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PUBLIC DOCUMENT No. 24

# FIFTY-THIRD REPORT

OF THE

# CONNECTICUT AGRICULTURAL EXPERIMENT STATION

NEW HAVEN

FOR THE YEAR
1929

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The Board of Control

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