this rule is—that if one or more of these substances abound in the soil, they may be omitted from the manure prepared for that soil; if any of them abound in all soils, they may be uniformly omitted.

2. The organic part of a plant always contains a certain proportion of gluten or of some similar compound of which nitrogen is a constituent. The nitrogen which is necessary to the produc-

tion of this gluten is derived from the soil. A manure, therefore, which shall restore to the soil all that any crop has carried off or will require to make it grow in a healthy manner, must contain some compound of nitrogen which the roots of plants can take up.

3. We have seen that one of the most important functions performed by the organic matter in the soil is to produce ammonia and nitric acid at the expense of the nitrogen of the atmosphere. This function is of great consequence to the growth of plants. It supplies that loss of nitrogen which the soil is continually undergoing by the agency of vegetation and other natural causes.

But by continued arable culture the proportion of organic matter in the soil gradually diminishes. Hence the necessity of adding animal but especially vegetable matter in considerable quantity to arable land, if it is to be kept in good condition. When laid down to grass the vegetable matter naturally increases.

When the soil is already rich in vegetable matter, or when the straw is returned to the soil in the form of farm yard manure, the addition of this vegetable matter becomes unnecessary. On the other hand, it is the necessity for this addition of vegetable matter which renders it better husbandry to employ half dung along with guano or with any artificial saline manure.

Thus a well prepared artificial or manufactured manure ought to contain:

*a.* The saline substances found in the ash of the plant we wish to grow.

*b.* A proportion of some substance capable of yielding nitrogen to the crop.

*c.* A constant or occasional admixture of vegetable matter to make up the natural waste of this kind of matter which the soil undergoes during constant cropping.

The supply of nitrogen bears some relation to the known wants and period of growth of the crop to which it is to be applied—while the mixture of inorganic substances must be specially prepared for each crop, in comformity with the composition of the ash it has been found to leave when burned."

Johnston remarks further, in substance, as follows:

"*a.* That mention of vegetable matter has been omitted. If the soil is rich in humus—if straw, green herbage or yard manure be ploughed in—or if vegetable composts be added to the land every two or three years, that is enough; otherwise saw-dust, dried peat or other convenient vegetable substance may be added.

*b.* Silica and oxide of iron are omitted because abundant in soils. If in any case one of the ingredients of the mixtures be abundant in the soil that ingredient may be omitted.

*c.* Instead of the substances named, any refuse or cheap matter representing them in composition may be used.

*d.* In the crops named except flax and the turnip, the straw or tops are supposed to be returned to the land. When this is not done a mixture made up as the above, according to the average composition of the ash of the stem or straw may be applied."

Johnston's special manures for sixteen staple crops are the following:

| | Wheat. | Barley. | Oats. | Rye. | Rice. |
|---|---|---|---|---|---|
| Bone dust, | 180 | 150 | 88 | 190 | 26 |
| Sulphuric acid, | 90 | 75 | 44 | 95 | 13 |
| Carbonate potash, | 30 | 20 | 18 | 32 | 5 |
| " soda, | 20 | 14 | 10 | 20 | 3 |
| " magnesia, | 70 | 16 | 14 | 22 | 4 |
| To replace 100 lbs. ash, use | 390 lbs. | 275 lbs. | 174 lbs. | 359 lbs. | 51 lbs. |
| Use | 224 lbs. | 200 lbs. | 105 lbs. | | 50 lbs. |
| to replace a crop of | 40 bu. | 50 bu. | 50 bu. | | 350 lbs. rice. |

| | Maize. | Potato. | Turnip bulb. | Turnip bulbs & tops. | Cabbage. |
|---|---|---|---|---|---|
| Bone dust, | 152 | 50 | 30 | 32 | 48 |
| Sulphuric acid, | 76 | 25 | 15 | 16 | 24 |
| Carbonate potash, | 40 | 80 | 62 | 52 | 17 |
| " soda, | 13 | 5 | 9 | 9 | 35 |
| " magnesia, | 35 | 12 | 12 | 19 | 13 |
| " lime, | -- | -- | -- | -- | 27 |
| To replace 100 lbs. ash, use | 316 lbs. | 172 lbs. | 128 lbs. | 128 lbs. | 164 lbs. |
| Use | 3 lbs. | | 24 lbs. | 48 lbs. | 50 lbs. |
| to replace a crop of | 1 bu. corn. | | 2240 lbs. | 2240 lbs. bulbs. | 2240 lbs. |

| | Tobacco. | Sugar cane. | Coffee. | Flax seed. | Flax stem. |
|---|---|---|---|---|---|
| Bone dust, | 15 | 26 | 52 | 144 | 50 |
| Sulphuric acid, | 8 | 13 | 26 | 72 | 25 |
| Carbonate potash, | 31 | 33 | 75 | 36 | 17 |
| " soda. | 5 | 8 | 25 | 6 | 20 |
| " magnesia, | 25 | 17 | 24 | 22 | 21 |
| " lime, | 60 | -- | -- | - | -- |
| To replace 100 lbs. ash, use | 144 lbs. | 97 lbs. | 202 lbs. | 280 lbs. | 133 lbs. |
| Use | lbs. | | 202 lbs. | 13 lbs. | 150 lbs. |
| to replace a crop of | lbs. | | 1½ tons coffee berries. | 100 lbs. seed. | 2240 lbs. stem. |

"In preparing such manures, the acid is diluted with twice its bulk of water, the bone dust is then completely dissolved in it, and with the still wet mass, the other ingredients are mixed.

In these recipes,

*a.* For every 100 pounds carbonate potash may be substituted 126 pounds sulphate potash, or 108 pounds chloride of potassium.

*b.* For every 100 pounds carbonate soda may be substituted 209 pounds sulphate soda, or 110 pounds salt.

*c.* For every 100 pounds carbonate magnesia may be substituted 265 pounds sulphate magnesia, or 300 pounds of a mild lime rich in magnesia.

*d.* For every 100 pounds carbonate lime may be substituted 170 pounds sulphate (gypsum)."

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Special manuring in accordance with these suggestions does not appear to have found any favor in British Agriculture.

The progress of investigation in Europe, during the ten years succeeding Johnston's proposals for special fertilizers, demonstrated that *in general* the deficiencies of soils, either those naturally occurring, or those caused by exhaustive cropping, lie, so far as plant-food is concerned, in nitrogen, phosphoric acid and potash. That is to say, soils, broadly speaking, contain and yield enough lime, magnesia, iron, and sulphuric acid for the wants of crops.*

Prof. Ville of France, imitating experiments first made by Boussingault, came to nearly this result, and has given extensive circulation to a theory of manuring based upon it, which he sums up in the following propositions: "1. Give the earth more phosphates, more potash and lime than the harvests have taken from it. 2. Give it fifty per cent. of the nitrogen they contain." (Agricultural Lectures at Vincennes, 1867. Miss Howard's Translation, 3d edition, Atlanta, Ga., 1871.)

Ville gives recipes for six "complete fertilizers," and an "incomplete fertilizer," which are as follows:—

| Complete fertilizer, | No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|
| Acid phosphate of lime, | 355 lbs. | 355 lbs. | 355 lbs. | 534 lbs. |
| Nitrate of potash, | 177 lbs. | 177 lbs. | 266 lbs. | 444 lbs. |
| Sulphate of ammonia, | 222 lbs. | nitrate of soda, 266 lbs. | | |
| Sulphate of lime, | 312 lbs. | 268 lbs. | 266 lbs. | 355 lbs. |
| | 1066 lbs. | 1066 lbs. | 887 lbs. | 1333 lbs. |

| Complete fertilizer, | No. 5. | No. 6. | Incomplete fertilizer No. 2. |
|---|---|---|---|
| Acid phosphate of lime, | 534 lbs. | 355 lbs. | 355 lbs. |
| Nitrate of potash, | 177 lbs. | 177 lbs. | 177 lbs. |
| Sulphate of ammonia, | | 355 lbs. | |
| Sulphate of lime, | 355 lbs. | 297 lbs. | 355 lbs. |
| | 1066 lbs. | 1154 lbs. | 887 lbs. |

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*In "Lectures on Agricultural Chemistry," delivered at the Smithsonian Institution in Dec., 1859, the writer of this report said, p. 72: "It appears from experience that the ingredients which are rarest in the soil,—which are therefore most liable to exhaustion, and most needful to be replaced—are in general phosphoric acid, assimilable nitrogen and potash."

No. 1 is for Wheat, Hemp and Coleseed, half of No. 1 (533 pounds) for Barley, Oats, Rye and Natural Meadows. No. 2 is for Beets, Carrots, Cabbage, Hops and Garden Stuff. No. 3 is for Irish Potatoes. No. 4 is for Vines and Small Shrubs. No. 5 is for Turnips, Rutabagas, Artichokes, Sorghum, Sugar Cane and Maize. No. 6 is for Coleseed followed by Wheat. Incomplete fertilizer No. 2 is for Beans of all kinds, Clover, Sanfoin, Vetches, Lucerne. Ville gives directions for treating rotations or successions of crops, with the above fertilizers and 266 pounds, usually, of sulphate of ammonia.

Prof. Stockbridge of the Massachusetts Agricultural College, has recently patented a series of special fertilizers adapted, as he asserts, to "the worn out soils of New England." He declares to have found by experiment at the Agricultural College Farm and vicinity, that the only substances needful to supply, in order to get good crops, are nitrogen, potash and phosphoric acid. He compounds these substances in the proportions in which they are contained in crops, grain, or root and straw, or tops, as shown by an average of all reliable analyses. The nitrogen he supplies in the form of sulphate of ammonia or its equivalent, potash as

*Stockbridge Formulas.*

| | Increase over natural yield. | Nitrogen. | Potash. | Phos. Acid. | Sulphate of Ammonia, 24 per cent. | Muriate of Potash, 80 per cent. | Superphosphate, 13 per ct. sol. |
|---|---|---|---|---|---|---|---|
| Potatoes | 100 bush. | 21 | 34 | 11 | 105 | *225 | 85 |
| Field Beans | 20 " | 53 | 33 | 20 | 265 | *198 | 160 |
| Buckwheat | 25 " | 37 | 50 | 15 | 185 | 100 | 105 |
| Mixed Hay | 1 ton | 36 | 31 | 12 | 180 | 70 | 95 |
| Red Clover | " | 43 | 40 | 11 | 215 | 80 | 85 |
| Timothy | " | 24 | 27 | 10 | 120 | 54 | 80 |
| Fodder Corn | 2 tons | 20 | 66 | 16 | 100 | 132 | 128 |
| Oats | 25 bush. | 23 | 20 | 12 | 115 | 40 | 90 |
| Winter Rye | 20 " | 25 | 24 | 16 | 125 | 48 | 128 |
| Rye Straw | 2 tons | 10 | 31 | 8 | 50 | 62 | 64 |
| Beets | 100 bush. | 11 | 25 | 6 | 55 | *155 | 50 |
| Cabbage | 1 ton | 28 | 12 | 4 | 140 | *75 | 32 |
| Indian Corn | 50 bush. | 64 | 77 | 31 | 320 | 154 | 248 |
| Wheat | 25 " | 41 | 24 | 20 | 205 | 48 | 160 |
| Swede Turnips or Rutabagas | 100 " | 11 | 18 | 8 | 55 | *118 | 63 |
| Onions | 100 " | 11 | 9 | 4 | 55 | *54 | 32 |
| Tobacco† | 1500 lbs. | 119 | 172 | 16† | 595 | *1075 | 125 |

* Sulphate of potash of 35 per cent.

† In addition, 160 pounds lime and 38 pounds of magnesia are required, and are supplied by 500 pounds sulphate of lime (79 per cent. dry salt) and 475 pounds sulphate of magnesia (16 per cent. dry salt).

muriate or sulphate of potash, and phosphoric acid as super-phosphate of lime.

His formulæ for seventeen crops are here given, as stated in the 13th Report of the Massachusetts Agricultural College, 1876.

The table, page 43, signifies that to produce the named increase over the natural yield, the given quantities of nitrogen, phosphoric acid and potash are to be applied to an acre, and they are supplied by the given amounts of sulphate of ammonia, muriate of potash, and superphosphate of lime.

In 1847, when Prof. Johnston made out his formulæ for special fertilizers, comparatively few accurate analyses of most of our crops had been made. Since that time great numbers of good analyses of nearly all kinds of farm produce have been executed; and in 1876, Prof. Stockbridge had abundant material, in most instances, for arriving at the average composition of crops and for perfecting special manures, so far as the nature of the case admits. But several very important practical questions come up which claim notice in these pages.

One of these questions is—what do the patent-rights of Prof. Stockbridge cover? The correct answer would appear to be this, viz: they do not prevent anyone from compounding a mixture of sulphate of ammonia, sulphate of potash, and superphosphate of lime, and designating the same a wheat manure or potato fertilizer, or using it in farm practice; but they do prevent parties not authorized by the patentees from vending any mixture under the trade names, which are given to the mixtures specified in their patents.

Another question is—what can be the real practical value of such distinctions as are involved in applying to an acre of ground to be planted to potatoes, twenty-one pounds nitrogen, thirty-four pounds potash, and eleven pounds phosphoric acid, and to another acre to be sown to timothy, twenty-four pounds nitrogen, twenty-seven pounds potash, and ten pounds phosphoric acid?

If I desire one-half of a two acre field to produce me two tons of rye straw more than the natural yield, and the other half one hundred bushels of beets more than the natural yield, shall I put ten pounds nitrogen on the first and eleven pounds on the second, thirty-one pounds potash on the first and twenty-five pounds on the second, and eight pounds of phosphoric acid on the first and six pounds on the second,—and if I do, may I expect to get the amounts of increase named?

Common experience abundantly shows that such distinctions are too finely drawn, and it might be confidently anticipated that in a hundred trials the potato manure might be applied to timothy, and the timothy manure to potatoes, with no detriment to the crops and no difference to the producer.

The "worn out soils of New England" are very various in their crop-producing qualities. Many of them are able to supply potash in excess of all ordinary demands. Many of them require lime and sulphuric acid in order to feed crops, and most of them fail to yield rather on account of mechanical or physical deficiencies, or defect of water supply, than because they are exhausted of the nutritive elements of crops. With this diversity of soil it is vain to expect that we can rationally or successfully adapt special manures to our various crops. Even if our soils had been all originally alike in texture and composition, the different treatment they have undergone in what we politely term "cultivation" has been such as to draw upon their natural resources very unequally, and make it needful to adapt the manure to the soil as well as to the crop.

It is a very significant fact, pertinent to this subject, that when we appeal to practical experience to decide what fertilizing elements are best to apply to different crops *on the same soil*, the answer should sometimes be just the reverse of what we must expect if the Stockbridge manures are based on correct principles.

In British agriculture it was found some thirty years ago, in many localities, that soluble phosphoric acid was fairly a specific for the turnip crop, and that nitrogen acted with especial energy on wheat. Philip Pusey, M. P., President of the Royal Agricultural Society of England, in a paper "On the Progress of Agricultural Knowledge," written in 1850, after recounting some of this experience, said: "The upshot of the whole is that, practically, so far as artificial manures are concerned, we need not dwell upon mineral ingredients, but we must give ammonia to wheat and to turnips phosphorus."

In the world-famed field experiments of Mr. Lawes, nitrogen alone has wonderfully kept up the wheat crop for many years, while it failed totally to make turnips after three seasons; and soluble phosphates alone gave a large yield of turnips for a succession of crops, but had little effect on wheat. Many farmers on land similar to that of Mr. Lawes obtained like results.

These facts of experience are not indeed universally confirmed, but they have so far influenced practice as to lead us to expect in a British turnip-manure a predominance of soluble phosphoric acid, and in a British wheat-fertilizer a relatively large proportion of nitrogen.

Now what are the comparative demands of the wheat and turnip crops on the three substances, nitrogen, potash, and phosphoric acid?

According to Rohde in Germany the average turnip crop in good farming is about 13 tons of roots (26,295 lbs. av.) and about 2½ tons of tops (5,259 lbs. av.) per acre. The same authority gives the winter wheat crop at 1,862 lbs. = 31 bushels of grain and 3,505 lbs. = 1¾ tons of straw per acre. Dr. Anderson, in Scotland, gives the corresponding turnip and wheat crops at 13½ tons of roots for the former (makes no mention of weight of leaves), and 28 bushels of wheat (of 60 lbs.), and 2,576 lbs. of straw. Calculating from Rohde's figures, and Wolff's latest tables of the composition of crops, it results that these crops withdraw from the acre as follows:

| | Nitrogen.<br>lbs. | Potash.<br>lbs. | Phosphoric acid.<br>lbs. |
|---|---|---|---|
| Turnip tops | 15.8 | 14.7 | 4.7 |
| " roots | 47.2 | 86.7 | 23.7 |
| " crop | 63.0 | 101.4 | 28.4 |
| Wheat grain | 38.5 | 22.1 | 14.6 |
| " straw | 16.8 | 9.8 | 7.6 |
| " crop | 55.3 | 31.9 | 22.2 |

It appears from the above figures, which are unquestionably the most trustworthy that can be adduced (unless errors have been committed in the reduction of the foreign weights and measures to English equivalents), that the turnip crop removes nitrogen and phosphoric acid from the land in larger absolute quantities than the wheat crop, but in very nearly the same proportion. As to potash, the turnip crop carries off three times as much as wheat.

Now, the English practice of manuring heavily with stable manure accounts for the small use made in that country of potash salts as a fertilizer, and for the fact that Mr. Pusey did not need to "dwell upon mineral ingredients" other than "phosphorus" (phosphates) for turnip culture; but what is there in the composition of the wheat and turnip crops that explains why, when stable manure is supplemented or altogether replaced by "artificials," nitrogen is best for wheat and phosphorus for turnips?

Between turnips and rutabagas no essential difference of composition as respects dry substance has been established. The rutabagas are less watery and yield better, so that the crop would weigh more and would take from the soil larger quantities of nitrogen, potash, and phosphoric acid; but the relative proportions of these elements would not differ sensibly from those exhibited for the turnip crop. If we take the quantities of nitrogen removed by the turnip and wheat crops according to the above computation, as 100 in each case, and raise the quantities of potash and phosphoric acid in the same proportion, and also calculate the quantities in the Stockbridge rutabaga and wheat manures upon the same standard, we shall have a comparison of the relative demands which we find the two crops to make upon the three most important fertilizing elements, with the demands which Prof. Stockbridge reckons them to make.

For each 100 pounds of nitrogen are removed according to

| | | Prof. Stockbridge. | This Station. | Dr. Anderson. |
|---|---|---|---|---|
| In wheat crop | potash | 58 lbs. | 58 lbs. | 68 lbs. |
| | phos. acid | 49 " | 40 " | 43 " |
| In turnips or rutabagas | potash | 164 " | 160 " | 95* " |
| | phos. acid | 73 " | 45 " | 37* " |

The relative quantities of nitrogen and potash agree in all cases, but Prof. Stockbridge finds the rutabaga to remove a much larger proportion of phosphoric acid relative to nitrogen than is shown by the computations made on the basis of Rohde's and Wolff's statistics. Which is right? Dr. Anderson, formerly chemist to the Highland and Agricultural Society of Scotland, who, himself performed many excellent analyses of wheat and turnips, reckoned in 1861 that thirteen and a half (long) tons of turnips removed 60.5 pounds of nitrogen, 57.4 pounds of potash, and 22.6 pounds of phosphoric acid from the acre. These amounts being reckoned upon 100 of nitrogen give thirty-seven of phosphoric acid, a figure just one-half that of Prof. Stockbridge. Which is right?

Evidently enough, the discrepancies between the Stockbridge calculations and those of Dr. Anderson and the writer of these pages, are enough to justify the gravest doubts whether the farmers who use the Stockbridge manures for wheat and rutabagas are not using too much phosphoric acid for the crops! Or has Prof. Stockbridge departed from the indications of chemical

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* Exclusive of leaves which contain to 100 of nitrogen, 93 of potash, and 29 of phosphoric acid.

analysis, and increased the proportion of phosphoric acid in order to hybridize his theory with the teachings of British Practice?

If, as may perhaps be true, the "reliable analyses" upon which Prof. Stockbridge bases his calculations are a selection of, or other than those which Wolff employed in making his tables, then we are forced to conclude that the analyses are too discrepant for the use to which they are put.

The Station has analyzed three Special Manures for Potatoes, viz: the Stockbridge Potato Manure, Mapes' Potato Fertilizer (Ville's formula), and Forrester's Potato Fertilizer. By a comparison of the quantities of fertilizing elements which they should contain according to the theories of their composition, we shall get some light as to the scientific certainty of these theories.

To institute such a comparison, I have taken the Stockbridge formula for 100 bushels of potatoes as a basis, have reduced the nitrogen of the other formulas to the Stockbridge figure, and the other ingredients proportionally. I have also calculated the results of the analyses of these special manures upon the same basis, so that in the subjoined table we have, first, a comparison of all three Potato Manures in respect to what they claim to be, and secondly, a comparison of what each claims to be, with what it really is.

### RELATIVE COMPOSITION OF SPECIAL POTATO MANURES.

| | | Nitrogen. | Phosphoric acid<br>Soluble. | Phosphoric acid<br>Reverted. | Potash. |
|---|---|---|---|---|---|
| Stockbridge | theory | 21 | 11 | | 34 |
| | analysis | 21 | 31 | 7½ | 61½ |
| Mapes' (Ville) | theory (guarantee) | 21 | 34 | | 77 |
| | analysis | 21 | 9 | 17 | 85 |
| Forrester's | theory (guarantee) | 21 | 33 | | 60 |
| | analysis | 21 | 12½ | 15½ | 42 |

The above figures show that while the theory of the Stockbridge Potato Manure requires to a given quantity of nitrogen, but one-third as much soluble phosphoric acid, and one-half as much potash as the Ville formula (guaranteed by the Mapes Company), the Stockbridge article in the market really approaches the Ville formula pretty closely in its relative proportions of these elements, and is quite identical with the guarantee of the Forrester Potato Fertilizer. The Mapes Potato Fertilizer gives less phosphoric acid, and more potash in relation to nitrogen than its guarantees, while the Forrester Potato Fertilizer gives less, both of phosphoric acid and potash in relation to its nitrogen.

It is evident enough that Prof. Stockbridge does not regard a wide deviation from his theories as fatal to the potato crop, and that it respect he is probably in harmony with most sagacious farmers.

In honest truth there is no possibility of compounding special fertilizers adapted to each of our various crops, nor even to our various classes of crops. There are no principles of science as yet discovered or conceivable, nor are there any results of practical experience attained, or presumably attainable, which can lead to such a result. On the contrary, experience and science most fully agree as to the vanity and folly of such attempts. Special Manures for particular crops are in fact least heard of where agriculture is guided by the clearest light of science and the widest range of experience.

Having thus expressed our sentiments in respect to the theory and pretensions of "Special Fertilizers" so-called, in general, it remains to notice in particular the twelve articles of this class, which have fallen under the scrutiny of the Station in 1878. Here follow their analyses.

### STOCKBRIDGE MANURES.

Manufactured by W. H. Bowker & Co., Boston and New York. No. **137** was sampled by Andrews Bros. of Southington, **146** by S. M. Wells of Wethersfield, **175** by P. M. Augur of Middlefield, and **193**, **195**, **196** and **197** by J. J. Webb of Hamden.

| Station Number. | Crop. | Nitrogen as Nitrates. | Nitrogen as Ammonia. | Organic Nitrogen. | Soluble Phos. Acid. | Reverted Phos. Acid. | Insoluble Phos. Acid. | Potash. | Estimated Value per Ton. | Cost per Ton. | Cost per Bag. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 137 | Corn, | ---- | ---- | 5.89 | 2.01 | 3.35 | 1.32 | 6.60 | $46.37 | $50.00 | 100 lbs.<br>$2.50 |
| 195 | " | 1.39 | 2.23 | 2.61 | 2.11 | 1.64 | 2.22 | 6.95 | 45.31 | 50.00 | 200 lbs.<br>5.00 |
| 146 | Potatoes, | ---- | ---- | 3.49 | 5.15 | 1.24 | 0.18 | 10.22 | 44.65 | 50.00 | |
| 175 | Strawberries, | 0 | 2.32 | 2.10 | 6.64 | 1.13 | 0.24 | 6.49† | 48.24 | 53.33 | 150 lbs.<br>4.00 |
| 193 | Kitchen Garden, | 0 | 0 | 4.57 | 4.83 | 0.79 | 0.17 | 7.22* | 40.68 | 50.00 | 100 lbs.<br>3.00 |
| 196 | Squashes, Cucumbers and Tomatoes, | 0 | 1.45 | 3.61 | 4.05 | ---- | ---- | 7.66 | 43.02 | 55.00 | 200 lbs.<br>5.50 |
| 197 | Grass. Top Dressing. | 8.68 | 0 | 0 | 2.11 | ---- | ---- | 10.38 | 56.28 | 66.67 | 150 lbs.<br>5.00 |

* As sulphate valued at seven and a half cents per pound.

† As low grade sulphate valued at six cents per pound. In the others potash as muriate is valued at four and a half cents, except **137** and **146**.

**137** and **146** were not examined for nitrates and ammonia-salts. Their potash is valued at seven and a half cents.

All but **175** were sold by Olds & Whipple, Hartford, Ct.

### BOWKER'S LAWN DRESSING.

Manufactured by W. H. Bowker & Co., Boston and New York, and sold by Olds & Whipple, Hartford, Conn. Sampled by J. J. Webb, Hamden, Ct.

| Station No. | | Nitrogen as Ammonia. | Organic Nitrogen. | Soluble Phos. Acid. | Reverted Phos. Acid. | Insoluble Phos. Acid. | Potash. | Estimated value per ton. | Cost per ton. | Cost per bag. |
|---|---|---|---|---|---|---|---|---|---|---|
| **181** | Lawn Dressing-- | 7.99 | ---- | 5.17 | ---- | ---- | 6.35* | $58.01 | $65.00 | 10 lbs.<br>$0.65 |

* As muriate at four and a half cents per pound.

### FORRESTER'S SPECIAL FERTILIZERS.

Manufactured by H. J. Baker & Bro., New York, and sampled by M. S. Baldwin, Naugatuck, Ct.

| Station No. | Crop. | Nitrogen as Ammonia. | Organic Nitrogen. | Soluble Phosphoric Acid. | Reverted Phos. Acid. | Insoluble Phos. Acid. | Potash. | Estimated value per ton. | Cost per ton. |
|---|---|---|---|---|---|---|---|---|---|
| **116** | Potatoes ---- | ---- | 5.65 | 3.36 | 4.21 | 0.68 | 11.42 | $49.23 | $47.50 |
| **201** | Grass ------ | 4.71 | 0.95 | 1.01 | 3.07 | 1.04 | 12.11 | 46.82 | 45.00 |

### MAPES' SPECIAL FERTILIZERS.

Manufactured by the Mapes Formula and Peruvian Guano Co., New York, No. **128** was sampled by Moses Sherwood, Green's Farms, Ct., and **144** by S. M. Wells, Wethersfield, Ct.

| Station No. | Crop. | Nitrogen as Nitrates. | Nitrogen as Ammonia. | Organic Nitrogen. | Soluble Phos. Acid. | Reverted Phos. Acid. | Insoluble Phos. Acid. | Potash. | Estimated value per ton. | Cost per ton. |
|---|---|---|---|---|---|---|---|---|---|---|
| **128** | Potatoes --------- | ---- | ---- | 3.67 | 1.59 | 2.96 | 1.49 | 14.82 | $38.67 | $51.49 |
| **144** | Grass and Grain (top dressing---- | 1.17 | 2.24 | 0.87 | 1.81 | 4.18 | 1.32 | 3.65 | 36.85 | ? |

All the above Special Manures or Fertilizers stand well up to the composition guaranteed by the manufacturers. These guarantees are here given.

| | | | Phosphoric acid. | |
|---|---|---|---|---|
| | Nitrogen. | Potash. | Soluble. | Available. |
| **137** | 5.75–6.5 | 7–8.5 | 3–4 | 6–8 |
| **195** | 5.75–6.5 | 7–8.5 | 3–4 | 6–8 |
| **146** | not reported to Station. | | | |
| **175** | 4.5–5 | 6–6.6 | 6–7 | ---- |
| **193** | 4.5–5.25 | 7–8 | 2–3 | 4–5 |
| **196** | 4.75–5 | 7–8 | 4.5–5 | ---- |
| **197** | 8–8.5 | 9.5–10.5 | 2.5–3 | ---- |
| **181** | 6–8 | 4–6 | 4–6 | ---- |
| **116** | 4.25 | 5.5 | 10 | ---- |
| **201** | 5 | 2⅛ | 6 | ---- |
| **128** | 3.7 | 6 | 13.6 | --- |
| **144** | not reported to Station. | | | |

In contrasting the estimated value and selling prices of the above special manures, it should be remembered that some or most of them are rarely sold to one purchaser in quantities of more than a few bags, and therefore cannot be afforded so cheaply as goods that are in more demand. Again, manufacturers obtain very little discount on nitrates or ammonia-salts, and where they use these substances in preparing a "special manure" or "formula," they have to charge something for the expenses of mixing, etc., more than they need to where animal matters are the source of nitrogen, because the latter are bought in large quantities at a considerable discount.

## RED ROCK.

The composition of the red sandstone that is of such frequent occurrence in the valleys of the Connecticut and Quinnipiac Rivers has not been studied from an agricultural point of view as it deserves. The subject was brought to my notice in June last by a letter from Elizur Andrews, Esq., of Southington. Mr. Andrews wrote as follows:

"The soil of our farm is made up very largely of decomposed red sandstone shale, and is underlaid and underdrained by this rock at a depth of from a few inches to several feet. This rock, if left exposed to the weather, is soon decomposed, and is covered in a short time with a luxuriant growth of vegetation. Have any analyses of this kind of rock ever been made, and if so, can you give me the result? It seems to me that if this rock contains potash or other valuable fertilizing ingredients, that it will not be necessary for us to supply them at least for some time to come."

In answer to Mr. Andrews, it was written that no analyses were extant, to my knowledge, bearing upon the subject of his inquiries; that it was proposed to make analyses of characteristic soils and soil-materials in order to learn their natural qualities or deficiencies; that presumably the red rock of Connecticut would vary in composition considerably in different localities, in some places being a very pure quartz sandstone, in others containing a large admixture of feldspar, and therefore capable of yielding up potash and perhaps lime on disintegration. It was further said that the Station would analyze the rock or better the newly-formed, uncultivated soil resulting from it. The Messrs. Andrews accordingly sent a large keg full of the rock underlying their land.

"The sample was from an exposure which had been broken up a few years ago for the purpose of repairing roads, and had lain undisturbed since. The rock was imperfectly disintegrated, and yet was covered with quite a growth of red and white clover."

Messrs. Andrews stated further that the soil of their farm originated quite exclusively from the red sandstone, having been mostly sheltered by a trap-dyke from the bowlder-drift which covers so large a share of the surface of the State.

The sample consisted of fine and coarse material, and included masses of several pounds weight, which were however easily broken by rough handling. The whole was crushed with a wooden pestle and shaken on a sieve with round holes of one-sixth inch diameter. What passed, amounting to thirty-seven *per cent.* of the whole, was used for the analysis without further pulverization.

### *Analysis of Red Rock.*

| | | |
|---|---|---|
| Lime | .079 | |
| Magnesia | .944 | |
| Potash | .071 | |
| Soda | .024 | |
| Sulphuric acid | .008 | |
| Phosphoric acid | .081 | |
| Oxide of iron and alumina | 8.610 | |
| Matters soluble in hydrochloric acid | | 9.817 |
| Sand and insoluble silicates | | 82.573 |
| Moisture | | 3.190 |
| Organic matters* | | 4.420 |
| | | 100.000 |

* With nitrogen, .085.

A portion was treated with strong hydrochloric acid (sp. gr., 1.15), as Wolff recommends, and in the solution thus obtained the various ingredients were determined. The percentages refer to the air-dry rock. See previous page.

Comparison of the above figures with analyses of good soils, as, for instance, the wheat soil of Illinois (see Report for 1877, p. 33) makes evident that potash, lime, phosphoric acid, and especially magnesia, are abundant, while sulphuric acid is present in small quantity, and liable to become deficient in a relatively short time.

The cubic foot of crumbled air-dry rock weighed 86 pounds. The weight calculated for a foot in depth and an acre of area would be 3,746,160 pounds, and this amount of the rock would contain 2,660 pounds of potash, 2,880 pounds of lime, 3,000 pounds of phosphoric acid, and but 300 pounds of sulphuric acid. Besides these quantities, there are large stores of the same kinds of plant-food not soluble in acids, which by further action of the weather, and especially under the influence of vegetation and decaying vegetable matters, will gradually become serviceable to crops.

These results of chemical analysis confirm the general verdict of experience, which places our red rock soil among the best, while it shows that, excepting the sulphuric acid, this rock is about equally rich in all the needed elements of plant-food.

The red-rock soil, while good, has not the great fertility of prairie-land, chiefly, no doubt, because it has not that fineness of texture and great depth, which by presenting a vast exposure to the rootlets of plants, enable the latter to extract from the soil more in a given time than they can from earth of less depth and of a coarse grain.

The relative assimilability or availability of the different nutritive ingredients in this soil is not definitely determined by our analysis. Only actual experiments or observations on the power of the soil to support vegetation can establish such a point. The ready growth of clover on the recently exposed rock indicates, however, that the various elements, especially potash and lime, are sufficiently assimilable.

## FODDER AND FEEDING STUFFS.

I have here to report upon the analyses of thirty-one (31) articles of this class that have been made in the Station Laboratory, viz:

5 samples of maize fodder.
9 " " grain.
9 " " cob.
1 sample of rye bran.
1 " steam-cooked grain.
1 " Glen Cove corn feed.
1 " condimental cattle food.
2 samples of animal meal.
1 sample of egg food.
1 " yam.

Before entering into details of these analyses, I copy here from my Report for 1878, some paragraphs that may serve to explain what is to follow.

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Thanks to the laborious investigations carried on of late years in the Experiment Stations and University Laboratories of Europe, and especially of Germany, the simple analysis of an article of cattle food may be usefully employed in fixing its place and nutritive value in the feeding-ration, and also in deciding how much the farmer can afford to pay for it, or at what price, and to what extent he can substitute it for other materials customarily used.

In order to make our analyses of cattle feed directly useful, it is needful to adduce some of the results of the prolonged study of this subject made in other countries.

The following Table of the Composition, Content of Digestible Nutritive Ingredients and Money Value, of some of the most important Feeding Stuffs (page 57), is taken from the German of Dr. Emil Wolff, of the Agricultural Academy at Hohenheim, and represents the most recent and most trustworthy knowledge on these subjects.*

The *composition* of feeding stuffs, as here stated, is the average result of the numerous analyses that have been made within twenty-five years, mostly in the German Experiment Stations.

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* From "*Mentzel u. Lengerke's Landw. Kalender*," for 1879.

The *quantities of digestible nutrients* are partly derived from actual feeding experiments, and are partly the result of calculation and comparison.

The percentages of the *three classes* of digestible matters, viz: *Albuminoids*, *Carbhydrates* and *Fat*, form the basis for calculating the money-value of feeding stuffs. The values attached to them by Dr. Wolff are the following, the German mark being considered as equal to twenty-four cents, and the kilogram equal to 2.2 pound avoirdupois.

1 pound of digestible albuminoids is worth $4\frac{1}{3}$ cents.
1 " " fat " $4\frac{1}{3}$ "
1 " " carbhydrates " $\frac{9}{10}$ "

These figures express the present average *money-values* of the respective food elements in the German markets. Whether or not these values are absolutely those of our markets, they represent presumably the *relative* values of these elements approximately, and we may provisionally employ them for the purpose of comparing together our feeding stuffs in respect to money value.

These money or market values are to a degree independent of the feeding values. That is, if of two kinds of food, for example, Hungarian hay and malt sprouts, the one sums up a value of 66 cents, and the other a value of $1.31 per hundred, it does not follow that the latter is worth for all purposes of feeding twice as much as the former, but it is meant that when both are properly used, one is worth twice as much money as the other. In fertilizers we estimate the nitrogen of ammonia salts at $22\frac{1}{2}$ cents per pound, and soluble phosphoric acid at $12\frac{1}{2}$ cents, but this means simply that these are equitable market prices for these articles, not that nitrogen is worth twice as much as soluble phosphoric acid for making crops. In the future more exact valuations may be obtained from an extensive review of the resources of our markets, in connection with the results of analyses of the feed and fodder consumed on our farms.

The column headed "nutritive ratio" in the table on page 57 gives the proportion of digestible albuminoids to digestible carbhydrates inclusive of fat.* The albuminoids, which are represented in animal food by the casein or curd of milk, the white of

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* Fat and carbhydrates have, it is believed, nearly the same nutritive function, and it is assumed that 1 part of fat equals 2.4 of carbhydrates.

egg and lean meat, and in vegetable food by the gluten of wheat (wheat gum), and other substances quite similar to milk-casein and egg-albumin, have a different physiological significance from the carbhydrates, which are fiber or cellulose, starch, the sugars, the gums, and similarly constituted matters.

The albuminoids may easily be made over by the animal into its own substance, i. e., into muscles, tendons, and the various working tissues and membranes which are necessary parts of the animal machine, because they are the same kind of materials, are, chemically speaking, of the same composition.

The carbhydrates, on the other hand, probably cannot serve at all for building up the muscles and other parts of the growing animal, and cannot restore the waste and wear of those parts of mature animals, because they are of a very different nature. They contain no nitrogen, an element which enters into all the animal tissues (albuminoids) to the extent of some fifteen per cent. of their dry matter.

The carbhydrates cannot restore the worn out muscles or membranes of the animal any more than coal can be made to renew the used up packing, bolts, valves, flues and gearing, of a steam-engine. The albuminoids are to the ox or the man what brass and iron are to the machine, the materials of construction and repair.

The carbhydrates are, furthermore, exactly to the animal what coal and fuel are to the steam-engine. Their consumption generates the power which runs the mechanism. Their burning (oxidation) in the blood of animals produces the results of life just as the combustion of coal in the fire-place of the steam-engine produces the motion and power of that machine.

There is, however, this difference between the engine and the animal. The former may be stopped for repairs, the latter may run at a lower rate, but if it be stopped it cannot resume work. Hence the repairs of the animal must go on simultaneously with its waste. Therefore, the materials of which it is built must admit of constant replacement, and the dust and shreds of its wear and tear must admit of escape without impeding action. The animal body is as if an engine were fed with coal and water not only, but with iron, brass and all the materials for its repair, and also is as if the engine consumed its own worn out parts, voiding them as ashes or as gas and smoke. The albuminoids, or blood- and tissue-formers, are thus consumed in the animal, as

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*Average Composition, Digestibility and Money Value of Feeding Stuffs as given by Dr. Wolff for Germany for 1878, except those in italics.*

| | Water. | Ash. | Albuminoids. | Fiber. | Other carbhydrates. | Fat. | Digestible nutrients. | | | *Nutritive ratio. | Value. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Albuminoids. | Carbhydrates incl. fiber. | Fat | | Dollars per 100 pounds. | Comparison with meadow hay = 1. |
| Meadow hay, inferior | 14.3 | 5.0 | 7.5 | 33.5 | 38.2 | 1.5 | 3.4 | 34.9 | 0.5 | 10.6 | 0.48 | 0.74 |
| " " better | 14.3 | 5.4 | 9.2 | 29.2 | 39.7 | 2.0 | 4.6 | 36.4 | 0.6 | 8.3 | 0.55 | 0.86 |
| " " average | 14.3 | 6.2 | 9.7 | 26.3 | 41.4 | 2.5 | 5.4 | 41.0 | 1.0 | 8.0 | 0.64 | 1.00 |
| " " very good | 15.0 | 7.0 | 11.7 | 21.9 | 41.6 | 2.8 | 7.4 | 41.7 | 1.3 | 6.1 | 0.74 | 1.17 |
| " " extra | 16.0 | 7.7 | 13.5 | 19.3 | 40.4 | 3.0 | 9.2 | 42.8 | 1.5 | 5.1 | 0.84 | 1.32 |
| Clover hay, average | 16.0 | 5.3 | 12.3 | 26.0 | 38.2 | 2.2 | 7.0 | 38.1 | 1.2 | 5.9 | 0.69 | 1.08 |
| " best | 16.5 | 7.0 | 15.3 | 22.2 | 35.8 | 3.2 | 10.7 | 37.6 | 2.1 | 4.0 | 0.88 | 1.39 |
| Timothy hay | 14.3 | 4.5 | 9.7 | 22.7 | 45.8 | 3.0 | 5.8 | 43.4 | 1.4 | 8.1 | 0.69 | 1.09 |
| Hungarian hay | 13.4 | 5.7 | 10.8 | 29.4 | 38.5 | 2.2 | 6.1 | 41.0 | 0.9 | 7.1 | 0.66 | 1.04 |
| Rye straw | 14.3 | 4.1 | 3.0 | 44.0 | 33.3 | 1.3 | 0.8 | 36.5 | 0.4 | 46.9 | 0.35 | 0.55 |
| Oat " | 14.3 | 4.0 | 4.0 | 39.5 | 36.2 | 2.0 | 1.4 | 40.1 | 0.7 | 29.9 | 0.44 | 0.69 |
| Rich pasture grass | 78.2 | 2.2 | 4.5 | 4.0 | 10.1 | 1.0 | 3.4 | 10.9 | 0.6 | 3.6 | 0.27 | 0.42 |
| Average meadow grass, fresh | 70.0 | 2.1 | 3.4 | 10.1 | 13.4 | 1.0 | 1.9 | 14.2 | 0.5 | 8.1 | 0.22 | .36 |
| Green maize, German | 85.0 | 1.0 | 1.2 | 4.7 | 7.6 | 0.5 | 0.7 | 7.4 | 0.2 | 11.3 | .10 | .16 |
| " *Mr. Webb*, 1874 | 86.0 | 0.8 | 0.8 | 4.8 | 7.3 | 0.3 | 0.6 | 8.3 | 0.2 | 14.4 | .11 | .17 |
| *Cured Maize Fodder, Mr. Webb* | 27.3 | 4.2 | 4.4 | 25.0 | 37.9 | 1.3 | 3.2 | 43.4 | 1.0 | 14.4 | .57 | .91 |
| Potatoes | 75.0 | 0.9 | 2.1 | 1.1 | 20.7 | 0.2 | 2.1 | 21.8 | 0.2 | 10.6 | .29 | .46 |
| Carrots | 8.50 | 0.9 | 1.4 | 1.7 | 10.8 | 0.2 | 1.4 | 12.5 | 0.2 | 9.3 | .18 | .28 |
| Mangolds | 88.0 | 0.8 | 1.1 | 0.9 | 9.1 | 0.1 | 1.1 | 10.0 | 0.1 | 9.3 | .14 | .22 |
| Rutabagas | 87.0 | 1.0 | 1.3 | 1.1 | 9.5 | 0.1 | 1.3 | 10.6 | 0.1 | 8.3 | .15 | .24 |
| Turnips | 9.20 | 0.7 | 1.1 | 0.8 | 5.3 | 0.1 | 1.1 | 6.1 | 0.1 | 5·8 | .11 | .16 |
| Sugar beets | 81.5 | 0.7 | 1.0 | 1.3 | 15.4 | 0.1 | 1.0 | 16.7 | 0.1 | 17.0 | .19 | .30 |
| Maize, German | 14.4 | 1.5 | 10.0 | 5.5 | 62.1 | 6.5 | 8.4 | 60.6 | 4.8 | 8.6 | 1.10 | 1.73 |
| " *American* | 14.4 | 1.5 | 10.7 | 2.0 | 66.5 | 4.9 | 9.0 | 63.3 | 3.7 | 8.0 | 1.12 | 1.75 |
| Oats | 14.3 | 2.7 | 12.0 | 9.3 | 55.7 | 6.0 | 9.0 | 43.3 | 4.7 | 6.1 | .97 | 1.53 |
| Rye | 14.3 | 1.8 | 11.0 | 3.5 | 67.4 | 2.0 | 9.9 | 65.4 | 1.6 | 7.0 | 1.09 | 1.68 |
| Barley | 14.3 | 2.2 | 10.0 | 7.1 | 63.9 | 2.5 | 8.0 | 58.9 | 1.7 | 7.9 | 0.95 | 1.47 |
| Peas | 14.3 | 2.4 | 22.4 | 6.4 | 52.5 | 2.0 | 20.2 | 54.4 | 1.7 | 2.9 | 1.44 | 2.25 |
| Field Beans | 14.5 | 3.1 | 25.5 | 9.4 | 45.9 | 1.6 | 23.0 | 50.2 | 1.4 | 2.3 | 1.51 | 2.36 |
| Squashes | 89.1 | 1.0 | 0.6 | 2.7 | 6.5 | 0.1 | 0.4 | 7.1 | 0.1 | 18.4 | 0.8 | .13 |
| Malt sprouts | 10.1 | 7.2 | 24.3 | 14.3 | 42.1 | 2.1 | 19.4 | 45.0 | 1.7 | 2.5 | 1.31 | 2.06 |
| Wheat bran, coarse | 12.9 | 6.6 | 15.0 | 10.1 | 52.2 | 3.2 | 12.6 | 42.6 | 2.6 | 3.9 | 1.04 | 1.63 |
| " fine | 13.1 | 5.4 | 14.0 | 8.7 | 55.0 | 3.8 | 11.8 | 44.3 | 3.0 | 4.4 | 1.03 | 1.62 |
| Middlings | 11.5 | 3.0 | 13.9 | 4.8 | 63.5 | 3,3 | 10.8 | 54.0 | 2.9 | 5.7 | 1.07 | 1.68 |
| Rye Bran | 12.5 | 5·2 | 14.5 | 5.7 | 58.6 | 4.5 | 12.2 | 46.2 | 3.6 | 4.5 | 1.10 | 1.72 |
| Palm-nut cake | 10.5 | 4.2 | 16.9 | 17.4 | 41.0 | 10.0 | 16.1 | 55.4 | 9.5 | 4.9 | 1.61 | 2.51 |
| Cotton seed cake decorticated | 11.2 | 7.6 | 38.8 | 9.2 | 19.5 | 13.7 | 31.0 | 18.3 | 12.3 | 1.6 | 2.05 | 3.22 |
| *Fish scrap, by Goodale's process* | 11.5 | ---- | 64.0 | ---- | ---- | 4.6 | 57.6 | ---- | 4.1 | 0.2 | 2.67 | 4.17 |
| *Fish scrap, dry ground* | 11.7 | ---- | 51.5 | ---- | ---- | 8·1 | 46.4 | ---- | 6.2 | 0.3 | 2.28 | 3.56 |
| Dried blood | 12.0 | 4.1 | 80.8 | ---- | 2.6 | 0.5 | 54.1 | 2.6 | 0.5 | ---- | 2.39 | 3.76 |
| Whey | 92.6 | 0.7 | 1.0 | ---- | 5.1 | 0.6 | 1.0 | 5.1 | 0.6 | 6.6 | .11 | .18 |
| Milk | 87.5 | 0.7 | 3.2 | ---- | 5.0 | 3.6 | 3.2 | 5.0 | 3.6 | 4.4 | .34 | .53 |

* Nutritive ratios are read, 1 : 10.6, 1 : 8.3, etc. See page 55.

well as the carbhydrates, or fuel proper. The fact that the albuminoids admit of consumption implies that when the carbhydrates or proper fuel are insufficient, they, the albuminoids, may themselves serve as fuel. Such is the case, in fact. But, nevertheless, the two classes of substances have distinct offices in animal nutrition, and experience has demonstrated what science predicted, viz: that for each special case of animal nutrition a special ratio of digestible albuminoids to digestible carbhydrates is the best and most economical, and, within certain limits, is necessary. This proportion we designate as the *nutritive ratio*, and these explanations make its significance evident.

To allow of directly comparing the money-value of feeding stuffs with some universally accepted standard, the last column of the table (page 57) gives a comparison with good average meadow hay taken as 1.

## MAIZE FODDER IN DIFFERENT STAGES OF GROWTH.

The Secretary of the Board of Agriculture last year proposed to the Station to undertake the study of the composition of fodder maize at several stages of its growth, and furnished four samples for that purpose.

The seed was a medium or large variety of sweet corn, and was planted about June 1st, 1877, in good garden soil. The hills were 2½ feet apart in the rows, and the rows were 3 feet distant from each other, making 30 hills to the square rod, or 4,800 per acre. The samples sent to the Station were but a single hill each, and were cut as follows:

XIII, cut July 25, just before staminate flowers (tassels) appeared. Weighed fresh 11 lbs. 10 oz. (= 5273 grams).

XIV, cut August 9, in full silk, weighed 10 lbs. (= 4536 grams) inclusive of 3 immature ears or "nubbins."

XVII, cut August 25, the kernel full size for eating as "green corn," weighed 16¾ lbs. (= 7597½ grams) inclusive of 10 ears and nubbins.

XX, cut September 25, stalks and ears nearly dry, weighed 5 lbs. 14 ozs. (= 2665 grams) including 5 ears and nubbins.

The stubble and "roots" were received but not analyzed, and are not included in these or subsequent statements.

The details of the analyses of the above samples from Mr. Sec'y Gold may be advantageously combined with the results of the examination of a sample of stover,* XXIII, from a field of Ohio Dent corn raised by J. J. Webb, Esq., of Hamden, in 1877. The corn in this case was planted at the usual time 3 feet apart, more or less, in the row, the rows being 3 ft. 4 in. apart. On September 15, Mr. Jenkins assisted in staking out an average plot of 22 ft. × 9 ft. 7 in. = 210.83 sq. ft. At the harvest, which followed some weeks later, the yield of this plot was separately stacked, and it was brought to the Station Nov. 1, 1877, when its stover weighed 48½ lbs., corresponding to 10,020.6 lbs. per acre.

The weights of the several crops calculated in pounds per acre are as follows:

| | | Fresh. | Air dry. | | | |
|---|---|---|---|---|---|---|
| | | Total. | Fodder. | Corn. | Cob. | Total. |
| XIII. | Mr. Gold's | 55,800 | XIII. 4,297 | 0 | 0 | 4,297 |
| XIV.* | " | 48,000 | XIV. 6,192 | XV. 589 | XVI. 116 | 6,897 |
| XVII † | " | 80,400 | XVII. 7,705 | XVIII. 3,995 | XIX. 1,149 | 12,849 |
| XX.‡ | " | 28,200 | XX. 5,006 | XXI. 3,318 | XXII. 870 | 9,196 |
| XXIII.§ | Mr. Webb's | Field-cured.<br>20,454 | XXIII. 7,218 | XXIV. 7,029 | XXV. 1,364 | 15,611 |

* Including XV and XVI.
† Including XVIII and XIX.
‡ Including XXI and XXII.
§ Including XXIV and XXV.

| | Water-free. | | | |
|---|---|---|---|---|
| | Fodder. | Corn. | Cob. | Total. |
| XIII. | 3,958 | 0 | 0 | 3,958 |
| XIV. | 5,536 | XV. 529 | XVI. 105 | 6,170 |
| XVII. | 7,164 | XVIII. 3,592 | XIX. 1,045 | 11,801 |
| XX. | 4,626 | XXI. 3,005 | XXII. 794 | 8.425 |
| XXIII. | 6,444 | XXIV. 6,271 | XXV. 1,251 | 13,966 |

It is to be regretted that the samples sent by Mr. Gold were too small to fairly represent the *quantity* of crop in the different stages. The air-dry and dry matter of XX should be greater than that of XVII. Whether the former is too small or the latter too large for the average crop is a point that cannot be certainly decided, though the results in Mr. Webb's corn XXIII, which was so sampled as to represent the crop with a good degree of fairness, make probable that XX is too small, and XVII too large.

Here follow the results of the chemical examination of the maize fodder. The analyses were made on the air-dry material. The results are calculated both on the fresh or field-cured fodder, and on the absolutely dry substance. The "air-dry" material was considerably drier than corn fodder can become in the stack or barn, having been freely exposed to dry air, after being cut fine

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* Stover is the stalks, leaves, and husks of ripe maize.

for the purpose of obtaining a suitable average for analysis. The analysis reckoned on dry substance is needful because the variable amount of water in the air-dry fodder prevents a strict comparison.

### Composition of Maize Fodder and Stover.

| | Fresh. | | | | Field-cured. |
|---|---|---|---|---|---|
| | XIII. | XIV. | XVII. | XX. | XXIII. |
| Water, | 92.908 | 88.289 | 90.480 | 80.740 | 36.490 |
| Ash, | .980 | 1.269 | 1.104 | 2.334 | 2.874 |
| Albuminoids, | .866 | 1.310 | .864 | 1.538 | 4.623 |
| Fiber,* | 1.903 | 3.227 | 2.694 | 5.939 | 19.077 |
| Other Carbhydrates,* etc., | 3.198 | 5.736 | 4.719 | 9.207 | 35.781 |
| Fat, etc. (ether extract),† | .145 | .169 | .139 | .244 | 1.155 |

| | Air-dry. | | | | |
|---|---|---|---|---|---|
| | XIII. | XIV. | XVII. | XX. | XXIII. |
| Water, | 7.89 | 10.60 | 7.02 | 7.60 | 10.72 |
| Ash, | 12.73 | 9.69 | 10.78 | 11.20 | 4 04 |
| Albuminoids, | 11.25 | 10.00 | 8.44 | 7.38 | 6.50 |
| Fiber,* | 24.72 | 24.63 | 26.31 | 28.45 | 26.82 |
| Other Carbhydrates,* etc., | 41.53 | 43.79 | 46.09 | 44.20 | 50.31 |
| Fat, etc., | 1.88 | 1.29 | 1.36 | 1.17 | 1.61 |

| | Water-free. | | | | |
|---|---|---|---|---|---|
| | Gold. | | | | Webb. |
| | XIII. | XIV. | XVII. | XX. | XXIII. |
| Ash, | 13.82 | 10.84 | 11.59 | 12.12 | 4.52 |
| Albuminoids, | 12.22 | 11.19 | 9.08 | 7.89 | 7.28 |
| Fiber, | 26.84 | 27.45 | 28.30 | 30.78 | 30.04 |
| Other Carbhydrates, etc.. | 45.08 | 49.08 | 49.57 | 47.94 | 56.36 |
| Fat, etc., | 2.04 | 1.44 | 1.46 | 1.27 | 1.80 |

The somewhat larger proportion of ash and albuminoids here noticed in the maize fodder in the earlier stages of growth, is accordant with the general result of observations on other plants. Young plants and the newly formed parts are, as a rule, richer in ash and albuminoids than mature plants or parts.

The proportion of carbhydrates increases in Mr. Gold's samples from XIII, cut July 25th, to XVI, cut Aug. 25th, thereafter a slight falling off is noticed.

Fiber increases toward the maturity of the crop, XX containing 4 per cent more than XIII.

Fat, etc., diminishes with the progress of growth.

Mr. Webb's stover, XXIII, agrees closely in respect to albuminoids and fiber with the ripest of Mr. Gold's samples, XX. In ash, the former is 7½ per cent richer than the latter, while the latter exceeds the former in carbhydrates, etc. (not including fiber), by nearly 8½ per cent.

The ash here given is "pure ash," exclusive of sand or soil, etc., and is remarkably larger in the sweet corn raised in rich garden soil than in the field crop.

These differences partly belong to the different varieties of maize grown in the two cases, for Mr. Gold's four samples of sweet corn are strikingly similar to each other in composition, the differences that have been already pointed out amounting to but a little more than four per cent. at the highest. These differences are, however, sufficient to affect the quality of the fodder very decidedly, as will appear from the comparison of their nutritive ratios.

The results of practical feeding experiments in which the undigested matters of maize fodder have been determined by chemical analysis have shown that 73 per cent. of its albuminoids, 67 per cent. of its carbhydrates, 72 per cent. of its fiber and 75 per cent. of its fat are digestible. Accordingly we have the actual nutritive matters, or *digestible nutrients*, as follows, to which we add the *nutritive ratio*, and the *relative money value;* both for the fresh, or, in case of XXIII, for the field-cured fodder and, to enable a strict comparison, for the water-free substance.

### *Digestible Nutrients.—Nutritive Ratio* and Money-value of Maize Fodder.*

| | Gold.<br>Fresh. | | | | Webb.<br>Field-cured. |
|---|---|---|---|---|---|
| | XIII. | XIV. | XVI. | XX. | XXIII. |
| Albuminoids, | 0.632 | 0.956 | 0.631 | 1.123 | 3.375 |
| Carbhydrates, incl. fiber, | 3.512 | 6.167 | 5.101 | 10.445 | 37.728 |
| Fat, | .109 | .127 | .104 | .183 | .866 |
| Nutritive Ratio, | 1: 6 | 1 : 6.8 | 1 : 8.5 | 1 : 9.7 | 1 : 11.8 |
| Calculated value per 100 lbs. | $.06 | .10 | .08 | .15 | .52 |

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* The Carbhydrates properly include fiber, starch, sugar, gum and bodies of similar chemical constitution. There are other substances present in vegetation whose chemical nature is not well understood, that are here included with the carbhydrates, while fiber is stated separately.

† Fat, etc., includes whatever is extracted by ether from the perfectly dry fodder.

* i. e., Ratio of Albuminoids to Carbhydrates, including Fiber and Fat.

They were again weighed February 8th, passed through a straw cutter which reduced them to half-inch pieces, and in that state were brought to the laboratory. The results of the analyses calculated upon the material in the different stages of dryness in which it was weighed, are the following:

*Composition of Mr. Webb's Maize Fodder, Crops of 1874.*

| | Fresh-cut, Sept. 1. | | Field-cured, Nov. 11. | | In barn, Feb. 8. | | Water-free. | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Water, | 87.18 | 85.04 | 27.59 | 26.92 | 53.76 | 54.95 | ---- | ---- |
| Ash, | 0.84 | 0.74 | 4.76 | 3.62 | 3.04 | 2.24 | 6.57 | 4.95 |
| Albuminoids, | 0.88 | 0.78 | 4.97 | 3.79 | 3.18 | 2.34 | 6 87 | 5.19 |
| Fiber, | 4.38 | 5.16 | 24.76 | 25.18 | 15.81 | 15.52 | 34.19 | 34.45 |
| Other carbhydrates, &c., | 6.44 | 8.06 | 36.37 | 39.42 | 23.22 | 24.29 | 50.23 | 53.95 |
| Fat, &c. (ether extract), | 0.28 | 0.22 | 1.55 | 1.07 | 0.99 | 0.66 | 2.14 | 1.46 |
| | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

This maize-fodder was less rich in albuminoids by one to two per cent. than XX and XXIII, and contained four per cent. more fiber. In respect of carbhydrates, &c., it stands intermediate between XX and XXIII, which differ more than eight per cent. from each other.

*Digestible Nutrients, &c., of Mr. Webb's Maize Fodder,* 1874.

| | 1. | 2. |
|---|---|---|
| Albuminoids, | 5.01 | 3.79 |
| Carbhydrates, | 58.27 | 60.95 |
| Fat, | 1.61 | 1.10 |
| Nutritive ratio, | 1:12.4 | 1:16.8 |
| Calculated value per 100 lbs., | $0.81 | $0.76 |

The money-value of these samples is not different from those already considered, but in feeding quality they are seen (from the nutritive ratio) to be still further removed from the class of concentrated foods and in this respect rank pound for pound below the inferior kinds of hay, pea straw, or potatoes. Such fodder is a proper complement to concentrated foods like brewer's grains, cotton seed meal, palm nut meal, bran and the like, and where good hay and even rye straw command high prices, it may be economically fed with the concentrated foods just named to make an effective substitute for hay and straw in cattle rations.

The yield per acre of these crops of 1874 is calculated to have been as follows, and from the uniform stand of the crops, the size of the measured plots and the care used throughout, the figures are undoubtedly quite correct.

*Yield of Mr. Webb's Maize Fodder per acre.*

| | Crop 1. | | Crop 2. | |
|---|---|---|---|---|
| | Lbs. | Tons. | Lbs. | Tons. |
| Fresh cut, Sept. 1, | 54.723 | 27.0 | 51.074 | 25.5 |
| Containing water, | 47.184 | 23.5 | 43.413 | 21.7 |
| Field-cured, Nov. 11, | 9.583 | 4.8 | 10.454 | 5.2 |
| Containing water, | 2.644 | 1.3 | 2.793 | 1.4 |
| In barn, Feb. 8, | 15.028 | 7.5 | 16.988 | 8.5 |
| Containing water. | 8.089 | 4.0 | 9.327 | 4.7 |
| Dry, | 6.939 | 3.5 | 7.661 | 3.8 |

The total yield of dry matter in these two crops (6,939 and 7,661 lbs) is not much different from that found in case of XVII and XXIII (7,164 and 6,444 lbs.).

In South Germany and Austria the yield of fresh maize fodder is reported in four instances as 50,000, 72,000, 72,000 and 52,800 kilos per hectare, respectively. The average is equal to 53,440 lbs. per acre or quite the same as these two crops of 1874. One of the largest foreign crops, equal to 64,130 lbs. per acre, fresh, made 12,470 lbs. of cured fodder, "maize hay." The loss of water in curing was 80½ per cent. of the green maize.

It is quite remarkable what an amount of water must be handled in the crop of maize fodder, and what variations of weight the fodder may undergo from loss or gain of water during or after curing.

The fall-weather of 1874 was exceptionally fine and dry, and the fodder in the field became very well cured, with a water content of 27 per cent., while the stover from Mr. Webb's farm in 1877 contained 36 per cent. After the crops of 1874 were housed, during the warm and damp winter of 1874-5 they absorbed moisture from the air to such an extent that the average 5 tons of fodder as stored Nov. 11, became 8 tons as it lay in the barn Feb. 8. This gain of water was greatest with 2, amounting to more than 3½ tons for the produce of an acre or as much as the field-cured fodder contained at the time of storing and one-half as much as the fresh-cut crop lost in field-curing. Such variability in the water-content of a harvested crop appears to be unexampled.

It should perhaps be stated, that the fodder was not closely packed away in the barn but, on the contrary, was stored as loosely as possible for the purpose of favoring further curing, and this very circumstance enabled it the more readily to recover water during the early winter rains, although it was perfectly sheltered from their direct contact. No other kind of forage is so absorbent of moisture as this.

## INDIAN CORN (THE KERNEL).

The nine samples of Indian Corn (maize kernel) examined in 1878 were, with one exception, the produce of Connecticut. Three of them were sweet corn belonging to the maize fodder already noticed, sent by Mr. Gold, and show the composition of the grain in different stages of growth. A fourth grew to maturity upon the stover of Mr. Webb. A fifth was raised near Raleigh, N. C., in the year 1874. The others were very handsome specimens, and are characterized below.

XV, Immature Sweet Corn from T. S. Gold, West Cornwall. Grew upon XIV. Harvested Aug. 9, 1877.

XVIII, Immature Sweet Corn from T. S. Gold. Grew upon XVII. Harvested Aug. 25, 1877.

XXI, Full grown Sweet Corn from T. S. Gold. Grew upon XX. Harvested Sept. 25, 1877.

XXIV, Ripe Ohio Dent, crop of 1877, sent by J. J. Webb, Hamden. Grew upon XXIII.

XXVI, Norfolk White, ripe, from Capt. W. E. Pierce, Raleigh, N. C.

XXVIII, Tuscarora, crop of 1877, ripe, from J. B. Olcott, South Manchester, Conn.

XXX, Vermont White Cap, crop of 1877, ripe, from A. L. Avery, Groton.

XXXII, Rowley Corn, crop of 1877, ripe, from J. N. Hollister, South Glastonbury.

The yield of the first three samples, viz: XV, XVIII, XXI, has been stated already in connection with the fodder; see p. 59.

The yield of XXIV for the plot of 210.8 square feet was 50½ pounds of corn and cob, or 10,433.8 pounds per acre when harvested, of which 8,738.6 pounds was corn, and 1,695.2 pounds was cob. In the highly cured state in which the corn was analyzed, its weight per acre would be 7,029 pounds, and absolutely dry it would weigh 6,271 pounds.

As to the yield of the other samples, no exact data are known.

### *Composition of Maize Kernel.*

Air-dry.

| | XV. | XVIII. | XXI. | XXIV. | XXVI. | XXVIII. | XXX. | XXXII. |
|---|---|---|---|---|---|---|---|---|
| Water | 10.12 | 10.09 | 9.45 | 10.78 | 11.17 | 11.25 | 10.86 | 11.00 |
| Ash | 2.19 | 2.08 | 2.06 | 1.37 | 1.31 | 1.47 | 1.53 | 1.61 |
| Albuminoids | 14.50 | 15.31 | 14.38 | 10.06 | 10.88 | 11.44 | 11.06 | 11.63 |
| Fiber | 2.57 | 2.52 | 1.93 | 1.35 | 1.90 | 1.28 | 1.04 | .78 |
| Carbhydrates | 62.70 | 61.78 | 63.05 | 71.30 | 70.04 | 68.82 | 71.22 | 70.15 |
| Fat | 7.92 | 8.22 | 9.13 | 5.14 | 4.70 | 5.74 | 4.29 | 4.83 |

Water-free.

| | Sweet Corn. | | | Ohio Dent. | Norfolk. | Tuscarora. | Vermont White Cap. | Rowley. |
|---|---|---|---|---|---|---|---|---|
| | XV. | XVIII. | XXI. | XXIV. | XXVI. | XXVIII. | XXX. | XXXII. |
| Ash | 2.44 | 2.31 | 2.27 | 1.54 | 1.48 | 1.66 | 1.72 | 1.81 |
| Albuminoids | 16.14 | 17.02 | 15.88 | 11.27 | 12.25 | 12.89 | 12.41 | 13.06 |
| Fiber | 2.86 | 2.80 | 2.13 | 1.51 | 2.14 | 1.44 | 1.17 | .88 |
| Carbhydrates | 69.75 | 68.73 | 69.64 | 79.92 | 78.84 | 77.54 | 79.89 | 78.83 |
| Fat | 8.81 | 9.14 | 10.08 | 5.76 | 5.29 | 6.47 | 4.81 | 5.42 |

The sweet corn is decidedly richer in ash, albuminoids, fiber and fat (oil), than the other kinds of maize, and contains correspondingly (9–10 per cent.) less carbhydrates, which in case of maize kernel are starch, sugar and gum. We notice that ash and fiber diminish, while the fat increases as the corn matures. The albuminoids also are less in the oldest than in the youngest sweet corn, but their greatest proportion is found in the sweet corn of intermediate age, where it reaches as high as 17 per cent. of the dry substance. Stowell's Evergreen Sweet Corn, according to the analysis made by Dr. Atwater in 1869, is not so rich in albuminoids as these samples raised by Mr. Gold. It contained 12.45 per cent., or not more than the average of the kinds to be presently noticed. In fat, however, sweet corn stands highest, the Stowell containing 8.59 per cent.

The other five varieties are not strikingly different in composition. Ohio Dent has least, and Rowley most albuminoids, the difference being 1.8 per cent.; the Norfolk, Vermont White, and Tuscarora agree pretty closely. The differences in respect to other ingredients are in any case scarcely greater.

It is seen that the soft grains like Ohio Dent and Tuscarora exhibit no differences in common from the flinty varieties such as Norfolk White, Vermont White Cap and Rowley, either in albuminoids, fat or carbhydrates. This fact is confirmed by a series of analyses of Michigan Corn made at the Laboratory of the Michigan Agricultural College, some results of which I shall quote subsequently.

Since fat is most abundant in the embryo or germ, it would follow that kernels with large embryos, or small kernels in which the embryo is relatively large, are the richest in fat or oil. The embryo constitutes a large share of the "chit," but whether the dimensions of the chit, as that part of the seed is commonly understood, correspond accurately, in all cases, to the dimensions of the germ, and therefore to the proportion of fat in the kernel, is a point to be further inquired into. I find from a few hasty comparisons, made at the moment of writing, that the germs of Tuscarora, Ohio Dent, Rowley and Vermont White Cap, when dissected out, obviously bear as to size, in comparison with their respective kernels, the same relation which is observed in their respective percentages of fat, which are greatest in Tuscarora (6.47 per cent.) and smallest in Vermont White Cap (4.81 per cent.).

*Digestible Nutrients, &c., of Maize Kernel in per cent. of air-dry substance.*

| | XV. | XVIII. | XXI. | XXIV. | XXVI. | XXVIII. | XXX. | XXXII. |
|---|---|---|---|---|---|---|---|---|
| Albuminoids | 12.18 | 12.86 | 12.08 | 8.45 | 9.14 | 9.61 | 9.29 | 9.77 |
| Carbhydrates | 59.89 | 59.00 | 59.98 | 67.52 | 66.54 | 65.16 | 67.33 | 66.23 |
| Fat | 6.02 | 6.25 | 6.94 | 3.90 | 3.57 | 4.36 | 3.26 | 3.67 |
| Nutritive ratio | 1:6.1 | 1:5.8 | 1:6.3 | 1:9.1 | 1:8.2 | 1:7.9 | 1:8.1 | 1:7.7 |
| Calculated value | $1.33 | 1.36 | 1.36 | 1.14 | 1.15 | 1.19 | 1.15 | 1.17 |

The coëfficients of digestibility used in calculating the digestible nutrients of Indian Corn are those adopted in the Report for 1877, viz: for albuminoids, 84 per cent.; for carbhydrates, 94 per cent.; for fiber, 37 per cent.; and for fat, 76 per cent.

It is noticeable how much more concentrated and valuable the sweet corn is than the other kinds. Its nutritive ratio is that of good clover hay and oats, while the other varieties of corn have a less favorable nutritive ratio, which in Ohio Dent is that of rather inferior hay. The money-value of the sweet corn is some 18 cents per 100 pounds more than that of the other kinds, owing to its more abundant albuminoids and fat. This greater value of sweet corn holds good generally, so far as the few analyses show, but Stowell's Evergreen in 1869 was not so rich or valuable as this sweet corn of Mr. Gold's. Its value calculated on the same data amounts to $1.22 per 100 pounds.

The samples of Canada Yellow, Early Dutton and King Phillip, analyzed by Dr. Atwater in 1869, agree essentially as to nutritive ratio and money value with the samples of other than sweet corn here reported.

Prof. Kedzie of the Agricultural College of Michigan, has recently printed detailed analyses of thirteen samples and ten varieties of Indian Corn raised in Michigan in 1877. These analyses recalculated upon water-free substance and with starch, sugar and gum, grouped together as carbhydrates, are given upon the adjoining page, where are also to be found their digestible nutrients, and nutritive ratios. These samples of Michigan Maize show wider differences of composition than our Eastern corn, if we exclude from the comparison the Sweet Corn of Mr. Gold. The albuminoids in 8-rowed Flint are 2.57 per cent. more than in Hackberry Dent. The averages of albuminoids in the Michigan Corn (12.76 per cent.) and of fat (5.68 per cent.) are slightly greater than those of the Eastern Corn (not sweet) here reported (12.37 per cent. albuminoids and 5.55 per cent. fat). The same variety is shown to differ not inconsiderably when raised in different localities; the Pony Dent No. 7 contains 0.73 per cent. more albuminoids than the same kind of corn No. 8. Tuscarora of Michigan contains 0.25 per cent. less albuminoids than the same variety raised in Connecticut. It is seen in all the cases where two samples of the same kind raised in different places have been analyzed, that the sample which contains most albuminoids has the least fat, and the reverse.

In New England we commonly understand "Western Corn" to be some variety of Dent. The analyses before us show that Dent corn is neither better nor worse than the Flint varieties. The Flint Corn includes both the lowest and the highest percentages of albuminoids, as well as the lowest and nearly the highest percentages of fat. On the other hand the Dent Corn includes a range of these ingredients nearly as great.

It must be concluded then from this comparison of 13 samples of corn grown in Michigan, with 9 samples grown in Connecticut and North Carolina (including 4 reported on last year), that the average of Eastern and Western maize is essentially the same, and that neither Dent nor Flint varieties are uniformly the richer in albuminoids or in oil.

## Analyses of Michigan Corn, Crop of 1877.

*Communicated by Prof. R. C. Kedzie, Michigan Agricultural College.*

| | Yellow Dent. | | White Dent. | Hackberry Dent. | Strawberry Roan. | White-oil Corn. | Pony Dent. | | Tuscarora. | Smut-Nose. | | Eight-rowed Flint. | Sanford. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water-free substance | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | |
| Ash ........ | 1.62 | 1.71 | 1.85 | 1.68 | 1.62 | 1.44 | 1.62 | 1.51 | 1.77 | 1.76 | 1.72 | 1.65 | 1.58 | 1.66 |
| Albuminoids ........ | 13.47 | 12.99 | 13.35 | 11.29 | 12.00 | 11.83 | 12.99 | 12.26 | 12.64 | 13.55 | 13.27 | 13.86 | 12.34 | 12.76 |
| Fiber ........ | 2.85 | 2.81 | 2.62 | 2.74 | 2.36 | 2.14 | 2.49 | 2.55 | 2.09 | 2.29 | 2.87 | 2.61 | 2.42 | 2.53 |
| Other carbhydrates ... | 76.75 | 76.75 | 76.81 | 78.84 | 78.68 | 79.10 | 77.32 | 77.88 | 76.78 | 76.63 | 76.21 | 76.30 | 77.82 | 77.37 |
| Fat ........ | 5.31 | 5.74 | 5.37 | 5.45 | 5.34 | 5.49 | 5.58 | 5.80 | 6.72 | 5.67 | 5.93 | 5.58 | 5.84 | 5.68 |
| Digestible albuminoids | 11.31 | 10.91 | 11.21 | 9.48 | 10.08 | 9.94 | 10.91 | 10.30 | 10.61 | 11.38 | 11.15 | 11.64 | 10.37 | 10.72 |
| " carbhydrates | 73.20 | 73.18 | 73.17 | 75.12 | 74.83 | 75.15 | 73.60 | 74.15 | 72.95 | 72.88 | 72.70 | 72.69 | 74.05 | 73.66 |
| " fat ........ | 4.04 | 4.36 | 4.08 | 4.14 | 4.06 | 4.17 | 4.24 | 4.41 | 4.99 | 43.1 | 4.51 | 4.24 | 4.44 | 4.32 |
| Nutritive ratio ........ | 1 : 7.3 | 1 : 7.7 | 1 : 7.4 | 1 : 9.0 | 1 : 8.4 | 1 : 8.5 | 1 : 7.7 | 1 : 8.2 | 1 : 8.0 | 1 : 7.3 | 1 : 7.5 | 1 : 7.1 | 1 : 8.1 | 1 : 7.8 |

These conclusions apply naturally to well-cured maize. Whether Western Corn in bulk as it comes into the markets is equal to Eastern Corn is a question yet open and one to which the Station will give attention next, with a view to learn what causes the decided inferiority of our commercial corn meal as compared with New England Corn.

### Maize Cob.

The question of the feeding-value of corn cobs has long been under discussion, but practical farmers are by no means unanimous in their sentiments or their practice in reference to this subject. The objections to using cob-meal founded on the mechanical irritation which it is liable to excite do not come within the province of the Station to discuss here. Whether or no the cob is mere ballast in the fodder, whether it is mere cellulose or fiber as it appears, or whether it contains a considerable proportion of nutrient matters, are the points toward which our investigations have been directed. For this purpose, nine analyses of cobs have been made, mostly those which bore the corn (grain) already reported upon.

The Station numbers and sources of these samples of maize cob are as follows:

XVI, Immature Sweet Corn from T. S. Gold, West Cornwall. Belonged to XIV. Harvested Aug. 9, 1877.

XIX, Immature Sweet Corn from T. S. Gold. Belonged to XVII. Harvested Aug. 25, 1877.

XXII, Sweet Corn from T. S. Gold. Belonged to XX. Harvested Sept. 25, 1877.

XXV, Ohio Dent. Crop of 1877. Sent by J. J. Webb, Hamden. Belonged to XXIII.

XXVII, Norfolk White Corn from Capt. W. E. Pierce, Raleigh, N. C. Belonged to XXVI.

XXIX, Tuscarora. Crop of 1877 from J. B. Olcott, South Manchester. Belonged to XXVIII.

XXXI, Vermont White Cap. Crop of 1877 from A. L. Avery, Groton. Belonged to XXX.

XXXIII, Rowley. Crop of 1877 from J. N. Hollister, South Glastonbury. Belonged to XXXII.

XXXVII, Canada Yellow. This cob was from the sample of Canada Corn analyzed in the writer's laboratory by Dr. Atwater in 1869. It was furnished by Mr. Sec'y Gold, and was, I believe, raised in Litchfield.

*Analyses of Maize Cob.*

Air-dry.

| | Sweet Corn. | | | Ohio Dent. | Norfolk White. | Tuscarora. | Vt. White. | Rowley. | Canada Yellow. |
|---|---|---|---|---|---|---|---|---|---|
| | XVI. | XIX. | XXII. | XXV. | XXVII. | XXIX. | XXXI. | XXXIII. | XXXVII. |
| Water. | 10.10 | 9.02 | 8.82 | 8.21 | 7.18 | 8.37 | 8.40 | 8.05 | 7.52 |
| Ash, | 6.70 | 2.60 | 1.47 | .97 | 1.33 | 1.57 | .96 | .98 | 2.14 |
| Albuminoids, | 8.56 | 3.00 | 2.69 | 2.56 | 1.81 | 2.56 | 2.63 | 1.81 | 2.35 |
| Fiber, | 21.40 | 29.63 | 30.57 | 30.99 | 29 80 | 30.01 | 30.47 | 32.39 | 29 76 |
| Carbhydrates, | 51.14 | 54.91 | 55.53 | 56.99 | 59.57 | 57.15 | 57.21 | 56.54 | 57.72 |
| Fat, | 2.10 | 0.84 | .92 | .28 | .31 | .34 | .33 | .23 | .51 |

Water-free.

| | XVI. | XIX. | XXII. | XXV. | XXVII. | XXIX. | XXXI. | XXXIII. | XXXVII. |
|---|---|---|---|---|---|---|---|---|---|
| Ash, | 7.45 | 2.86 | 1.61 | 1.06 | 1.43 | 1.71 | 1.05 | 1.07 | 2.31 |
| Albuminoids, | 9.52 | 3.30 | 2.95 | 2 79 | 1.94 | 2.79 | 2.87 | 1.97 | 2.54 |
| Fiber, | 23.80 | 32.56 | 33.54 | 33.75 | 32.10 | 32.75 | 33.27 | 35.21 | 32.17 |
| Carbhydrates, | 56.89 | 60.36 | 60.89 | 62.10 | 64.20 | 62.38 | 62.45 | 61.50 | 62.43 |
| Fat, | 2.34 | .92 | 1.01 | .30 | .33 | .37 | .36 | .25 | .55 |

In 1859 Stoeckhardt published two analyses of maize cob meal from Gratz, in Styria; the analyses differed but slightly and I give here their average:

| | | |
|---|---|---|
| Water, | | 9.0 |
| Ash, | | 3.0 |
| Albuminoids, | | 1.5 |
| Fiber, | | 40.5 |
| Starch, | Carbhydrates, etc., =45.6 | 6.5 |
| Sugar, | | 3.0 |
| Gum, | | 14.5 |
| Substances soluble in weak alkali, | | 21.6 |
| Fat, | | 0.4 |

We have found no starch whatever in the cob (the most immature sample, XVI, was, however, consumed in the quantitative analysis without being tested for starch). Cold water extracted from XXXVII, 1.6 per cent. organic matters, which gave faint indications of sugar, and hot water took up 2.4 per cent. additional.

The sample XXVII was repeatedly extracted with boiling water, the action being continued for several hours. The first extraction dissolved 5.4 per cent., the second 2.7, and the third 3.4, making a total of 11.5 per cent. The nature of the dissolved matters is yet to be investigated. Boiling the cob with dilute acids gives a solution which acts toward the usual test (Fehling's copper solution) like grape sugar. Further studies as to the qualitative composition of the cob are in progress.

From his analyses, Stoeckhardt ventured the opinion that the air-dry cob meal would prove as nutritious as an equal weight of fresh potatoes. Wolff, basing his conclusions also on the same analyses, gives maize cob a probable money value greater than potatoes.

In the absence of any feeding trials upon the digestibility of corn cobs, it would be premature to offer any statement of its digestible nutrients. Our analyses agree in a content of 30 per cent. of fiber against 40 given by Stoeckhardt, in 1.8 to 3 per cent. of albuminoids against his 1.5 per cent. and show 55 to 59 per cent. of carbhydrates against his 46 per cent. in air-dry substance.

It is highly probable that a considerable share of cob meal would undergo digestion in the intestinal apparatus of our ruminating animals, but it is evident the kind of nutriment to be derived from it is mostly of the carbhydrate kind, and it is probable that the nutritive ratio would show it to be one of the least concentrated kinds of dry feed that the farmer can use, less concentrated than straw or chaff of the poorest sort, and yet it may be serviceable as these are when appropriately combined in the ration with concentrated foods.

We notice that the analyses show for the less mature cob XVI, a content of 8.56 per cent. albuminoids, and of 2.1 per cent. fat, 3 to 4 times greater than occurs in the fully ripe cobs. This would naturally be expected since the elements of the kernel which are produced in the leaves of the plant must pass the cob on their way to the seed. The cob, in fact, nourishes the grain until the latter is ripe, and in its young condition is charged with the soluble matters which go to the development of the kernel. Such young cobs are equal or superior to the poorer grades of hay or to pea-straw, so far as the analysis alone can decide.

## PROPORTIONS OF CORN AND COB.

The proportion of grain and cob in different varieties of Indian Corn is a matter of some importance. The subjoined table gives the results of some weighings. The first five are of samples whose analyses have been already given; the last seven refer to varieties of maize raised in this State, which are in process of examination. The weighings were made in all cases on two ears, and although this number is too small and the ears were in most cases too large and fair to represent the ordinary crops, they are yet of value in showing how unlike may be the actual yield of shelled corn from an equal weight of ears. It is seen that the Vermont White Cap, a rather small but perfectly covered ear, has the smallest proportion of cob to corn (1 : 8.4), while Tuscarora, Norfolk White, Ohio White and Mammoth Sweet, contain more than twice as much cob to the same amount of corn. The average is nearly 1 : 5, the proportion which is given by some writers as that found in weighings on the large scale.

It would be very instructive to obtain accurate weighings of corn and cob on several samples of 100 pounds or more for each of our largely cultivated varieties. Such statistics, together with accurate weighings of the yield per acre, and determinations of the shrinkage by curing (from loss of water) are essential to learning what we do not now know—the comparative productiveness of the kinds of Indian Corn which we cultivate.

*Weights of Corn and Cob, cured.*

| | Tuscarora. | Vermont White Cap. | Rowley. | Norfolk White. | Canada Yellow. | Ohio White. | Wisconsin. |
|---|---|---|---|---|---|---|---|
| Corn (weight in grams) ---- | 407 | 330 | 469 | 423 | 265.6 | 467 | 574 |
| Cob " " | 116 | 39 | 88 | 113 | 50.9 | 111 | 103 |
| Relation of cob to corn ---- | 1 : 3 5 | 1 : 8.4 | 1 : 5.3 | 1 : 3.7 | 1 : 5.2 | 1 : 4.2 | 1 : 5.6 |
| Cob expressed in per cent. of corn ---------------- | 28½ | 12 | 19 | 27 | 19 | 24 | 18 |

| | Coe's Prolific. | Old Fashioned Yellow. | Benton. | Mammoth Sweet. | Scioto. | Average. |
|---|---|---|---|---|---|---|
| Corn (weight in grams) - | 451 | 467 | 509 | 424 | 518 | ---- |
| Cob " " | 98 | 94 | 84 | 116 | 78 | ---- |
| Relation of cob to corn - | 1 : 4.6 | 1 : 4.9 | 1 : 6.0 | 1 : 3.6 | 1 : 6.6 | 1 : 5.1 |
| Cob expressed in per cent. of corn ------------- | 22 | 20 | 16½ | 27 | 15 | 19½ |

### RYE BRAN.

XXXVI, Bought of D. B. Crittenden, New Haven, Feb. 11th, 1878, contains:

| | Air-dry. | Dry. | Digestible nutrients in air-dry bran. |
|---|---|---|---|
| Water ---------------- | 10.30 | ---- | ---- |
| Ash ------------------ | 3.54 | 3.95 | ---- |
| Albuminoids ---------- | 16.81 | 18.74 | 13.12 |
| Fiber ---------------- | 4.07 | 4.54 | 48.82 |
| Carbhydrates ------- - | 62.68 | 69.87 | |
| Fat ------------------ | 2.60 | 2.90 | 1.82 |

The nutritive ratio is 1 : 4.1 ; the calculated value is $1.09.

This rye bran is slightly better than the wheat brans analyzed last year, which ranged in value from $0.96 to $1.04. It is even superior to the middlings reported in 1877, whose value was calculated at $1.07, being some 2.6 per cent. richer in albuminoids.

### STEAM-COOKED GRAIN FOR HORSES.

XLVII, Sold by N. W. Merwin & Co., New Haven. Manufactured by Henry French & Son, Hartford, under license of the "National Steamed Grain Company."

This article is stated to be "composed only of corn, oats and barley," which "after being judiciously mixed, are by an improved process steam-cooked, dried and ground." When a portion of this material is carefully inspected, it becomes evident that the chief ingredient is Indian corn. A few oats are also to be seen, but no barley was recognized in the sample. Under the microscope a little oat starch is discovered, but the characteristics of maize meal are predominant.

The chemical analysis agrees closely with that of the less nitrogenous varieties of maize, as seen from the subjoined statement.

| | | Water-free. | | |
|---|---|---|---|---|
| | XLVII. | XLVII. | Early Dutton. | Common Yellow. |
| Water---------- | 15.97 | ---- | ---- | ---- |
| Ash ---------- | 1.70 | 2.02 | 1.66 | 1.46 |
| Albuminoids ---- | 8.74 | 10.40 | 10.46 | 10.86 |
| Fiber ---------- | 2.66 | 3.17 | 2.74 | 2.68 |
| Carbhydrates --- | 66.59 | 79.24 | 78.98 | 80.06 |
| Fat ---------- | 4.34 | 5.16 | 6.16 | 4.94 |
| | 100.00 | 100.00 | 100.00 | 100.00 |

The nutritive ratio is 1 : 9.7, and the calculated value $1.03 per 100 pounds. The selling price is $1.15 per 80 pounds, or $1.44 per 100 pounds. In another sample more recently brought to the Station, there appears to be greater abundance of oats, but no barley is distinguishable.

It is claimed for this material that it is "by an improved process steam-cooked, dried and ground, which destroys the germ or fermenting qualities, from which so much danger arises with raw or uncooked grain." It is quite certain that no steam cooking short of prolonged boiling or roasting could destroy those germs which give fermenting qualities to grain. The "Cooked Food" is not cooked to this extent or in this sense, for the starch grains are quite unaltered in appearance and structure, and the germs of ferment are not destroyed, as is shown by the microscope. This instrument reveals the cause of a slight caking together of a sample of the cooked food, which has been standing in a sealed bottle for a few weeks. This is due to the growth of a fungus or mould, whose delicate filaments are rapidly developing in the meal, which, with 16 per cent. of water, is moist enough to make an excellent soil for fungi when it is brought into a warm apartment. The statements that "the above process adds over 25 per cent. more nutriment, and makes the same over 30 per cent. easier of digestion," are too exaggerated and absurd to require any notice here, further than that they excite distrust as to the correctness of the other claims made for the "Steam-cooked Food."

## Glen Cove Corn Feed.

This substance, XLVI, sold by S. D. Bradley, 2, 4, 6 Grand St., New Haven, is a waste product of the starch manufacture from maize at Glen Cove, Long Island. It is a moist, slumpy mass, with a sourish smell, and is sold at 20 cents per bushel. The bushel is said to weigh on the average 56 pounds, and to range from 55 to 60 pounds.

The composition in the fresh state, air-dry as prepared for analysis, and water-free, is as follows:

Composition of Glen Cove Corn Feed.

| | Fresh. | Air-dry. | Water-free. |
|---|---|---|---|
| Water | 62.27 | 14.78 | ---- |
| Ash | .27 | .60 | .70 |
| Albuminoids | 5.67 | 12.81 | 15.03 |
| Fiber | 1.58 | 3.57 | 4.19 |
| Carbhydrates | 28.90 | 65.29 | 76.62 |
| Fat | 1.31 | 2.95 | 3.46 |
| | 100.00 | 100.00 | 100.00 |

Digestible Nutrients of Glen Cove Corn Feed.

| | Fresh. | Air-dry. | Water-free. |
|---|---|---|---|
| Albuminoids | 4.76 | 10.76 | 12.63 |
| Carbhydrates | 27.75 | 62.69 | 73.57 |
| Fat | 1.00 | 2.24 | 2.63 |

This maize slump (air-dry) is 2 per cent. richer in albuminoids than average American maize and correspondingly poorer in fat, but otherwise closely resembles good maize meal. Its nutritive ratio, 1 : 6.3, is better than that of the best maize meal and equal to that of oats. Its calculated value is 29 cents per bushel of 56 pounds or 52 cents per 100 pounds, in the fresh state. Although inconvenient to handle and liable to putrefactive decay in warm weather, it must be regarded as an excellent and cheap cattle food.

## Animal Meal for Fowls and Swine.

Manufactured by W. H. Bowker & Co., Boston, Mass.
XI. Sold by Leavenworth and Dickerman, Waterbury.
XII. Sent by Gong Bell Manufacturing Co., East Hampton.

| | XI. | XII. |
|---|---|---|
| Moisture | 8.74 | ---- |
| Organic matters | 75.83 | ---- |
| Ash | 15.23 | ---- |
| | 100.00 | |
| Nitrogen | 5.13 | 5.20 |
| Albuminoids | 32.06 | 32.50 |
| Phosphoric acid | 2.92 | 6.38 |

This Animal Meal has the aspect of meat-scraps with some bone, that has been subjected to high pressure steam and dried with admixture of damaged and in part unground maize.

This article is sold at $3.00 per 100 pounds. Ordinary dried and ground meat scraps and steamed fish scraps containing 35 to 60 per cent. of albuminoids and suitable for feeding purposes may be had for $1.50 to $2.00 per 100 pounds. Corn meal of good quality costs $1.00 per 100 lbs. Cotton Seed Meal, containing 40 per cent. of albuminoids, and in no respect inferior in nutritious quality to this animal meal, may be bought for $1.50 per 100 pounds. It thus appears that the "Animal Meal" costs too much to be profitable feed except, perhaps, where small quantities only are required, or where convenience rather than cost is regarded.

## IMPERIAL EGG FOOD FOR POULTRY.

X. This article, of which Allen & Sherwood, 29 Pearl Street, Hartford, are proprietors, is stated to have been patented Feb. 24th, 1875, and is sold in packages of about 1 pound weight, for $0.50 per package. Its chemical composition is as follows:

| | X. |
|---|---|
| Moisture | 1.53 |
| Organic matters, by difference | 10.80 |
| Sand and matters insoluble in acids | 4.35 |
| Oxide of iron | 1.96 |
| Lime | 43.17 |
| Magnesia | .43 |
| Phosphoric acid | 3.42 |
| Sulphuric acid | 2.18 |
| Carbonic acid | 32.16 |
| | 100.00 |

The above analysis, together with a careful microscopic examination, shows that the Egg Food consists essentially of—

| | | | |
|---|---|---|---|
| Ground (oyster?) shells, | about 70 % | Oxide of iron | about 2 % |
| Ground bone | " 15 " | Sand | " 4 " |
| Ground gypsum | " 5 " | Cayenne pepper | " 4 " |

The oxide of iron is apparently the same as the so-called "carbonate of iron" of the apothecary, and is, perhaps, intended to act as a "tonic." It is evident that the use of any and all the ingredients of this Egg Food is no new discovery and cannot be patented. It is only the "combination" and trade name that are protected by the patent.

## YAM.

XXXV. Raised by Mr. Jesse Cooper, Hamden, and received from him October 8th, 1877. The single tuber weighed fresh 2708 grams or about 9½ ounces. Its composition is as follows: For comparison I give also the composition of the Improved Nansemond Sweet Potato (from Hanover Co., Va., analyzed by Mr. Jenkins and myself in 1875; *American Journal of Science and Arts*, 3d Series, vol. xiii, p. 200), and the average composition of the common potato.

| | Yam. | Sweet Potato. | Potato. |
|---|---|---|---|
| Water | 71.23 | 73.39 | 75.0 |
| Ash | .67 | 1.07 | .9 |
| Albuminoids | 2.06 | 1.28 | 2.1 |
| Fiber | .75 | .98 | 1.1 |
| Carbhydrates | 25.14 | 23.60 | 20.7 |
| Fat | .25 | .28 | .2 |

The above comparison shows the Yam to furnish a greater percentage of nutriment than either the sweet or common potato.

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## RATIONS FOR FARM ANIMALS.

The matter of the following four pages is here reprinted from my Report for 1877, because the Board of Control of the Station desires to induce our farmers to experiment on the newer modes of cattle feeding, and because the Report for 1877, having been limited by law to an edition of 1000 copies, is no longer to be obtained.

### *Feeding Standards.*

A.—PER DAY AND PER 1,000 LBS. LIVE WEIGHT.

| | Total organic substance. | Nutritive (digestible) substances. | | | Total nutritive substance. | Nutritive ratio. |
|---|---|---|---|---|---|---|
| | | Albuminoids. | Carbhydrates. | Fat. | | |
| | lbs. | lbs. | lbs. | lbs. | lbs. | |
| 1. Oxen at rest in a stall, | 17.5 | 0.7 | 8.0 | 0.15 | 8.85 | 1 : 1.2 |
| 2. Wool sheep, coarser breeds, | 20.0 | 1.2 | 10.3 | 0.20 | 11.70 | 1 : 9. |
| " " finer breeds, | 22.5 | 1.5 | 11.4 | 0.25 | 13·15 | 1 : 8. |
| 3. Oxen moderately worked, | 24.0 | 1.6 | 11.3 | 0.30 | 13.20 | 1 : 7.5 |
| " heavily worked, | 26.0 | 2.4 | 13.2 | 0.50 | 16.10 | 1 : 6. |
| 4. Horses moderately worked, | 22.5 | 1.8 | 11.2 | 0.60 | 13.60 | 1 : 7. |
| " heavily worked, | 25.5 | 2.8 | 13.4 | 0.80 | 17.00 | 1 : 5.5 |
| 5. Milk cows, | 24.0 | 2.5 | 12.5 | 0.40 | 15.40 | 1 : 5.4 |
| 6. Fattening oxen, 1st period, | 27.0 | 2.5 | 15.0 | 0.50 | 18.00 | 1 : 6.5 |
| " " 2d " | 26.0 | 3.0 | 14.8 | 0.70 | 18.50 | 1 : 5.5 |
| " " 3d " | 25.0 | 2.7 | 14.8 | 0.60 | 18.10 | 1 : 6.0 |
| 7. Fattening sheep, 1st period, | 26.0 | 3.0 | 15.2 | 0.50 | 18.70 | 1 : 5.5 |
| " " 2d " | 25.0 | 3.5 | 14.4 | 0.60 | 18.50 | 1 : 4.5 |
| 8. Fattening swine, 1st period, | 36.0 | 5.0 | 27.2 | | 32.50 | 1 : 5.5 |
| " " 2d " | 31.0 | 4.0 | 24.0 | | 28.00 | 1 : 6.0 |
| " " 3d " | 23.5 | 2.7 | 17.5 | | 20.20 | 1 : 6.5 |
| 9. Growing cattle: | | | | | | |
| Age, months, Average live weight per head. | | | | | | |
| 2—3 150 lbs.* | 22.0 | 4.0 | 13.8 | 2.0 | 19.8 | 1 : 4.7 |
| 3—6 300 " | 23.4 | 3.2 | 13.5 | 1.0 | 17.7 | 1 : 5.0 |
| 6—12 500 " | 24.0 | 2.5 | 13.5 | 0.6 | 16.6 | 1 : 6.0 |
| 12—18 700 " | 24.0 | 2.0 | 13.0 | 0.4 | 15.4 | 1 : 7.0 |
| 18—24 850 " | 24.0 | 1.6 | 12.0 | 0.3 | 13.9 | 1 : 8.0 |
| 10. Growing sheep: | | | | | | |
| 5—6 56 lbs. | 28.0 | 3.2 | 15.6 | 0.8 | 19.6 | 1 : 5.5 |
| 6—8 67 " | 25.0 | 2.7 | 13.3 | 0.6 | 16.6 | 1 : 5.5 |
| 8—11 75 " | 23.0 | 2.1 | 11.4 | 0.5 | 14.0 | 1 : 6.0 |
| 11—15 82 " | 22.5 | 1.7 | 10.9 | 0.4 | 13.0 | 1 : 7.0 |
| 15—20 85 " | 22.0 | 1.4 | 10.4 | 0.3 | 12.1 | 1 : 8.0 |
| 11. Growing fat pigs: | | | | | | |
| 2—3 50 lbs. | 42.0 | 7.5 | 30.0 | | 37.5 | 1 : 4.0 |
| 3—5 100 " | 34.0 | 5.0 | 25.0 | | 30.0 | 1 : 5.0 |
| 5—6 125 " | 31.5 | 4.3 | 23.7 | | 28.0 | 1 : 5.5 |
| 6—8 170 " | 27.0 | 3.4 | 20.4 | | 23.8 | 1 : 6.0 |
| 8—12 250 " | 21.0 | 2.5 | 16.2 | | 18.7 | 1 : 6.5 |

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[*] The German pound is equal to $1.\frac{1}{10}$ lb. avoirdupois. The above weights are therefore to be increased $\frac{1}{10}$ to represent our weights. For practical purposes, however, this reduction will be in most cases unnecessary as the weights are but relative and approximate.

(*Feeding Standards, continued from page* 79.)

B.—Per Day and per Head.

| Growing cattle: Age, Months. | Average live weight per head. | Total organic substance. | Nutritive (digestible) substances. Albuminoids. | Carbhydrates. | Fat. | Total nutritive substance. | Nutritive ratio. |
|---|---|---|---|---|---|---|---|
| | | lbs. | lbs. | lbs. | lbs. | lbs. | |
| 2—3 | 150 lbs. | 3.3 | 0.6 | 2.1 | 0.30 | 3.00 | 1 : 4.7 |
| 3—6 | 300 " | 7.0 | 1.0 | 4.1 | 0.30 | 5.40 | 1 : 5.0 |
| 6—12 | 500 " | 12.0 | 1.3 | 6.8 | 0.30 | 8.40 | 1 : 6.0 |
| 12—18 | 700 " | 16.8 | 1.4 | 9.1 | 0.28 | 10.78 | 1 : 7.0 |
| 18—24 | 850 " | 20.4 | 1.4 | 10.3 | 0.26 | 11.96 | 1 : 8.0 |
| Growing sheep: | | | | | | | |
| 5—6 | 56 lbs. | 1.6 | 0.18 | 0.87 | 0.045 | 1.095 | 1 : 5.5 |
| 6—8 | 67 " | 1.7 | 0.17 | 0.85 | 0.040 | 1.060 | 1 : 5.5 |
| 8—11 | 75 " | 1.7 | 0.16 | 0.85 | 0.037 | 1.047 | 1 : 6.0 |
| 11—15 | 82 " | 1.8 | 0.14 | 0.89 | 0.032 | 1.062 | 1 : 7.0 |
| 15—20 | 85 " | 1.9 | 0.12 | 0.88 | 0.025 | 1.047 | 1 : 8.0 |
| Growing fat swine: | | | | | | | |
| 2—3 | 50 lbs. | 2.1 | 0.38 | 1.50 | | 1.88 | 1 : 4.0 |
| 3—5 | 100 " | 3.4 | 0.50 | 2.50 | | 3.00 | 1 : 5.0 |
| 5—6 | 125 " | 3.9 | 0.54 | 2.96 | | 3.50 | 1 : 5.5 |
| 6—8 | 170 " | 4.6 | 0.58 | 3.47 | | 4.05 | 1 : 6.0 |
| 8—12 | 250 " | 5.2 | 0.62 | 4.05 | | 4.67 | 1 : 6.5 |

In the foregoing tables of Feeding Standards from Dr. Wolff are stated the quantities and proportions of the digestible food elements which, according to the extensive experience of the German Experiment Stations, are to be given in the daily rations of farm animals in order to secure the best results of feeding. By "total organic substance" is meant the organic matter of feed considered free from water and ash. The difference between total organic substance and "total nutritive substance" expresses the quantity of indigestible or undigested matters of the ration. We are told that animals will indeed often do well with a ration less rich in albuminoids, the total amount of nutritive matters being kept up to the figures given below; but when by the use of the more highly nitrogenous feeding stuffs, such as brewer's grains, beans, peas, cotton seed cake, and meat or fish scrap, the nutritive ratio can be brought up to the subjoined standards, the results will be the most satisfactory.

The practical significance of these Feeding Standards is explained by the following paragraphs, which I have freely translated, from Dr. Wolff.

A milk cow is kept in good condition and with a full flow of milk on rich pasturage, or young clover, of which 30 lbs. are on an

average daily consumed per 1,000 lbs. of live weight of improved breeds. 30 lbs. of young clover or best clover hay contain:

| | Digestible. | | |
|---|---|---|---|
| Organic substance. | Albuminoids. | Carbhydrates. | Fat. |
| 23 lbs. | 3.21 | 11.28 | 0.63 |

Experiment in the stall shows that the same result can be had with the best meadow hay, obtained from rich ground and cut young, in which 30 lbs. contain

| | | Digestible. | | |
|---|---|---|---|---|
| | Organic substance. | Albuminoids. | Carbhydrates. | Fat. |
| | 23.2 | 2.49 | 12.75 | 0.42 |
| Feeding standard, | 24 | 2.5 | 12.5 | 0.4 |

or almost exactly the quantities of the feeding standard, and 0.7 lb. less of albuminoids than in the clover.

In the winter keep of cows the hay at disposal is usually of only average or even of inferior quality and not capable alone of suitably nourishing milk cows. It is therefore necessary to add something to it in order to get a proper feed. Where hay commands a high cash price, it is often cheaper to use straw, chaff or maize fodder in combination with richer maize meal, bran, brewer's grains, cotton seed meal, etc., than to feed hay alone. By help of the tables we can calculate the kind and quantities of these various feeding stuffs which may compose a ration that shall take the place of clover hay and correspond to the feeding standard. Suppose there is on hand and at the daily disposal of the cows, for each 1,000 lbs. of live weight, 12 lbs. of meadow hay of average quality, 6 lbs. of oat straw and 20 lbs. mangolds, while 25 lbs. brewer's grains daily can be cheaply got. By use of the tables it is easy to calculate that all these materials together will give a ration coming short of the standard by half a pound of albuminoids, while by adding to it 2 lbs. of cotton seed meal, the requirements of the ration are fully met, as shown by the following figures.

*Ration for Milk Cows.*

| | Dry organic matter. | Digestible. Albuminoids. | Carbhydrates. | Fat. |
|---|---|---|---|---|
| 12 lbs. average meadow hay | 9.5 | 0.65 | 4.92 | 0.12 |
| 6 lbs. oat straw | 4.9 | 0.08 | 2.40 | 0.04 |
| 20 lbs. mangolds | 2.2 | 0.22 | 2.00 | 0.02 |
| 25 lbs. brewer's grains | 5.6 | 0.98 | 2.70 | 0.20 |
| 2 lbs. cotton seed meal | 1.6 | 0.62 | 0.36 | 0.24 |
| | 23.8 | 2.55 | 12.38 | 0.62 |
| Standard | 24 | 2.5 | 12.5 | 0.4 |

I have calculated the following rations as examples of such combinations as may be made from materials in our markets. In the first ration, bulky corn fodder such as raised by Mr. Webb in 1874 (page 64) is a large ingredient. In the others, ordinary corn stalks or "stover" enters or may enter interchangeably with rye straw, since according to Wolff their nutritive value is the same, pound for pound. The use of these rations must of course finally depend upon whether the animals can be got to relish and digest them, as well as upon their cost. I have not made any computations as to the latter point, but it is easy to do so with a knowledge of the cost of the several materials used. Actual experience alone can determine whether cattle will eat these mixtures.

*Rations for Milk Cows.*

| | Dry organic substance. | Digestible. | | |
|---|---|---|---|---|
| | | Albuminoids. | Carbhydrates. | Fat. |
| 20 lbs. cured corn fodder--- | 13.7 | 0.64 | 8.68 | 0.20 |
| 5 lbs. rye straw, or stover- | 4.1 | 0.04 | 1.82 | 0.02 |
| 6 lbs. malt sprouts ------- | 5.0 | 1.16 | 2.70 | 0.10 |
| 2 lbs. cotton seed meal --- | 1.6 | 0.62 | 0.36 | 0.24 |
| | 24.4 | 2.46 | 13.56 | 0.56 |
| Standard --------------- | 24 | 2.5 | 12.5 | 0.4 |

Or again,

| | Dry organic substance. | Digestible. | | |
|---|---|---|---|---|
| | | Albuminoids. | Carbhydrates. | Fat. |
| 15 lbs. stover ------------ | 12.1 | 0.16 | 5.55 | 0.04 |
| 5 lbs. bran ------------- | 4.1 | 0.59 | 2.21 | 0.15 |
| 5 lbs. malt sprouts ------- | 4.1 | 0.97 | 2.25 | 0.08 |
| 3 lbs. maize meal -------- | 2.5 | 0.22 | 2.05 | 0.07 |
| 2 lbs. cotton seed meal ---- | 1.6 | 0.62 | 0.36 | 0.24 |
| | 24.4 | 2.56 | 12.42 | 0.58 |

In giving the foregoing tables the writer does not ignore the fact that other systems of feeding are followed, and that many good farmers are content with a practice which apparently cannot be reconciled with these standards. The German experimenters do not themselves imagine that they have by any means overcome the difficulties of the subject. Their results are simply the best they can offer after twenty-five years of arduous labor, after making thousands of analyses and hundreds of laborious feeding trials. They believe that they are using the right methods, but admit that many further experiments must be undertaken before the investigation can be closed. In fact they are experimenting to-day more industriously than ever, with the object to test and sift the theories which their past experience has led them to adopt, and to gain a nearer approach to the true science and best practice of cattle feeding. It is to be anticipated that their views will materially change as further knowledge is gained.

## EXPERIMENTS ON THE RELATIONS OF SOILS TO WATER.*

### Capillary Transmission and Evaporation.

The studies of the capillary power of typical soils, which were mentioned in the last report (pp. 76–80), have been continued as far as the time available from other work has allowed. Although no little labor has been expended on this subject, yet the results so far attained cover but a small part of the whole field of investigation, and various discrepancies and apparent contradictions will be noticed which require further investigation for their explanation. Errors are unavoidably incident to the use of a new method of experiment, the capabilities of which can only be ascertained by repeated and varied trials.

The results already obtained upon some points seem to be tolerably certain; those on others, although they appear probable, need to be confirmed by additional investigations. The experiments here described include some noticed in the Station Report for 1877; the order is not that in which the experiments were made, but is followed for convenience in presentation.

*Materials.*—Two kinds of material have been used in these experiments, viz: a clay-loam from New York State and five sizes of common emery.

The clay-loam was taken in the air-dry state, and was divided

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* The general plan of this investigation, and of the apparatus thus far used in its prosecution, originated with the writer. The development of the research has been the joint work of Mr. Armsby and myself. Mr. Armsby has carried into execution all the experimental details, and at my request drew up an account of the experiments and discussions of the results, which after our joint revision is herewith printed in substantially the form prepared by him. Both as respects hand-work and head-work Mr. Armsby is now entitled to the larger share of any credit which this laborious study of a complicated question may be worthy of.

S. W. J.

by sifting through round holes into three grades of fineness, one consisting of lumps between $\frac{3}{16}$ and $\frac{1}{16}$ of an inch in diameter, another of smaller lumps from $\frac{1}{16}$ to $\frac{1}{50}$ inch diameter, and a third comprising all the finer parts from $\frac{1}{50}$ inch down to dust. This clay-loam in all these grades consists of highly and finely *porous* lumps or grains.

The material chiefly used thus far, however, has been commercial emery, in the belief that with it a nearer approach could be made to an exact knowledge and control of the conditions of experiment than with any other readily accessible substance. It is impossible in experiments made on so small a scale, as these of necessity have been, to obtain results which can be directly applied to the conditions of agricultural practice. What is needed first of all, in order to a thorough understanding of the behavior of water in the soil under the complex and ever varying conditions to which it is subject, is a better knowledge than we now have of the general laws, which, in their various combinations, produce the effects that we see.

To this end we need numerous and carefully conducted experiments, made under known and definite conditions and directed toward ascertaining the separate effect of each of the causes which, combined, determine the rate of evaporation, and it is upon such experiments that most of our labor has been spent.

In emery we have a material which, in its several grades, affords powders of different and tolerably uniform fineness, the size of whose particles can be measured under the microscope, and which serves to represent fairly a soil composed of *impermeable* mineral fragments, i. e., a sandy soil. Such an artificial soil, while it may poorly correspond to the conditions in nature, is evidently far better fitted for the elucidation of general laws than a natural soil of unknown and largely unascertainable composition and fineness.

At the same time emery is not satisfactory in all respects. The size and figure of its particles varies somewhat, and in the finest grade (flour of emery), which includes everything of a less diameter than about .007 inch, the variation is very considerable. The flour especially is difficult to pack uniformly, and all the grades were found to contain some soluble salts, which, although they were removed as completely as possible by washing the emery, slowly formed anew as the emery stood in contact with water.

Five grades of emery were used, viz., Nos. 46, 54, 80, 100 and flour. All were ignited before using and, after the first series of experiments was interrupted by the formation of a saline crust, were washed with water.*

The particles of the different sizes had approximately the following diameters:

| Number. | Range. | Average. |
|---|---|---|
| 46 | .0125—.0200 in. | .0175 in. |
| 54 | .0110—.0175 " | .0140 " |
| 80 | .0065—.0125 " | .0090 " |
| 100 | .0035—.0100 " | .0055 " |
| Flour. | Finest dust—.0065 " | .0030 " |

*Apparatus.*—The apparatus used in all the experiments was essentially the same. The material experimented upon was placed in a glass or copper tube two inches in diameter, whose lower end was closed, in case of glass by a cloth tied tightly over the end, in that of copper by a perforated copper bottom covered by thick filter paper. The tube when filled was placed in a glass vessel about six inches in diameter and of such height as to allow the top of the tube to project and its lower end was kept constantly supplied with water by means of an inverted bottle or similar vessel, while a tin cover, wrapped with rubber where it joined the tube and the outside vessel, prevented evaporation except from the surface of the soil.

*Method of experiment.*—After the material had become wet to the top the apparatus was weighed accurately, exposed to evaporation and weighed again, at first every day and later less frequently; the differences between successive weighings represented the amounts of water which had evaporated in the intervening time.

An advantage of this apparatus is that, by refilling the supply bottle occasionally, the experiment may be continued for any

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* The emery in all its grades is not chemically homogeneous, being a mixture of true emery with magnetic oxide of iron and various other minerals, some of which have a micaceous or laminated structure. In the flour especially these softer substances are present in large proportion, and give it a texture to a degree unlike that of the coarser grades. The emery obtained in commerce is more or less difficult to wet, as if enfilmed with grease. To remove this it was heated to full redness for some time. When washed with water after this ignition, the washings were reddened with finely divided peroxide of iron, which was usually most abundant in the finer grades. The saline incrustations consisted chiefly of aluminum sulphate.

desired length of time, while in evaporation-experiments as frequently made, by exposing the wet soil to evaporation, the earth is continually growing drier and thus a disturbing element is introduced.

*Conditions of evaporation.*—The rapidity of evaporation from the surface of a soil depends partly upon external and partly upon internal conditions. The former are temperature, exposure, &c., and do not require notice here. The internal conditions are essentially the two following:

1. The amount of moisture in the upper layer of soil.
2. The extent of evaporating surface.

The amount of moisture in the upper layer of soil depends on the rapidity with which water can rise from below to supply the loss by evaporation, it having been shown by Schulze (*Jahresber. ü. Agr. Chem.*, **3**, 31), W. Wolf (*Landw. Jahrb.*, **2**, 384), Wollny (*same*, **5**, 441) and Haberlandt (*Jahresber. ü. Agr. Chem.*, **9**, 49) that the drier a layer of soil the less the evaporation.

This rise of water from below to supply the loss by evaporation from the surface is due to capillary action, and hence we may properly designate the capillarity of the soil as one of the factors that determine evaporation.

By the capillarity of a soil we here understand the rapidity with which it permits water to rise in it to supply a deficiency at any point, and *not* merely the height to which water will fill its interstices, though there is doubtless a relation between the two.

Most experiments on the capillarity of the soil have been made by allowing water to rise into dry soils and noting the comparative rates of ascent; but in the first place the adhesion of air to the surface of the particles of a dry soil renders the value of such results doubtful, and in the second place a knowledge of the rapidity with which water will rise into the empty interstices of a dry soil is of little practical value since the conditions in nature are entirely different. There the tendency is simply to preserve the original distribution of water by a motion through the already filled or partly filled interstices toward the point from which water is being abstracted—generally the surface.

In order to get an idea of the capillarity of the soil under natural conditions we need to determine the amount of water evaporated. This will in most cases be a measure of capillarity since it cannot evaporate for any length of time faster than it is supplied from below.

If we have a soil subject to evaporation and in contact below with hydrostatic water, two cases are possible.

1st. The amount evaporated is less than or equal to what can rise through the soil. In this case the moisture of the upper layers and consequently the evaporation will remain the same.

2d. The evaporation is greater than the amount that can rise through the soil. In this case the upper layers of the soil will dry out and the evaporation will consequently diminish till it and the supply come into equilibrium, and so the evaporation is determined by the supply and becomes a measure of it.

Sometimes the top of the soil may, under such circumstances, become air-dry and then evaporation will take place from a point below the surface. In this case the access of air to the evaporating surface would be largely decreased and the evaporation greatly diminished.

Our experiments have been chiefly directed to ascertaining the effect upon the capillary power of the soil of variations in the depth and in the fineness of the materials. For these purposes the apparatus described above has proved well adapted, permitting as it does a continuation of the experiment under uniform conditions until supply and evaporation come into equilibrium. Its defect is that it is small, and that therefore small variations in the filling of the tubes or other conditions are liable to produce relatively large errors. This defect admits of obvious remedy, but the Station has not at present the means of working on a larger scale.

Two experiments in blank showed that the leakage of the apparatus itself was extremely slight and could be neglected.

The diameter of the glass tubes varied somewhat. In the following statement, the numbers express in *grammes* (28.349 grms. =1 oz., Av.), the amounts of water evaporated, either by a square inch of surface, or by a circular area two inches in diameter (3.1416 sq. in.). The volumes or capacities are expressed in *cubic centimeters* (16.386 c. c. = 1 cub. inch).

### A. *Influence of the Height of the Soil-Column on Evaporation.*

Experiments were made on packed flour of emery and on No. 80 emery. Three series of trials were made on the former, each including two single experiments with columns respectively 14 and 10½ inches high. The results were as follows:

*Effect of Height—Flour of Emery.—Series I.*

| Number of Tube. | Height. | Volume. | Weight of Emery. | Weight of 1 c. c. | Evaporated in 7 days. |
|---|---|---|---|---|---|
| XIII. | 14 in. | 675 c. c. | 1407.85 grms. | 2.09 grms. | 19.73 grms. |
| II. | 10½ " | 560 " | 1096.78 " | 1.96 " | 12.29 " |

It will be seen from the different weights of 1 c. c. that the degree of packing was not quite the same. Furthermore, II was not filled quite to the top and was started after XIII had been mounted for nine days.

The experiments were stopped at this point by covering the tubes and II was started afresh Jan. 2, 1878, along with others, one of which (V) is comparable with II. In this *second series*, II suffered from the same sources of inaccuracy as before and in addition a saline crust began to show itself on the surface. That this crust may have interfered is apparent from the experiments on the effects of fineness. (See pp. 92 and 93.) The following are the results of this second experiment:

*Effect of Height—Flour of Emery.—Series II.*

| Number of Tube. | Height. | Volume of Tube. | Weight of Emery. | Weight of 1 c. c. | Evaporated in 17 days. |
|---|---|---|---|---|---|
| II. | 10½ in. | 560 c. c. | 1096.78 grms. | 1.96 grms. | 20.73 grms. |
| V. | 14 " | 726 " | 1467.50 " | 2.02 " | 33.99 " |

Here the packing was not quite alike in the two tubes, but it was more nearly so than in the former experiment, and, as before, the shorter column evaporated the least water.

To remove the saline crust just mentioned, II was dismounted and the emery washed with water. On Feb. 7th the experiment was renewed with the washed emery, of which 1225.07 grms. were used instead of 1096.78 as in the former trial; the weight of 1 c. c. was therefore 2.19 grms. and the emery was considerably more compact than before. In all these experiments the emery was filled into the weighed tube and packed down by tapping the tube on the table till full; the weight of the whole being then taken the difference expressed the amount of emery used. Flour of emery is peculiarly difficult to pack evenly, and this, perhaps, accounts in part at least for the variations in the different experiments. In later experiments the proper quantity of emery was weighed out and filled into the tubes, and thus more uniform conditions were secured, though this method also is not without its inaccuracies.

The result of this *third series* was exactly the reverse of that of the two former ones; the shorter column evaporated considerably more water than the longer one, viz:

*Effect of Height—Flour of Emery.—Series III.*

| Number of Tube. | Height. | Volume of Tube. | Weight of Emery. | Weight of 1 c. c. | Evaporated per sq. inch in 46 days. |
|---|---|---|---|---|---|
| II. | 10½ inches. | 560 c. c. | 1225.07 grms. | 2.19 grms. | 89.54 grms. |
| V. | 14 " | 726 " | 1467.50 " | 2.02 " | 79.55 " |

This experiment was more carefully conducted than the other two; its result is confirmed by those obtained in three series of experiments on a coarser grade of emery, immediately to be described, and is probably correct.

No. 80 Emery was the subject of three series of experiments on the effect of height. The glass tubes of the former experiments were replaced by copper tubes of the same diameter whose heights were respectively 4½, 9 and 13½ inches, or in the ratios 1 : 2 : 3. In two other series carried on at the same time, a similar tube of No. 80, 7 inches high, was used, and the results may be included in these experiments. The trials in the first two series, except those with the 7 inch tube, were made in duplicate, and the results were in most cases fairly accordant.

In the *fourth series*, lasting from Aug. 5th to Sept. 16th, 1878, the tubes were filled, in the manner already described, as full as possible; the following were the quantities of emery used and the amounts of water evaporated:

*Effect of Height—No. 80 Emery.—Series IV.*

| No. of Tube. | Height. | Weight of Emery. | Evaporated.* | Average. |
|---|---|---|---|---|
| 1 | 4½ inches. | 522.22 grams. | 189.24 grams. | 192.62 grams. |
| 2 | 4½ " | 519.94 " | 195.99 " | |
| 9 | 7 " | 812.42 " | 192.83 " | 192.83 " |
| 3 | 9 " | 1057.48 " | 184.03 " | 188.33 " |
| 4 | 9 " | 1026.66 " | 192.63 " | |
| 5 | 13½ " | 1593.46 " | 175.24 " | 177.81 " |
| 6 | 13½ " | 1590.93 " | 180.37 " | |

* From 3.1416 square inches.

Although there are some discrepancies, the general result is to show decidedly that the shortest columns evaporated most and the longest least.

A *fifth series* of experiments was made, like the preceding in all points except the filling of the tubes, which was done by weighing out quantities of emery proportional to the length of the tubes, pouring them into the latter, and packing sufficiently to make the emery just fill them. The quantities used were less than in the fourth series, in order to make the trials comparable in this respect with others conducted at the same time on flour of emery, which cannot be made as compact as the coarser grades. The experiments covered the time from Oct. 2 to Dec. 13, 1878; on Nov. 18 they were removed from the room where they had previously been to a warmer one, in order to get a more rapid evaporation.

The results were as follows:

*Effect of Height—No.* 80 *Emery.—Series V.*

| No. of Tube. | Wt. of Emery. | Oct. 2–Nov. 18. | | | Nov. 18 to Dec. 13. | | |
|---|---|---|---|---|---|---|---|
| | | Evaporated. | Average Per day. | Average Total. | Evaporated. | Average. Per day. | Average. Total. |
| | *grams.* | *grams.* | *grams.* | *grams.* | *grams.* | *grams.* | *grams.* |
| 1 | 473.1 | 142.48 | 3.06 | 143.73 | 132.72 | 5.36 | 133.93 |
| 2 | 473.1 | 144.98 | | | 135.14 | | |
| 9 | 735.7 | 164.82 | 3.51 | 164.82 | 113.50 | 4.54 | 113.50 |
| 3 | 946.2 | 136.83 | 2.96 | 139.37 | 114.22 | 4.73 | 118.24 |
| 4 | 946.2 | 141.90 | | | 122.25 | | |
| 5 | 1419.3 | 143.32 | 3.12 | 146.60 | 115.78 | 4.48 | 112.00 |
| 6 | 1419.3 | 149.87 | | | 108.22 | | |

While the experiments are not in all respects as satisfactory as could be wished, still, taken in conjunction with the results of the other series, they seem to show decidedly that the greater the depth of the (sandy) soil is to hydrostatic water, the less evaporation takes place from it, other things being equal.

This result is what we should expect. The deeper the soil is, the greater is the distance which the water has to rise, and the more resistance it encounters from friction along the sides of the capillary interstices. Furthermore, if the surface of the soil be above the point to which water will fill the interstices, the water must move over the surface of the particles, where it probably encounters still greater resistance. These experiments, indeed, were at first designed to test the latter supposition.

Water appeared to fill the interstices of No. 80 emery to a height of about 9 inches, as nearly as could be observed. One of the columns of emery was therefore chosen of this height, one was taken of half this height (4½ inches), while that of the third was 13½ inches, so that the water had to rise 4½ inches on the surface of the particles. As compared with the shortest column, the water in the 9 inch column encountered an additional resistance in its upward motion due to an additional 4½ inches of height, and in the 13½ inch column the same *plus* the resistance due to the upper 4½ inches where the interstices were not full of water. The object was to see if the 4½ inches added to the 9 inch tube produced any greater decrease in the evaporation than the 4½ inches added to the 4½ inch tube.

That such was the case, we are not justified in concluding from the amounts of evaporation observed; but it must be remembered that evaporation is a measure of capillarity only when it reaches the limit of the capacity of the soil to raise water (page 87), and we have no proof that this was the case here.

In a *sixth series* of experiments the rate of evaporation was artificially increased by placing the apparatus near a stove, with the precautions described on page 97. The following results were obtained:

*Effect of Height—No.* 80 *Emery.—Series VI.*

| Date. | Evaporated by | | |
|---|---|---|---|
| | 4½ inch column. | 9 inch column. | 13½ inch column. |
| Jan. 7– 8, | 20.03 grams. | 19.08 grams. | 15.21 grams. |
| " 8– 9, | 22.22 " | 21.26 " | 14.27 " |
| " 9–10, | 18.14 " | 17.73 " | 14.29 " |
| " 10–13, | 61.83 " | 64.69 " | 51.05 " |
| " 13–14, | 27.33 " | 27.45 " | 18.43 " |
| " 14–15, | 25.44 " | 22.95 " | 16.12 " |

The effect of the greater height of the 13½ inch column was shown by an evident drying out of the surface and the relatively smaller amount of evaporation from it.

But even in these experiments we have no absolute certainty that the evaporation is a measure of capillarity, though we believe it probable. In the longest column evaporation has probably reached the limit imposed by the power of the emery to raise water, but whether this be the case with the other two we have no certain evidence. If so, our experiments show that water rises with more difficulty in that part of the soil where the interstices are not full of water; if not so, the experiments prove nothing either for or against this theory. It is evident that the solution of the question must be sought by some other method of experiment.

### B. *Effect of the Fineness of the Materials upon Evaporation.*

On this point some rather interesting results have been obtained. Series VII-XII of experiments have been made with emery, some of which were reported last year, but are included here for comparison.

In the *seventh series*, extending from Oct. 29th to Dec. 19th, 1878, Nos. 46, 80 and Flour, were used in glass tubes 14 inches long. The results were the following:

#### *Effect of Fineness.—Series VII.*

COLUMNS 14 INCHES HIGH.

| No. of Tube. | Capacity of Tube. | Weight of Emery. | Weight of 1 c. c. of Emery. | Evaporated. | |
|---|---|---|---|---|---|
| | | | | Oct. 29–Nov. 19. | Nov. 19-Dec. 19 |
| I (No. 46), | 712 c. c. | 1555.36 grms. | 2.18 grms. | 49.36 grms. | 66.96 grms. |
| IV (No. 80), | 718 " | 1581.42 " | 2.20 " | 91.16 " | 109.03 " |
| V (Flour), | 726 " | 1249.26 " | 1.72 " | 83.22 " | 131.56 " |

Up to about Nov. 19th No. 80 evaporated the most water and next came Flour, while No. 46 fell much below either; after that date the evaporation from No. 80 fell below that from Flour and remained so.

At the time that No. 80 began to evaporate less than Flour, a saline incrustation was observed on its surface, which filled up the interstices and rendered the upper part of No. 80 really finer grained than the Flour. Apparently the amount of evaporation reaches a maximum at a certain degree of fineness, and any increase in closeness of texture beyond that point decreases the evaporation.

To ascertain whether the relatively diminished evaporation from No. 80 in the second period was due, as was supposed, to the decrease in the size of the interstices caused by the deposition of salts, and also to ascertain more nearly what size of the particles would give the maximum evaporation, the emery was thoroughly washed with water, and an *eighth series* of experiments, including five sizes, viz: Nos. 46, 54, 80, 100 and Flour, was set up.

The experiments extended from Jan. 1st to March 25th, 1878, and confirmed fully the results of the former series, as the following table shows.

#### *Effect of Fineness.—Series VIII.*

COLUMNS 14 INCHES HIGH.

| No. of Tube. | Size of Emery. | Capacity of Tube. | Weight of Emery. | Weight of 1 c. c. of Emery. | Amount evaporated per square inch. |
|---|---|---|---|---|---|
| I, | No. 46 | 712 c. c. | 1592.54 grms. | 2.23 grms. | 40.27 grms. |
| XVIII, | " 54 | 675 " | 1529.86 " | 2.26 " | 138.38 " |
| IV, | " 80 | 718 " | 1629.78 " | 2.27 " | 155.09 " |
| XVI, | " 100 | 668 " | 1558.36 " | 2.33 " | 150.64 " |
| V, | Flour | 726 " | 1467.50 " | 2.02 " | 144.65 " |

It should be added that, although only the total evaporation is given above, the weighings were repeated at intervals of from one to seven or sometimes more days for nearly three months, and that the order of most evaporation was the same in every case as that shown by the total result, so that the latter can hardly be due to accident. Moreover the differences appear smaller in the table than they really were, having been reduced to an area of one square inch.

These results are very interesting in their bearings on the capillary power of the soil. It has already been explained (p. 87) that the evaporation from a soil is a measure of its capillarity only when the amount of water evaporated equals that which the soil is capable of raising to the surface under the given conditions. That the amount at first evaporated by Nos. 46 and 54 in the above experiment was greater than could be supplied from below was made evident by a perceptible drying out of the top to a depth of nearly an inch in No. 46 and of about one-eighth inch in No. 54, and by a gradual decrease of their rate of evaporation for the first few days. In the finer grades the surface did not, as in the coarser, become air-dry, but it appeared less moist to the eye, after a time, and we believe that without doubt in these also the evaporation was great enough to afford a means of determining the capillary power, in the above sense, of the materials used.

That such was the case is further indicated by the results of other experiments shortly to be described, in which the evaporation was less rapid than in these, and therefore less likely to exceed the capillary power of the soil. In the experiments referred to the rate of evaporation increased regularly from the coarsest emery to the finest, showing that the conditions were in some respects different from those of the experiments now under consideration.

The most natural and indeed the only explanation of this difference is that in the other experiments the amount of evaporation was less than could be supplied by the capillary power of the soil, while in these it was equal to and limited by it. That this is the correct explanation is shown by the change which took place in the order of most evaporation in those experiments, when the evaporation was artificially increased. (See pp. 97 and 98.) Assuming this to be the fact, it would seem at first sight that our experiments show that the capillary power of the soil reaches a maximum at a certain degree of fineness of grain and that any variation in either direction decreases it. A little reflection, however, suffices to show that such a maximum evaporation as was found in these experiments can only be produced by the combined action of two or more factors. Indeed several factors are included in the general expression, "The capillary power of the soil." In a soil of any given degree of fineness, the interstices are capable of *filling themselves* with water to a certain distance above standing (hydrostatic) water; this distance is called the capillary height of the soil. Above this point water will be held on the surface of the particles and in the angles where they touch each other, but will not fill the larger interstices.

Now it is evident that the "capillary power" or transmitting rate (for water) of these two portions of the soil will in all probability be different. Lack of time has prevented any decisive experiments on this point as yet, and none are recorded in the literature of the subject (see, however, pp. 90 and 91), but it is quite certain that water would move with more difficulty over the surface of the particles than in that portion of the soil where the interstices are full, just as water flows in a stream or pipe more freely and more rapidly in the center than at the sides where the liquid drags against the channel or tube in which it has to move. If this be so, we have a simple explanation both of the existence of a maximum evaporation in our experiments and of its falling on No. 80, rather than some other number. When the tubes were filled with dry emery and placed with their lower ends in water, it was observed that while in Flour, No. 100 and No. 80, the water rose until it wet the emery at the very top of the tube, a height of 14 inches, it rose in No. 54 about 11 inches and in No. 46 only about 8 inches. The wetting of the emery in these two tubes was accomplished by immersing them in water nearly to the top, the surplus water which they contained being allowed to drain off before the experiments began.

When evaporation began, the interstices of No. 46 were full of water to a height of about 8 inches, those of No. 54 to a height of 11 inches, and those of No. 80 to the top, 14 inches; in No. 46 the water had to rise 6 inches, and in No. 54, 3 inches, upon the surface of the particles, while in No. 80 it rose all the way in the full interstices.

If, as we assume, the ascending water encounters greater friction where it has to rise along the surface of the merely moistened particles, than when it goes up in the saturated interspaces, we can readily understand why the rise of water and consequently the evaporation should increase up to No. 80. But why should it decrease beyond this point? In No. 80 and the higher numbers the motion was entirely in the full interstices; the three therefore were exposed to like conditions.

It has generally been taught that the capillarity of the soil increases with increasing fineness; were this so, we should expect the finest emery to evaporate more than the coarser grades. We conceive, however, that this teaching is an error, based on an ambiguous use of the word capillarity. Most experiments on capillarity have been directed toward ascertaining the height to which water will rise in the pores of the soil, that is, to determining its "capillary height," and the soil in which water rose farthest was said to have the greatest capillarity. It is entirely proper to attach this meaning to the term capillarity, and in this sense the finest soil must have the greatest capillarity.

In connection with evaporation, however, the word capillarity is used in a very different sense to mean the rate at which water will rise to supply a loss by evaporation, and the error has consisted in attempting to apply the results of experiment upon the capillarity of the soil in the other sense to this latter phenomenon. The two phenomena are quite different in their nature, the latter resembling more nearly a flow of water in fine tubes, which is more rapid, not in the smallest but in the *largest* tubes, not in the finest but in the *coarsest* soil. Using the word in this sense the capillarity of a soil (that is, its rate of raising water, not the distance to which it will raise water) *decreases* with the fineness.

Hence in the above experiments the maximum evaporation took place from No. 80, because it was the coarsest powder in which the water reached the top and had to move only in the full interstices. If shorter tubes had been taken, the maximum might as readily have fallen on a lower number.

To test the truth of this theory, a *ninth series* of experiments was made on Nos. 54, 80, 100 and Flour, in copper tubes 7 inches long, i. e., of such a length that the water filled the interstices to the top in every one. It must be taken into account, however, that in previous experiments it has been found that a longer soil-column evaporates less than a shorter one, so that a more rapid and probably a considerably more rapid evaporation would be required in the latter to reach the limit of supply and thus to show the capillarity of the soil. As a matter of fact the rate of evaporation was considerably less on the average in these experiments than in the eighth series and but little more than in the seventh series.

The results showed a regular increase of the evaporation with the fineness, but in view of the above considerations it seems probable that this was not due to the greater capillarity of the finer powder but to other circumstances yet to be investigated.

A *tenth series* of experiments made in the same way with greater care to ensure uniform filling of the tubes, gave the same result. The total evaporation per tube and the average rate per day in the two series are given in the following tables:

*Effect of Fineness.—Series IX.* (*Aug.* 5*th–Sept.* 16*th*, 1878.)

COLUMNS 7 INCHES HIGH.

| Number. | Size of emery. | Total evaporation. | Average evaporation per day.* |
|---|---|---|---|
| 7 | No. 54 | 188.96 grams. | 4.50 grams. |
| 8 | " 54 | 188.17 " | 4.48 " |
| 9 | " 80 | 192.83 " | 4.59 " |
| 10 | " 100 | 193.62 " | 4.61 " |
| 11 | Flour | 210.41 " | 5.01 " |
| 12 | " | 224.99 " | 5.35 " |

*Effect of Fineness.—Series X.* (*Oct.* 2*d–Dec.* 13*th*, 1878.)

COLUMNS 7 INCHES HIGH.

| Number. | Size of emery. | Total evaporation. | Average evaporation per day.* |
|---|---|---|---|
| 7 | No. 54 | 273.48 grams. | 3.80 grams. |
| 8 | " 54 | 266.66 " | 3.70 " |
| 9 | " 80 | 278.32 " | 3.87 " |
| 10 | " 100 | 327.76 " | 4.55 " |
| 11 | Flour | 344.42 " | 4.79 " |
| 12 | Flour | 322.01 " | 4.47 " |

The average daily evaporation in the seventh and eighth series was:

| Size of Emery. | Series VII.* | Series VIII.* |
|---|---|---|
| No. 46, | 2.28 grams. | 1.52 grams. |
| 54, | ---- | 5.24 |
| 80, | 3.92 | 5.87 |
| 100, | ---- | 5.70 |
| Flour, | 4.21 | 5.48 |

* From an area of 3.1416 square inches.

Although the tubes in series IX and X were only half the length of those in series VII and VIII, thus decreasing the resistance to the rise of water, the rate of evaporation in the former two was less than that in VIII and not much greater than that in VII.

It might very well be the case, then, that the evaporation was less than the possible supply and was determined entirely by other factors, such as the quality and degree of moisture of the surface, etc., and this we believe to be the fact. Exactly what these other factors are which cause the greater evaporation from the finer powder under these circumstances we can at present only surmise; it is hoped that time will permit a study of them in the future.

If it be a fact that the apparent contradiction between the experiments with long and short tubes is due to the cause we suppose, a sufficient increase in the rate of evaporation ought to have the result of reversing the order and making the coarsest powder evaporate most.

To test this, the tubes Nos. 8, 9, 10, 11 and 12 of series X were taken for an *eleventh series*. A slight crust which had formed on the top was removed, the tubes were filled up carefully to the top with fresh emery, and the apparatuses when mounted were arranged at equal distances of about eighteen inches from a cylindrical stove in which an anthracite fire was constantly burning. Three accordant thermometers were placed, one at each end and one in the middle of the line of apparatus, and their readings frequently compared, in order to judge of the equality of the radiation received by the several tubes. The readings of the thermometers were as satisfactory as could have been expected, seldom differing more than five degrees centigrade and generally agreeing much closer. If there was any difference, the tubes 11 and 12, containing the flour of emery, were kept warmer than the others.

The results of this series of experiments were in general confirmatory of the theory above enunciated.

The coarser grades of emery evaporated more than the finer, and we believe that, in spite of the somewhat rude nature of the experiment, the differences are too great to be due entirely to differences in the amount of heat received. At the same time, it would be very desirable to repeat the experiments with some apparatus by which a steady and equal heat could be ensured.

The following are the amounts evaporated by each tube on each day of the experiment from an area of 3.1416 square inches:

### *Effect of Fineness.—Series XI.*

Columns 7 Inches high.—Exposed to Stove Heat.

| Date. | Size of Emery. | | | | |
|---|---|---|---|---|---|
| | No. 54. | No. 80. | No. 100. | Flour. | Flour. |
| Dec. 26–27, | 23.68 grms. | 21.23 grms. | 22.36 grms. | 21.68 grms. | 22.93 grms. |
| " 27–28, | 17.77 " | 18.33 " | 18.15 " | 17.14 " | 15.58 " |
| " 28–30, | 27.95 " | 29.63 " | 29.46 " | 26.73 " | 25.76 " |
| " 30–31, | 17.05 " | 18.42 " | 19.38 " | 16.98 " | 16.46 " |
| " 30–Jan. 1, | 14.02 " | 14.49 " | 14.08 " | 12.18 " | 11.84 " |
| Jan. 1–2, | 16.22 " | 17.70 " | 17.54 " | 15.14 " | 15.08 " |
| " 2–3, | 12.77 " | 13.25 " | 13.23 " | 12.78 " | 12.13 " |
| " 3–4, | 13.36 " | 14.04 " | 13.91 " | 13.07 " | 12.55 " |
| Total, | 142.82 " | 147.09 " | 148.11 " | 135.70 " | 132.33 " |

It seems very doubtful whether the small total differences (4.27 grams = 2.98 per cent. and 1.02 grams = 0.69 per cent. respectively) in the evaporation from Nos. 54, 80 and 100 are due to anything more than accidents of experiment, but the difference between these and the two tubes of flour is very decided and in the direction indicated by our theory.

That any difference in evaporation due to fineness of material should be more marked in the flour was to be expected; for while the other grades are tolerably uniform in the size of their grains, this is composed of all sizes below a certain maximum. In filling a tube the fine dust must, to a greater or less extent, fill up the interstices between the larger particles and thus make the average size of the capillary tubes much less than corresponds to the mean dimensions of the particles. Hence the difference in fineness of texture between, for example, No. 100 and flour is far greater than that between No. 54 and No. 80, or between No. 80 and No. 100, or even than between No. 54 and No. 100. The difference in texture between flour and the other grades is very perceptible both in their feel and appearance, and corresponds to the observed difference in evaporation. The fact here observed shows itself also in the eighth series of experiments. There also Nos. 80 and 100 evaporated almost the same amount, while from the flour the evaporation was much less.

Still another explanation is possible, viz: that while the evaporation reached the limit of supply in Flour and perhaps in No. 100, it did not do so in the coarser numbers, so that the evaporation from these was determined as before by other factors. Whether the observed result was the effect of one or the other of these causes or both combined it is scarcely possible to say with certainty in the present state of our knowledge.

It will be noticed that on the first day the flour evaporated nearly or quite as much as the others, while after that it fell below them. This seems to indicate a greater initial rapidity of evaporation and a subsequent drying out of the surface in accordance with our hypothesis.

To further test the truth of this supposition the apparatuses which served for the eleventh series were removed from the neighborhood of the stove to the location they previously occupied. The tops of the tubes were covered with glass plates for two days, to allow the surface of the emery to saturate itself with water, and were then uncovered and exposed again to the air. In this *twelfth series* the evaporation of course fell again approximately to the former amount (series IX and X), and what is of more importance the evaporation was again found to increase with the fineness.

The differences, it is true, are not as great as before, which is perhaps due to greater uniformity of surface in the several grades, but they are all in the same direction; even if they are to be regarded as within the limits of error, the large difference brought about by the heat in the evaporation from Flour as compared with the coarser grades has been caused to disappear by reducing the evaporation below the limits imposed by the power of the emery to transmit water upward.

The following table shows the results in detail:

### *Effect of Fineness.—Series XII.*

Columns 7 Inches high.

| Date. | No. 54. | No. 80. | No. 100. | Flour. | Flour. |
|---|---|---|---|---|---|
| Jan. 6–7 | 7.07 grams. | 7.19 grams. | 7.33 grams. | 7.45 grams. | 7.62 grams. |
| " 7–8 | 5.61 " | 6.11 " | 6.20 " | 6.30 " | 6.34 " |
| " 8–9 | 4.62 " | 5.01 " | 5.16 " | 5.12 " | 5.18 " |
| " 9–13 | 20.40 " | 22.25 " | 22.76 " | 22.49 " | 22.51 " |
| " 13–15 | 10.84 " | 12.01 " | 12.26 " | 12.24 " | 12.32 " |

A *thirteenth series* of similar experiments, with the clay-loam which has been described on page 83, are here adduced for the sake of comparison with those made on emery. The fragments of air-dry loam, sifted into three grades of fineness, were contained in glass cylinders 14 inches high and 2 inches in diameter. The results of these experiments up to December 7th, 1877, were given in the last Station Report, page 80.

The experiments lasted from Oct. 26th, 1877, to March 25th, 1878; the figures below give simply the total evaporation, but the apparatuses were weighed frequently and the order of most evaporation was always the same as that shown by the total result.

### *Clay-Loam.—Series XIII.*

COLUMNS 14 INCHES HIGH.

| Average dimensions of masses or particles. | Evaporation per square inch. |
|---|---|
| Coarse—$\frac{1}{8}$ inch. | 49.21 grams. |
| Medium—$\frac{1}{25}$ inch. | 73.83 " |
| Fine—less than $\frac{1}{100}$ inch. | 153.82 " |

Here we have the greatest evaporation from the finest materials. That the evaporation reached the limits enjoined by capillarity, was evident from the very decided drying out of the two coarser materials at the top.

This result, however, in no way contradicts the conclusions drawn from experiments on emery. In the first place, the fragments into which the clay loam was divided were comparatively coarse and the water did not fill the interstices nearly to the top, at least in the two coarser, so that in this respect we have the conditions present in the coarser grades of emery, Nos. 46, 54 and 80 in Series VIII, where also the evaporation increased with the fineness.

Further, and what is of more importance, the fragments of the clay-loam were *porous* fragments. In a paper in the Report for 1877, on the "Present State of Knowledge Regarding the Relations of the Soil to Water," it was said (page 93):

"If the particles of the soil are themselves porous, we have a second system of capillary tubes acting to a certain extent independently of the interstices between the particles. As compared with a soil of non-porous materials of the same grain, the porous would raise water faster because there are more spaces for the liquid to move in. (Mayer, *Landw. Jahrbücher*, **3**, 796–7) found this to be true of the rise of water into dry materials.

"With porous substances, the rise of water, especially at a considerable height, may take place chiefly in the pores of the particles. If this be so, making the grain finer (which has no effect on the pores) would not check the rise of water as making non-porous particles finer does, by increasing interstitial friction. Greater fineness of porous particles tends to increase their points of contact and thus far to favor motion of water from grain to grain. This view has been suggested by Haberlandt (*Wiss. prakt. Unters.*, p. 20); if correct, capillarity in porous-grained soils would increase with the fineness of their particles."

The above experiments seem to indicate that the view thus taken on theoretical considerations is correct, and that, with materials in which the movement of water takes place chiefly in the fine pores of the particles, the law deduced from our experiments on emery, a non-porous material, is essentially modified in its effects by other causes.

Experiments have also been made on the evaporation from packed as compared with loose materials, but as yet they have given no satisfactory results, and must be continued.

### *Conclusions.*

The experiments above described justify the following conclusions:

1st. The deeper the column of soil or soil-like material which intervenes between standing water and the surface, the slower will be the rate at which water can be transmitted upward and consequently the less the evaporation.

This is shown by Series III upon flour of emery and by Series IV, V and VI upon No. 80 emery. The discrepant results obtained in Series I and II seem to be accidental.

2d. The experiments of Series VI indicate, though they do not fully prove, that the upward motion of water is easier below than above the "limit of saturation" of the soil, i. e., the point to which water will completely fill the interstices; in other words, that water rises more readily in that part of the soil where the interstices are full of it than in that portion where the water simply coats the surface of the particles.

3d. The ease with which a soil transmits water upwards to supply a loss by evaporation from the surface is greater the coarser the texture of the soil, *provided* that the height of the soil-column is such that the interstices can fill themselves to the top with water, or in other words, is not greater than the "capillary height" of the soil. This is shown by Series XI.

4th. If, among several similar soil-columns of different degrees of fineness, there are some in which the interstices are full of water to the top and others in which they are not, the greatest ease of upward motion will be found in the coarsest of the first class; that is, a medium fineness will show the greatest transmissive power.

This is shown in Series VII and VIII, and, as explained on pages 93–95, is deducible from the two preceding conclusions.

5th. When the interstices are full of water to the top and the evaporation is less than the possible supply, the greatest evaporation takes place from the finest soil. This is shown by Series IX, X and XII. The cause of this phenomenon we have not yet sought for.

6th. All the above conclusions apply primarily to a soil composed of impermeable materials. In one composed of porous fragments the rise of water probably takes place chiefly in the fine pores of the fragments themselves, and to this extent is facilitated by fine division which gives more points of contact between the fragments. The truth of this view is indicated by Series XIII.

7th. The experiments show the importance of securing, in such investigations as these, an evaporation equal to the amount of water which can rise through the soil, if any conclusions are to be drawn respecting the capillary power of the latter. If this is not done, we may have the true conclusion masked as in Series V (compared with Series VI) or entirely hidden as in Series IX and X (compared with XI) by the effects of other conditions.

## ON STRINGY MILK OR CREAM.

Among the "faults" which affect milk, one has been brought to the notice of the Station which is not distinctly treated of in any work on milk, so far as I have been able to find. It is described in the following correspondence:

"*West Winsted, Sept.* 23, 1878.

"I have for many years retailed milk in this borough, and have been able to give seemingly perfect satisfaction to my customers with the exception of a short period of each year, usually during the month of September, when I have been troubled with "stringy," "ropy," or "tainted" milk. This trouble is now upon me in aggravated form. For full three weeks it has troubled me more or less. I have sought by every means in my power to search out the cause and to find a remedy, but without avail. I have presented the matter to Secretary Gold and many others, but have been able to arrive at no certain conclusion. Now I send a sample of milk, hoping that by analysis or some other means you may tell me the cause of this condition of the milk and suggest a remedy.

Doubtless your first conclusion will be that one or more of the cows (I keep twenty in all) are being milked too near the time of calving. From the record I keep there are none in milk now that will calve within ten weeks or three months. Next, it will perhaps be conjectured that the cows are supplied with too little water, or with an inferior quality. I have myself thought this may have been the cause in seasons past, but in the present we have had abundant rains and the cows have had a full supply of running spring water in every lot where they have pastured, as well as in the yard (from aqueduct) where they are milked morning and evening. They seldom drink in the yard, however. Next it may be suspected that the cans and pails are not thoroughly washed or scalded. I have always ranked "cleanliness next to godliness," and can assure you that the milk utensils are kept scrupulously clean and sweet. I salt my cows every third morning, giving one quart to fifteen cows, the number now in milk. They have fed on rowen for nearly a month, going to and from an adjoining pasture to drink. They do not appear feverish nor do they shrink in quantity or change in quality of milk so far as I know, and appear healthy and natural.

The milk is taken immediately to a cold spring and thoroughly cooled, but whether it goes there or is brought in small quantity into the house, it is all the same. I do not know that any of my neighbors are seriously troubled in this way, though I ascertain that many of them (they generally make butter and cheese) have sometimes noticed this peculiarity in their milk.

There is no decaying vegetable or animal matter within their reach, and I know of no circumstances or combination of circumstances that should produce such a condition. Do you think it possible that any noxious or poisonous weed, plant or shrub, at this season of the year could do this? Or can there be any chemical properties in the water they drink that could cause this trouble?

If you are able to unravel the mystery and furnish a remedy, you will confer lasting favors to myself and this community. Hoping the subject will receive your immediate attention, I subscribe myself,

Yours truly,

E. H. Barber.

P. S.—I omitted to state that the stringy condition of the milk is not apparent until the milk has stood over night and the cream separated. It is the cream that is stringy, not the milk.

The milk sent you is a day old, for as the stringiness is scarcely noticeable some days, I am not sure that to-day's milk will be affected. I hope it will reach you sweet. E. H. B."

The milk was so delayed in coming as to be sour on its arrival, but the microscope enabled me to see in it abundance of a fungus having a close resemblance to a well-known milk-fungus. The following is my answer to Mr. Barber's very interesting letter:

"*September* 30, 1878.

"Dear Sir:—The examination of the milk received from you showed that the stringiness is due to the growth of a fungus or mould in the milk. It is not an easy matter to identify the funguses which may develop in liquids like milk, but so far as I can decide in the little time I can devote to the subject, the fungus appears to be one long known as *Oidium lactis.* This fungus does not occasion the souring of milk,—so the best observers agree,—and it appears to be of no injury to the milk or cream except when it develops in such quantities as to bind the cream together into too coherent masses by its fine interlacing filaments. In the sample received from you, examined this morning under the microscope with a power of three hundred diameters, the "stringy" portion is a perfect "felt" or mat of delicate fibers, among which the fat globules and bits of curd are interspersed. This fungus multiplies *in the milk* by the rapid formation of young cells, which bud out from the maturer threads and from each other, then separate or fall apart. Each young cell then grows and multiplies in like manner.

The *Oidium lactis*, though first found in milk, naturally grows in cow-dung and may always be traced to the latter. When it has time to develop fully, it sends up either from cow-dung or from milk, *fruit-bearing stems* into the air forming a mould. These stems are excessively delicate, one-twelfth inch long, and carry at the tops, each, a globular spore-sac about one-hundredth of an inch diameter. These sacs, when ripe, burst and scatter thousands of spores or seeds of the fungus.

The milk of the cow usually exhibits more or less of the fungus when kept some hours or days, because the spores are so likely to be in the air of milking places and to fall into the milk, where they shortly develop into the filament form.

Your difficulty in all probability comes from the occasional rapid development of the fungus in excessive quantity. This development is favored, in the first place, by the abundance of spores or germs; second, by hot and moist weather. The more dry, airy and free from wet or moist dung the milking place is, the less the chance of impregnating the milk with the germs of the fungus. The cooler the milk when set for cream and the cleaner and drier the milk-room, the less rapid will be the growth of the *Oidium lactis*, and the less likely will it be to propagate in the milk-room. Sour milk serves like cow-dung for the propagation of the fungus, and any vessels or troughs which serve for holding or carrying it should be kept clean. The pig-pen where sour milk is kept or fed should be distant from the milk-room.

If I am correct in attributing your trouble to the growth of this fungus in unusual quantities, you should be able to connect its appearance with hot, "muggy" weather, and with the occurrence of such a *spore-bed*—moist dung or sour milk—as has been stated to be the appropriate breeding place of the *Oidium lactis.*

Please inform me whether the facts justify my conclusions. If not, I will give the subject such further study as lies in my power."

I am indebted to the researches of Reess* and Fr. Haberlandt† for the figures and description which led me to suppose the fungus in Mr. Barber's milk to be *Oidium lactis.*

Reess asserts that this fungus grows in sweet milk and has nothing to do with the souring or lactic fermentation; that milk is impregnated with its spores in the milking places where the fungus is always growing, with other fungi, on dung; and furthermore, that it flourishes also on all substances which nourish mould, especially on waste food. Reess is certain from his own observations that *Oidium lactis* does not develop from or into the more common kinds of mould (*Penicilium* and *Mucor*).

Haberlandt, from long continued observations, confirms the statements of Reess, and adds that it is very probable that *Oidium lactis* is at home everywhere where cows are kept and

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* *Untersuchungen über die Alkoholgährungspilze.* Leipzig, 1870, p. 48.

† *Untersuchungen auf dem Gebiete des Pflanzenbaues.* Wien, 1875. Bd. 1, pp. 202–229.

milk is handled, also that *Oidium lactis* protects the surface of milk, cream and especially cheese, from settlement of other fungi. Haberlandt found no sort of cheese whose rind was free from this fungus; admits, however, that under special circumstances other fungi may develop upon and within cheese.

Haberlandt states further that *Oidium lactis* is never found in the milk-glands of the animal nor in fresh-drawn milk, but it always occurs in the contents of the stomach and intestines of stabled cattle, and may under some conditions develop there abundantly. This is especially the case with young animals which are hand-fed with milk that is no longer fresh, but has stood some time, so that the *Oidium* has had opportunity to develop. The indigestions and diarrheas of young calves kept from their dams, and of children "brought up on the bottle," are not improbably due in part or wholly to an excessive growth of this fungus in the digestive canal.

Since the above was written, a letter has been received from Mr. Barber, the following extracts from which would indicate either that the ropiness is not due to *Oidium lactis*, or that the circumstances and conditions favorable for the propagation and growth of that fungus are not fully understood. I shall endeavor to coöperate with Mr. Barber next summer in a full investigation of the difficulty, should it recur, and would be glad meantime to hear from any who can contribute facts bearing on the case.

"You attribute the ropiness of the milk to a species of fungus, germs of which might come from sour milk, an adjacent pig-sty, or heaps of moist manure in the milking-yard.

Now as to the first; the milk is carried off the farm and sold every morning, so that none accumulates to sour, and all the milk vessels and utensils, as I wrote you, are kept perfectly clean and sweet. The pig-pen is so far removed from the milking-yard as not to come into the account at all.

As to the manure heaps; these were all carried away and the yard scraped the latter part of August, and no trouble resulted at the time of their removal, though a stench was at times noticeable, and the milking and straining into cans near by went on as usual.

After receiving your letter, I thought possibly there might be decaying refuse or manure under the stabling of the barn, from which germs of the fungus might come. So I ordered the cans carried quite a distance from the barn and yard, so far that the men grumbled loudly while journeying to and fro to empty their brimming pails.

And still the trouble continued. Some days it would be hardly noticeable, and then suddenly the milk would be as ropy as ever, with no apparent cause for the change. To be sure, as you suggested, the difficulty seemed to be aggravated by hot, muggy weather, but where the spores or germs could possibly spring from to impregnate the milk standing so far from any decaying or decomposed matter, is a problem I have vainly tried to solve.

I should have added that as soon as the cans were filled, they were carried to a tank of cold spring water some sixty or seventy rods away, where they remained until taken into the wagon for delivery. I wish also to add, that during the period of stringy milk, so many of my customers complained of its condition, that it was necessary to procure extra milk from a neighbor with which to supply them. This neighbor not only milks in the midst of manure heaps and refuse from a cider mill, in which swine are working much of the time, but his spring and spring house are in the center of the yard, and here, amidst all these unfavorable conditions, the milk is cooled and kept, and no ropy milk ever results. Now, as I think I wrote you at first, my difficulty occurs invariably in September, and lasts in some seasons a week or two, in others but a few days. Supposing your theory correct, would you not look for this condition of the milk more confidently in the close, muggy "dog-days" of August (during which in my case the difficulty never has occurred), than later in the season, when the atmosphere is usually dryer and cooler?

But before condemning your theory altogether, which as I stated seems exceedingly plausible, and which may after all account for some of the conditions, though I believe not for all, I wish to test it further when another season comes around and the difficulty returns again. As soon as the ropy condition appears, I shall yard and milk my cows in a dry mow-lot adjacent to the spring in which the milk is cooled and stored, and in this way shall be able to prove beyond doubt, I think, whether your suggestions are correct or not. Meantime if anything comes under your observation, throwing any light upon the subject, will you kindly call my attention to it. I am willing to answer all questions, and would gladly communicate with others similarly troubled.

I remain, gratefully yours,

E. H. Barber."

## STRAWBERRY BLIGHT.

The following correspondence on this subject is presented here as a contribution to the history of the ravages of a fungus which, long known in Europe, has but recently occasioned serious damage in this country, so far as I have been able to learn. The following letter is from J. B. Olcott, of South Manchester, who called my attention to this subject, and was written in obliging response to my request for an account of his observations on the strawberry blight.

"My acquaintance with strawberry rust, or blight, began about 1852 in my mother's garden. She sometimes had an acre, altogether, of old and new plantings. My eyes were not trained to observe plants then, and but little more so now. I recollect complaints, however, of short crops and the prevalence of foliage speckled with purple and brown blotches, like too many strawberry leaves of these days.

Last season two or three acres of my own were blighted by rust so as to damage the crop of certain varieties from one-fourth to a total loss in quantity and quality. This is the first serious failure I have experienced, but there is good reason to believe that a similar experience is quite common among small fruit growers. We are rather less inclined to confess disease among our plants and animals than among ourselves.

For two or three years previously I had seen small spots of a yard, or two or three yards in extent, scattered about, unaccountably, in various parts of the garden, that withered away in midsummer as if burned by fire. This was something apparently distinct from the speckled appearance of the foliage above mentioned. That has been so common as to seem quite natural—especially upon old plants after the fruiting season.

The damaging blight or rust of late years is either something new or else an aggravation of the old one. It affects the foliage worst, in my limited observation, during wet and warm weather. Wilson, Charles Downing and Kentucky were badly stricken with it during the short spell of "dog-day" weather immediately preceding the destructive frost in May of last spring. The finest and largest green leaves turned brown in a few hours. The effect of the blight was not sweeping, but a third or one-quarter of the leaves were more or less touched. That frost seemed to check the blight at once, but the plants never recovered their vigor.

To show a specimen of this deadly blight in its fresh state at the Station would require an express messenger. The leaves that are green and fresh yesterday might be so dry as to crumble to-morrow.

Our patches of Wilson, Downing and Kentucky, that were on a northern slope, where the subsoil retains more water, proved a total loss during the rains of June. From the withering of the foliage, quantities of fruit, that might have been second-rate after partial recovery from the early attack, failed to ripen. A plenty of such instances of suspended development were shown in the Hartford market. Very dry and sandy soil within gunshot in the same garden was not exempt from rust, but the earliest blossoms having been more exposed to frost, crop-results on the warm soil were a mixture of two disasters.

Other and larger plantations of Downings, mostly, with twenty-five or thirty varieties not so well known, brought a small crop of second-rate fruit.

Green Prolific—a small patch in the midst of blasted varieties—though not usually considered reliable by the writer, bore a heavy crop of its finest fruit.

A half acre of Crescent Seedling, side by side with half an acre of blighted Downings and under precisely the same treatment, yielded bountifully and without a tarnished leaf. An acre of Downings, newly planted last spring, with my best care seem, by a steady, dwarfed and stunted growth, to have the rust in a "chronic" form. A considerable patch of Champion of the same age and treatment has unblemished foliage of the healthiest growth.

Who can explain these curious exceptions?

Our five acre garden is barred like a gridiron with a score of manurial experiments, old and new, which throw no light upon the cause of the blight, except perhaps that a third of an acre of Downings heavily ashed three or four years since, may have been a shade or two the healthiest.

All our strawberries were ashed on the surface of the matted rows, but last season was the first time we had in recent years omitted a sprinkle of skimmed milk during the fall and winter preceding.

Last summer was a queer one, following an exceptional winter. No doubt the atmosphere favors parasitic growths on plants and animals, too, more at one time than another. This strawberry blight comes at its worst—not saying here whether it is the old spotted rust or not—as sudden as rust in damp weather upon oats.

Next season will be different, of course. These notes are as local as my insufficient study of the subject will let me make them. Strawberry troubles are very widely diffused, however. Our western brethren have a strawberry worm, beside this same blight, to contend with. Muscle, alone, will not be muckle enough for these problems. Let us hope for the current year that a great many more or less scientific noses—with microscopes to them—will be poked into this business.

A dust of lime, plaster or sulphur, might help in the beginning of the rust--say in the midst of those warm, damp spells--who knows?

Sometimes when I see "luck" going against our large undertakings, I get to thinking how it is a good time for everybody who can to help themselves to strawberries in a small way."

At my request, Prof. W. G. Farlow of Harvard University, kindly consented to examine the strawberry blight, and Mr. Olcott supplied specimens of affected plants. Prof. Farlow informed me under date of Nov. 25th, that "the strawberry blight is the same as the fungus which is common near Boston. The leaves sent were attacked by *Stigmatea fragrariæ*, Tulasne, in the conidial stage. The fungus is common everywhere in Europe. Just how much harm it does is hard to say. I am inclined to doubt that it occasions very much damage."

Prof. Farlow's identification of the blight enables me to give the following account of this fungus from Sorauer's *Handbook of the Diseases of Plants*,* page 336, which with the accompanying figures is taken from Tulasne's *Carpologia.*

The blight appears, at first, as a circular brown spot on the upper surface of the leaf. This spot enlarges and shortly becomes white at the center, where the juices of the leaf are exhausted and the cuticle separates from the empty cell-tissue beneath. This central white spot is surrounded by a red border which connects it with the brown exterior. Within the leaf at these spots, the long, delicate, usually colorless filaments (mycelium) of the fungus extend, consuming the juices of the leaf-cells and sending up to the surface and through the cuticle numerous bundles of longer or shorter filaments, which when young are white, but turn dark brown as they become older, and which bear at their free extremities the *conidia* or spores (single, oval sacs, or strings of them, each $\frac{6}{10000}$ inch long and $\frac{1}{5}$ as wide), which serve to reproduce the fungus. Other modes of spore-development occur which are hardly intelligible without figures.

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* *Handbuch der Pflanzenkrankheiten.* Berlin, 1874.

Sorauer states that this blight, which, in Germany, appears everywhere, occasions damage more often in loamy and close-textured than in open and sandy soils. He mentions an instance where plants forced in very rich earth were so severely attacked that the young leaves while yet unfolding exhibited numerous brown, red-bordered spots, and shortly dried away, but on transplanting in spring time into loose garden soil, recovered without further damage.

### ON THE

## DETERMINATION OF NITROGEN IN THE ANALYSIS OF AGRICULTURAL PRODUCTS.*

In the Report of this Station for 1877, p. 100, a new method of preparing soda-lime for use in determination of nitrogen was described as follows:

Equal weights of sal-soda in clean (washed) large crystals and of good white and promptly-slaking quick lime are separately so far pulverized as to pass holes of $\frac{1}{16}$ inch, then well mixed together, placed in an iron pot which should not be more than half filled and gently heated, at first without stirring. The lime soon begins to combine with the crystal water of the carbonate of soda, the whole mass heats strongly, swells up and in a short time yields a fine powder which may then be stirred to effect intimate mixture and to dry off the excess of water so that the mass is not perceptibly moist and yet short of the point at which it rises in dust on handling. When cold it is secured in well-closed bottles or fruit jars and is ready for use.

During the past year a large number of comparative analyses have been made on bone dust, dried blood, fish scraps, guano, maize meal, zein or maize fibrin, and egg-albumin, using soda-lime obtained as above described, and soda-lime either prepared by ourselves according to the directions of Varrentrap and Will,

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* This investigation and the one that follows "On a Method for the Determination of Phosphoric Acid," are the joint work of Mr. Jenkins and myself. Mr. Jenkins has not only performed all the analyses with great skill, but has also contributed many suggestions highly valuable to the progress of the inquiries and has mainly prepared the account of our results here given. S. W. J.

obtained by purchase (Merck's) or kindly supplied by W. M. Habirshaw, Esq., Chemist to the New York State Agricultural Society. These analyses have proved that the new soda-lime gives perfectly satisfactory results in all cases when soda-lime can be employed, or at least, results perfectly agreeing with those obtained by the help of the soda-lime as usually prepared. It is not needful to adduce analyses here in support of this statement since its truth will appear from the soda-lime combustions to be shortly given, all of which were made with this new mixture.

This soda-lime is to be recommended for the reasons that the materials for making it, sodium monocarbonate and quick-lime, are everywhere procurable in a state of purity, the preparation of several pounds of the mixture is accomplished in an hour or two with little trouble, and the resulting soda-lime is extremely convenient to use, not absorbing moisture in the mixing and never swelling in the tube to obstruct it on application of heat.

The controversy that has been so actively prosecuted of late years as to the applicability of the soda-lime method of determining nitrogen to the analysis of albuminoid matters, has led us to review the entire subject as far as possible. It is well known to chemists, that a number of experimenters, viz: Nowack, Seegen, Nencke, Liebermann, Voelcker, and Musso, have failed to obtain with the soda-lime method as high results on flesh, milk, and similar substances, as by the use of the so-called absolute method, in which the organic body is burned with oxide of copper and its nitrogen directly measured in the state of gas. Even Ritthausen, who has stoutly maintained the correctness of the soda-lime method, having employed it in his elaborate researches on the vegetable albuminoids, has very recently admitted that it fails to give all the nitrogen of some of this class of bodies and has fallen back on the absolute method as the only one to be depended upon.

Since it is a matter of high importance in agricultural and physiological work to use the most exact and especially the most trustworthy methods, we have endeavored to investigate the correctness of both modes of analysis, to study the sources of error to which they are severally subject and to learn what is essential to bring out the greatest accuracy they are susceptible of.

We have been led to the conclusion that with the substances above-named, both methods when properly worked give nearly accordant results. Dried blood, dried white of egg and maize fibrin (crude, obtained by Ritthausen's method) containing 13 or more per cent. of nitrogen have yielded us from one to two tenths of a per cent. less of nitrogen by the soda-lime combustion than by the absolute method. Our observations satisfy us, moreover, that this discrepancy is no more due to any fault of the soda-lime process than to the errors of the absolute method, errors caused, probably, by the impossibility of removing the last traces of common air from the mixture either by long continued transmission of pure carbonic gas or by exhaustion with the Sprengel mercury pump or by both conjointly.

The following results of analyses by both methods, are offered to sustain our assertions. We have not selected these analyses to establish the point, but give all the results we have obtained since learning the best mode of conducting the analytical processes and they fairly represent what the two methods can accomplish when applied with suitable precautions:

| | By the Absolute Method. | By Soda-lime. | Average difference. |
|---|---|---|---|
| Egg Albumin, | 12.54 per cent. | 12.34 per cent. | .17 per cent. |
| | 12.51 " | 12.36 " | |
| | 12.56 " | 12.38 " | |
| | 12.44 " | | |
| | 12.59 " | | |
| Maize Fibrin (crude) | 13.73 " | 13.60 " | .13 " |
| Dried blood, | 11.90 " | 11.78 " | .12 " |
| | 11.91 " | 11.72 " | |
| | | 11.88 " | |
| " " | 7.54 " | 7.58 " | .04 " |
| Fish scrap, | 9.21 " | 9.12 " | .14 " |
| | | 9.02 " | |
| " " | 8.79 " | 8.64 " | .11 " |
| | | 8.71 " | |
| | | 8.71 " | |
| Peruvian guano, | 8.27 " | 8.21 " | .06 " |
| " " | 8.63 " | 8.49 " | .15 " |
| | 8.66 " | 8.51 " | |
| " " | 8.21 " | 8.13 " | .12 " |
| | | 8.04 " | |
| " " | 9.68 " | 9.63 " | .03 " |
| | | 9.67 " | |
| " " | 7.56 " | 7.56 " | .00 " |
| | | 7.56 " | |

The above analyses illustrate a fact which is general in our experience, viz: that the agreement of several determinations made upon one substance is much closer by the soda-lime than by the absolute method. This fact goes far to show that the soda-lime process is, to say the least, equal in accuracy with the absolute determination.

The full details of the mode we follow in making an analysis by the absolute method cannot be given here. An outline of the process is as follows:

The substance mixed with *freshly ignited* copper oxide is burned in a long glass tube which has been exhausted by means of a mercury pump; the products of combustion after passing over ignited metallic copper and *finally over ignited copper oxide** are received in a graduated receiver surrounded by a water jacket and containing fifty per cent. solution of caustic potash. Complete combustion is ensured by heating, in due course, several grams of potassium chlorate at the rear of the tube, three inches of which is bent downward from the horizontal to retain the fused salt. The residual gas is transferred to the receiver by the pump, brought to a constant temperature by a stream of hydrant water and measured in the usual manner. The mercury pump employed is a very effective one, of simple and easy construction, devised for use in this kind of analysis.

With regard to the handling of the soda-lime method the following results have been arrived at:

1. Contrary to what is commonly stated, fine pulverization of the substance to be analyzed is not necessary. If the substance will pass holes of one millimeter in diameter it is fine enough.

A sample of dried blood which passed through a sieve with meshes one millimeter in diameter gave 7.58 per cent. of nitrogen. A portion of the same, ground extremely fine with sand, gave 7.64 per cent.

Fish scrap passed through the same sieve gave 8.98 per cent. of nitrogen, when ground with sand 8.95 per cent. A second sample of fish sifted as above gave 8.69 per cent. nitrogen. By the absolute method 8.79 per cent.

2. Neither the highest heat possible to obtain in an Erlenmeyer gas combustion furnace, nor a long layer of strongly heated soda lime, nor these two conditions united, occasion any appreciable dissociation of the ammonia formed in combustion.

A sample of dried blood gave 11.42 per cent. of nitrogen when the combustion was made in a tube 14 inches long at a dull red heat.

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* The use of a short layer of oxide of copper at the anterior end of the tube was adopted by the writer in 1873, when making analyses of Connecticut tobacco, he having found it impossible to make a blank combustion when using carbonic acid to sweep the tubes, without obtaining unabsorbed gas in the receiver, which proved to be combustible. By burning this gas in the analysis he was able to get results on uric acid and potassium ferrocyanide agreeing closely with theory and with those obtained by the soda-lime method. More recently, Frankland has adopted this use of copper oxide in nitrogen estimations for water analysis.

S. W. J.

The same sample yielded 11.56 per cent. when determined in a tube 30 inches long, the mixture occupying 12 inches, and the rinsings and clear soda lime 16 inches, using as high a heat as possible.

The same experiment was tried with egg albumin. In a tube 14 inches long it yielded 12.25 per cent., in one 30 inches long, filled as above, 12.34 per cent.

A superphosphate containing animal matter yielded 3.02 per cent. of nitrogen when the heat was kept quite low, 3.04 per cent. when the heat during combustion was very bright red.

3. The use of pure sugar or of oxalic acid as a diluent does not in any way affect the result.

| | | | | |
|---|---|---|---|---|
| Dried blood, | 0.5 grams, | gave | 10.33 | per cent. nitrogen. |
| " | " | with 0.5 grams sugar gave | 10.29 | " " |
| " | " | " 1.0 " " | 10.08* | " " |
| Dried blood, | " | gave | 11.56 | " " |
| " | 0.37 grams | with 1 gram sugar gave | 11.53 | " " |
| Egg albumin, | 0.5 " | gave | 12.51 | " " |
| " | 0.4 " | with 0.5 grams sugar gave | 12.41 | " " |
| " | 0.46 " | " " " | 12.50 | " " |
| " | 0.3 " | " " " | 12.54 | " " |

Experiments with oxalic acid gave similar results.

4. Iron tubes *of proper length* may be substituted for glass. The results are as satisfactory, but more time is required to make the combustion.

The iron tubes used in the following trials were 22 inches long. They were closed at the rear, and at the end of the combustion were cleared of ammonia by heating a mixture of oxalic acid or sugar and soda lime, which was kept cool in the rear of the tube till needed for this purpose.

| | In glass. | In iron. | |
|---|---|---|---|
| Egg albumin | 12.36 | 12.25 | per cent. nitrogen. |
| Dried blood | 11.42 | 11.56 | " " |
| Fish scrap | 9.01 | 8.99 | " " |
| " | 8.71 | 8.68 | " " |
| " | 8.66 | 8.72 | " " |
| Ammoniated superphosphate | 2.69 | 2.61 | " " |
| " " | 2.71 | 2.68 | " " |

In the Report for 1877 it was stated that combustions in iron tubes yielded 0.2 to 0.5 per cent. less than those in glass. This deficiency was occasioned simply by using too short an anterior layer of soda-lime, the tubes being but 14 inches long. Since iron is a good heat-conductor, these tubes had an effective length much less than glass tubes of the same dimensions would have.

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* In this analysis the combustion was not complete, owing to the large amount of sugar being mixed with insufficient soda-lime.

5. A suitable length of the anterior layer of soda-lime must be secured in order to get a good result. With 0.5 gram of substances, such as are encountered in agricultural chemistry, containing less than 8 per cent. of nitrogen, a glass tube of 12 to 14 inches is long enough. As the content of nitrogen increases to 10 per cent. or over, we make the tubes several inches longer. In the combustion of dried blood or egg-albumin we prefer a tube 25 to 30 inches long, and the mixture of soda-lime and substance should occupy rather less than half the tube, a layer of pure soda-lime of 12 or more inches long being essential for perfectly destroying the volatile organic matters.

6. The long anterior layer of pure soda-lime must be brought to a *full red heat* before heating the mixture, and must be so kept throughout the combustion.

7. No fumes or tarry matters, indicative of incomplete combustion, should appear in bulb-tube or receiver.

8. When the combustion proper is begun under the conditions above described, it can be carried on quite rapidly until completed. The contents of the tubes then show no sign of unburned carbon.

9. We get equally good results whether the mixture is made intimately in a mortar, or more roughly by stirring with a spatula in a metallic capsule or scoop, or by mixing in the tube with a wire.

10. We usually allow the glass tube to cool somewhat before aspirating with air to sweep out the ammonia, but have not as yet decided whether this precaution is essential.

11. We receive the ammonia of the combustion in a bulb-tube or flask containing standarded hydrochloric acid, and we measure the excess of acid by a standard ammonia solution, using tincture of cochineal as the indicator.

In conclusion, we recall the fact that some careful experimenters, Ritthausen, Märcker, Petersen, Kreusler, have repeatedly obtained results nearly as accordant as ours in the use of the two methods. Such results could scarcely be accidental, and we express our conviction that the discrepancies observed by others have been due to imperfect working of the processes. We have had great experience with both modes of determining nitrogen (one of us for twenty-five years), and not until recently have we learned how to be fairly certain of our results on *all* the classes of substances we have had occasion to analyze, either with the soda-lime process, or by the absolute method. The purity and uniformly satisfactory qualities of the new soda-lime have greatly facilitated our work. The use of cochineal as an indicator we consider very favorable to exact titration.

## ON A METHOD FOR THE DETERMINATION OF PHOSPHORIC ACID.

Otto long ago proposed a method for the separation of phosphoric acid from iron and aluminum which was based on the fact that ammonium tartrate will prevent the precipitation of the hydrates and phosphates of these metals in alkaline solutions, but does not prevent the precipitation of ammonio-magnesium phosphate.

W. Mayer (*Ann. Chem. u. Phar.*, 101, p. 164) has shown that unless a large amount of ammonia salts is present in solution, basic magnesium tartrate will also be precipitated with the phosphate. He prepared a solution for use in the determination of phosphoric acid in which the amounts of magnesia and ammonia salts were in such relation that a precipitation of basic magnesium tartrate was not to be feared. Such a solution cannot be used however for the direct gravimetric determination of phosphoric acid in the presence of much lime, because neutral calcium tartrate is apt to be precipitated with the ammonio-magnesium phosphate.

F. Stolba (*Fres. Zeitschrift*, xvi, 100) has shown that pure ammonio-magnesium phosphate can be determined by titration as well as by weighing, one molecule of the pure salt requiring two molecules of hydrochloric acid to destroy its alkaline reaction. Advantage has been taken of these observations in devising a plan of operating which should meet the want felt for a rapid and accurate method of determining phosphoric acid in commercial fertilizers. The standard acid used in other volumetric work answers perfectly for this. A strong, nearly saturated, solution of ammonium tartrate, free from carbonic acid, and a solution of some magnesium salt are also necessary. The latter is prepared by dissolving 70 grams of magnesium sulphate and 195 grams ammonium chloride in 1 liter of water. 10 cubic centimeters of this solution contain twice the amount of magnesium necessary to precipitate 0.1 gram phosphoric acid ($P_2O_5$). A suitable amount of the phosphate, in most cases 1 gram is a convenient quantity, is dissolved in hydrochloric acid, the solution nearly neutralized with ammonia, and ammonium tartrate solution is added, 10 cubic centimeters at a time till the solution remains perfectly clear when slightly alkaline. Add a suitable quantity of the magnesium mixture and either stir vigorously with a rod, or, if the precipitation is made in an assay flask, as it can be very conveniently, shake occasionally. When the precipitation is nearly complete add enough ammonia to make it very strongly alkaline, and let it stand 6–12 hours. It can then be filtered, preferably on the pump, and washed with equal parts of strong alcohol, 85–90 per cent., and water. No pains are taken to detach the precipitate from the glass. When the dish and precipitate are washed until the washings no longer react alkaline, the filter and precipitate are brought back into the beaker, or flask, a *little* water and a few drops of cochineal tincture are added, and it is titrated. This is best done by adding an excess of standard acid at once, stirring so that all the precipitate shall be wetted with it, and after it has stood a few minutes measure back with standard alkali.

The results given below (mostly duplicated) indicate the degree of accuracy to be expected.

| | Determined by use of ammonium molybdate. | Determined by the method just described. |
|---|---|---|
| Superphosphates, soluble phosphoric acid, | 8.92–8.96 | 8.83–8.91 |
| “ “ “ | 8.31 ---- | 8.32 |
| “ “ “ | 11.89–11.95 | 11.83–11.95 |
| “ “ “ | 5.14–5.08 | 5.07–5.11 |
| “ “ “ | 6.78 ---- | 6.68–6.84 |
| “ “ “ | 5.63–5.65 | 5.61–5.63 |
| “ total “ | 9.21–9.28 | 9.22–9.32 |
| “ “ “ | 10.70–10.72 | 10.76–10.87 |
| * “ “ “ | 16.66–16.66 | 16.55–16.65 |
| * “ “ “ | 13.94 ---- | 13.90–14.05 |
| Hair manure, ---- “ “ | 2.23 ---- | 2.19 ---- |
| Bone, ---------- “ “ | 21.90–21.90 | 21.87–21.75 |
| “ ---------- “ “ | 13.21–13.40 | 13.19–13.33 |
| “ ---------- “ “ | 22.57–22.62 | 22.57–22.76 |
| “ ---------- “ “ | 21.90–21.90 | 21.87–21.75 |
| Fish scrap, ------ “ “ | 6.17–6.27 | 6.17–6.28 |
| | Calculated. | |
| Tricalcic phosphate with 6.44 per cent. water, | 42.85 | 42.79 |
| The above (0.5 gram) with 0.22 gram iron in form of ferric chloride, ---------------- | 42.85 | 42.79 |

In the case of a few phosphatic materials rich in phosphoric acid, larger discrepancies than any above given have been occasionally encountered, and it is proposed to give them further attention, although it is our impression that they were accidental and do not invalidate the accuracy of the method.

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* Navassa superphosphates containing soluble iron and aluminum phosphates.

This process requires less than half the time and labor necessary for the molybdic method, is scarcely less accurate and appears to be generally applicable.

Some investigations, not completed as yet, lead us to hope that ammonium tartrate may be successfully substituted for ammonium citrate for bringing precipitated or reverted phosphates into solution. This step would still further simplify the analyses of superphosphates, since the entire phosphoric acid, soluble, reverted and insoluble, could be quickly estimated in a single portion.

Our investigations have also demonstrated that while ammonio-magnesium phosphate is totally insoluble in a very large excess of ammonium tartrate, it is soluble in excess of ammonium citrate, and when iron and aluminum are present, also in *insufficient* ammonium tartrate.

## CHEMICAL EXHIBIT.

The collection exhibited at the State Fair at Hartford by the Experiment Station is intended to illustrate the chemical composition of the various materials and products of our agriculture.

The exhibit contains:

1. Specimens of the fourteen CHEMICAL ELEMENTS out of which all soils, manures, plants and animals are made up, viz: the seven METALS, Hydrogen, Sodium, Potassium, Calcium, Magnesium, Iron and Aluminum, and the seven NON-METALS, Chlorine, Oxygen, Sulphur, Carbon, Silicon, Nitrogen and Phosphorus.

Of these elements, four ordinarily exist as gases, but all have been reduced by cold and pressure to the liquid and even to the solid state. Chlorine has a yellow color, Hydrogen, Oxygen and Nitrogen are colorless and undistinguishable by the eye from common air.

The exhibit contains:

2. Specimens of the commonly occurring MINERAL COMPOUNDS of these fourteen elements, classified as follows: OXIDES and HYDROXIDES, those of non-metals including *acids*, those of metals including *alkalies and other bases.* Then follow SALTS, viz: *Chlorides*, *Sulphides*, *Sulphates*, *Carbonates*, *Silicates*, *Nitrates* and *Phosphates.*

The exhibit shows:

3. The relative quantities by weight, and in case of gases the quantities by volume, according to which the elements combine chemically. The element, Hydrogen, which enters into chemical

union in the smallest quantity, is taken as the standard unit in the amount of one gram (=15.4 grains). The Compounds,—oxides, hydroxides and salts,—are represented in the quantities by weight (grams), which result from adding together the combining weights of their elements. This feature of the collection furnishes visible illustration of the law, that *chemical combination takes place only between simple and invariable proportions of the matters that unite.*

The collection serves—

4. To give definiteness to the conception of the various substances which now figure so prominently in all intelligent discussions of the fertilization and exhaustion of soils, such as "potash," "phosphoric acid," "nitrogen," "ammonia," "gypsum," etc. Without we have opportunity to see these things and learn their precise composition and nature, their names can suggest but indistinct and confused notions of their real character, and serious mistakes are constantly arising in attempting to deal with them in farm practice. The collection shows, for example, the elements, Hydrogen, Sulphur and Oxygen, then the compound of thirty-two parts *by weight* of Sulphur with forty-eight of Oxygen, known as *Sulphur Trioxide*, then the compound of eighty of the latter with sixteen of Oxygen and two of Hydrogen (=18 of water), which is *Sulphuric Acid.* Besides pure Sulphuric Acid, the various commercial grades of this acid are shown, viz: Oil of Vitriol, or 66° acid; Brown Oil of Vitriol, or 60° acid; and Chamber Acid of 50°. The labels state distinctly the composition of each and their differences. Similarly, the relations of phosphorus, phosphoric acid and the three phosphates of lime, those of nitrogen, ammonia and nitric acid are explained and, as far as may be, illustrated.

The collection contains—

5. Specimens of the ORGANIC COMPOUNDS (made up mostly of Carbon, Hydrogen, Oxygen and Nitrogen), which constitute Plants and Animals, or are products of vegetable and animal life. These are classified as Carbhydrates, Albuminoids, Fats, Acids, etc. Here *Starch*, the *Sugars*, *Dextrin*, *Fiber*, *Albumin*, *Casein*, etc., are represented.

The exhibit finally displays—

6. The CRUDE MATERIALS OF COMMERCIAL FERTILIZERS, as Native Phosphates, Bones, Potash Salts, Gypsum, Marls, Ashes, Guanos, etc. These are illustrated by characteristic specimens which are in many cases accompanied by a more or less detailed chemical analysis.

## WHITE HELLEBORE.

This article, in a powdered state, is in such large demand as an insecticide, that Prof. Brewer suggested the examination of a sample with a view to test its purity. The specimen was free from mineral adulterants, as it yielded on burning but nine per cent. of ash, of which 4.4 per cent. was silica and soil, insoluble in acids. The quantities of mineral matter are no greater than should be expected in a vegetable substance of the kind.

Under the microscope the powdered hellebore was seen to contain a good deal of starch, but the tissues which characterize the meal of ordinary grains were not recognizable. Whether this starch belongs to the hellebore or is added to adulterate or "extend" it, as is not improbable, can only be learned by comparison with hellebore of undoubted purity.

## COMPOSITION OF A SAMPLE OF PARIS GREEN.

A sample of unknown manufacture, sold as "strictly pure" by James O. May of Naugatuck, was sent June 10th, by J. B. Tolles, President Naugatuck Farmers' Club.

The composition of the sample is here compared with that of pure aceto-arsenite of copper, and it is seen to approach the chemically pure article as nearly as could be expected.

| | Aceto-arsenite of copper. | | "Strictly pure Paris green." |
|---|---|---|---|
| Copper | 25.01 | | 24.97 |
| Arsenious oxide (white arsenic) | 58.60 | | 55.19 |
| Acetic acid (radical) | 16.39 | undetermined | 19.84 |
| | 100.00 | | 100.00 |

## CAN A SUPERPHOSPHATE PROVE A FATAL POISON?

Early in July I received ~~a~~ package of a well-known superphosphate from Dr. A. W. Bell of Moodus, who stated that three patients of his had been seriously ill after using it, and an examination of it for poisons was desired. The circumstances were as follows: About June 15th a father, with three sons, applied the phosphate on a field of tobacco. The fertilizer was very dry, the day windy and rainy. The father dropped the phosphate, which had a strong, disagreeable smell, and blew into his face considerably. The two elder boys covered, and some blew against them. The youngest set the plants, perceived no odor and was not at all sick. Shortly after, the father was seized with pain in the head, swelling of the eyes and face, nausea and pain in the stomach, and general soreness. The last named symptom lasted about ten days before its disappearance. Numbness and cold of the right leg and foot came on, which yielded somewhat to friction, but the latter occasioned intense pain. The foot became more and more discolored, and finally required amputation. The patient died shortly after. The lads had the same swelling of the face and eyes, with pain in the stomach and diarrhea, but recovered.

The superphosphate received by me had the strong and peculiar odor of "Sludge Acid," i. e., the oil of vitriol which has been used for the purification of crude petroleum. Whether this sludge acid or the substances produced by its action on crude petroleum and brought by it into the superphosphate, in whose manufacture it is extensively employed, are capable of producing the symptoms above described, I cannot say, having never seen any account of ill effects resulting from it, or from the handling of superphosphates of which it is an ingredient.

Since some of the symptoms reported by Dr. Bell bear much resemblance to those sometimes occasioned by arsenic, and since arsenic is a common, though very small, ingredient of the oil of vitriol made in Europe from the sulphur obtained in the roasting of certain ores, the superphosphate was carefully tested for arsenic, but no trace of this poison was discovered.

It is not impossible that putrescent animal matters, used in the compounding of superphosphates, may poison by their inhalation. And in these days, when Paris green is used everywhere for destroying the potato bug, it might happen that its unsuspected admixture with some portion of the phosphate, or an accidental exposure to its dust on the day when the phosphate was used, may have been the real cause of these results.

The facts of this case show that great caution is needful in the handling of commercial fertilizers. Their dust should never be breathed. If they are so dry as to rise readily in the air, they should be damped enough to prevent it. Paris green especially should be used with extreme care. The leaving of it around in barns or sheds in open boxes or papers should not be permitted. In applying it, it is best to mix with water, and any small residues not used should be mixed with moist earth and well covered in the ground.

## A CASE OF SUPPOSED HORSE POISONING.

In August last, three horses belonging to Mr. Cyrus L. Barber, of Harwinton, Litchfield County, died in a manner that led to the suspicion that they were poisoned. The first symptom noticed was inability to swallow, from paralysis of the tongue, which was shortly followed by loss of power in the jaws, rigidity of the walls of the abdomen, and general paralysis, with congestion of all the internal organs. In the last stages the animals appeared to be in extreme distress, with profuse perspiration; some of them had spasms. The cases terminated fatally in one to five days.

The medical men who saw the horses thought the symptoms indicated poisoning with one or several vegetable alkaloids, probably those of *nux vomica.*

In response to the application of D. C. Kilbourn, Secretary of the Litchfield County Agricultural Society, the Station undertook to examine the stomach, liver, and intestines of one of the horses for poisons, and in August Mr. Jenkins tested the visceræ for the mineral poisons and for strychnine. Afterwards the assistance of Wm. T. Sedgwick, Ph.B., Instructor in Physiological Chemistry in the Sheffield School, was secured and he made a full examination for vegetable poisons according to the most recent methods. This work occupied several weeks in its completion, but no distinct evidence was obtained of the presence of any poisonous substance whatever.

Circumstances pointed strongly to a certain person as the cause of these calamities, and shortly after the death of a fourth horse belonging to Mr. L. O. Bradley, a neighbor of Mr. C. L. Barber, these suspicions led to such demonstrations as caused the sudden departure of the suspected person.

In reference to the failure of the Station to detect the poison which in all probability was administered in these cases, I should say that there are many vegetable poisons, which have not as yet been sufficiently studied by the chemist to admit of identification, when mixed with the food and secretions of the stomach and intestines. This kind of investigation is extremely difficult and can only be prosecuted to advantage by specialists who are able to devote their entire energies to the work.

## SUGAR BEETS.

The year 1878 is complained of by Connecticut farmers as having been very unfavorable to the root crops. This is probably the reason why so few samples of sugar beets were sent us for analysis and why those examined were mostly so deficient in sugar. The following statement gives the result of the testing of five samples. The per centage of sugar was determined by the Polariscope. For the loan of an excellent instrument the Station is indebted to the kindness of W. M. Habirshaw, Esq., Chemist to the New York State Agricultural Society.

| Variety. | Sent by | Specific gravity of juice. | Percentage of sugar in the juice. | Average weight of a single root. |
|---|---|---|---|---|
| Imperial Sugar Beet. | J. H. Dickerman, Mount Carmel. | 1.0404 | 7.83 | 12 ozs. |
| Unknown. | J. J. Webb, Hamden. | 1.0338 | 4.73 | 3 lbs. 2 ozs. |
| Lane's Improved Imperial Sugar Beet. | H. L. Fairchild, Bridgeport. | 1.0319 | 6.50 | 2 lbs. 1 oz. |
| White Silesian Sugar Beet. | H. L. Fairchild, Bridgeport. | 1.0521 | 9.53 | 1 lb. 3 ozs. |
| White French Sugar Beet. | H. L. Fairchild, Bridgeport. | 1.0687 | 11.40 | 1 lb. 4 ozs.<br>much withered. |

## MENHADEN STATISTICS FOR 1878.

In am indebted to H. L. Dudley, Esq., Sec'y, for the report of the U. S. Menhaden Oil and Guano Association for 1878, which gives the following statistics for the Menhaden fisheries of the Atlantic coast for that year.

| | |
|---|---|
| No. of factories in operation, | 56 |
| No. of men employed, | 3,337 |
| No. of sailing vessels employed, | 279 |
| No. of steam vessels employed, | 64 |
| No. of fish caught, | 767,779,250 |
| No. of barrels caught, | 2,559,264 |
| No. of gallons of oil made, | 3,809,233 |
| No. of tons of crude guano or green scrap made, | 83,719 |
| Amount of capital invested, | $2,350.000 |

The number of factories remains the same as in 1877. One more steamer, nine more sailing vessels, 706 more men, and $300,000 more capital, have been employed in 1878 than in the previous year. The gain in the amount of fish caught in 1878, over that taken in 1877, was 600,517 barrels. But 885 tons of guano (dried scrap) were held by the manufacturers, Jan. 15, 1879.

## CONDIMENTAL CATTLE FOOD.*

XXXIV. This article, prepared by the Condimental Food Co., 208 N. Front street, Philadelphia, is sold at $8.00 per 400 feeds of 100 pounds. It is represented, when used in connection with the usual feed, to secure "not only perfect digestion, but proper assimilation, rapid fattening, to save three-fourths the usual amount of feed, to increase the yield of milk on an average about three quarts per day and to improve the quality," etc., and is supported by the usual testimonials.

It consists chiefly of corn meal and bran. It contains enough fenugreek to give it a strong flavor of that aromatic seed, and likewise contains some seeds like caraway in appearance, but smaller and quite destitute of taste. Caraway, fennel, anise, ginger, elecampane and other stimulants and tonics have been used as condiments, and some of them may be present in this "Cattle Food."

The chemical analysis is as follows:

| | Condimental cattle food. | Equal weights of wheat bran and maize meal. |
|---|---|---|
| Water | 9.80 | 12.05 |
| Ash | 3.65 | 3.55 |
| Albuminoids | 10.88 | 11.00 |
| Fiber | 7.82 | 5.10 |
| Carbhydrates | 63.45 | 64.95 |
| Fat | 4.40 | 3.35 |
| | 100.00 | 100.00 |

The composition of a mixture of equal weights of wheat bran and maize meal, such as were analyzed in 1877 (see last Report, pp. 56 and 59), is given by way of comparison.

The value of the "condimental" *as food* is accordingly not far from $1.00 per hundred pounds. Its value as a condiment, commercially speaking, is the cost of the fenugreek, &c., it contains. Since fenugreek can be had of the druggist for 25 cents per pound, and a few pounds of it would be enough to make a hundred weight of corn meal and bran "condimental," the total money-value of this article is probably less than $2.00 per hundred.

As to the use of fenugreek and like aromatics in cattle food, there can be no doubt that they are occasionally serviceable, but their true place is as medicine, not as food. Mr. Lawes, of Rothamstead, England, made a most thorough, practical trial on the use of condiments in feeding, and demonstrated that there

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* Accidentally omitted from the account of Feeding Stuffs.

was no profit in it. One of his trials was made on twenty sheep (ten fed with plain food, ten with condiment) and continued twenty-eight weeks, when the animals were slaughtered and marketed. The *extra cost of feeding ten sheep with condiment* was £3 14s., the result of the feeding being alike with condiment and with plain food.*

Mr. Lawes has stated† that while sheep ate no more food under the stimulus of condiments than without, pigs did eat a larger quantity, but the pigs assimilated no more and got no benefit from the increased consumption.

Other testimony to the same effect may be found in the agricultural journals of Great Britain, where condimental foods were extensively tested fifteen to twenty years ago.

## LAW CONCERNING SALE OF FERTILIZERS.

### General Statutes of Connecticut.

### Revision of 1875.

Title 16, Chapter 15.

Sec. 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 12.

Sec. 5. Any manufacturer, or trader, who shall sell, or offer for sale, any package containing fifty pounds or more of commercial manure, not marked as required by law, or who shall affix thereto a stamp, impress, or card, claiming that it contains five per cent. more of any fertilizing ingredient than it does in fact, shall forfeit ten dollars for each hundred pounds thereof so offered for sale.

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* Experiments on the Question whether the use of Condiments increases the Assimilation of Food by Fattening Animals, or adds to the Profits of the Feeder; by J. B. Lawes, F.R.S., *Edinburgh Veterinary Review*, 1862.

† *Journal Royal Agricultural Society of England*, xxiii, p. 425.

## "AN ACT ESTABLISHING THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

"*Be it enacted by the Senate and House of Representatives in General Assembly convened:*

"Section 1. That for the purpose of promoting agriculture by scientific investigation and experiments, an institution is hereby established, to be called and known as The Connecticut Agricultural Experiment Station.

"Sec. 2. The management of this institution shall be committed to a Board of Control, to consist of eight members, one member to be selected by the State Board of Agriculture, one member by the State Agricultural Society, one member by the Governing Board of the Sheffield Scientific School at New Haven, and one member by the Board of Trustees of the Wesleyan University at Middletown, and two members to be appointed by the Governor of this State, with the advice and consent of the Senate. The Governor of the State, and the person appointed as hereinafter provided to be the Director of the Station, shall also be *ex officio* members of the Board of Control.

"Sec. 3. After the appointment of the members of the Board of Control as aforesaid, said members shall meet and organize by the choice from among their number of a President, a Secretary, and a Treasurer, who shall be elected annually, and shall hold their respective offices one year, and until the choice of their successors. Five members of said Board shall constitute a quorum thereof for the transaction of business.

"Sec. 4. Said Board shall meet annually after the first meeting thereof, on the third Tuesday in January in each year, at such place in the city of Hartford as may be designated by the President of said Board, and at such other times and places, upon the call of the President, as may be deemed necessary, and may fill vacancies which may occur in the officers of said Board.

"Sec. 5. Said Board of Control shall locate and have the general management of the institution hereby established, and shall appoint a Director, who shall have the general management and oversight of the experiments and investigations which shall be necessary to accomplish the objects of said institution, and shall employ competent and suitable chemists and other persons necessary to the carrying on of the work of the Station. It shall have power to own such real and personal estate as may be necessary for carrying on its work, and to receive title to the same by deed, devise, or bequest. It shall expend all moneys appropriated by the State in the prosecution of the work for which said institution is established, and shall use for the same purpose the income from all funds and endowments which it may hereafter receive from other sources, and may sue and be sued, plead and be impleaded, in all courts, by the name of The Connecticut Agricultural Experiment Station. It shall make an annual report to the Legislature which shall not exceed two hundred printed pages, of which not exceeding three thousand copies shall be printed.

"Sec. 6. The sum of five thousand dollars annually is hereby appropriated to said Connecticut Agricultural Experiment Station, which shall be paid in equal quarterly installments to the Treasurer of said Board of Control, upon the order of the Comptroller, who is hereby directed to draw his order for the same; and the Treasurer of said Board of Control shall be required, before entering upon the duties of his office, to give bond with surety to the Treasurer of the State of Connecticut in the sum of ten thousand dollars, for the faithful discharge of his duties as such Treasurer.

"Sec. 7. Upon the death or resignation of any of the members of the Board of Control, the authority or institution by which such deceased member was originally appointed shall fill the vacancy so occasioned.

"Sec. 8. Professor Samuel W. Johnson, of New Haven, is hereby empowered to appoint and call the first meeting of said Board of Control as soon as may be practicable after the appointment of the members thereof, and he shall notify all said members of the time and place of said meeting. Two of said members shall hold office for one year, two of them for two years, and two of them for three years; and at said first meeting they shall determine by lot which of said members shall hold office for one year, which for two years, and which for three years. All members of said Board thereafter chosen or appointed, except such as are appointed or chosen to fill vacancies in said Board, shall continue in office for the term of three years from the first day of July next succeeding such appointment.

"Sec. 9. This act shall take effect from its passage.

Approved March 21, 1877."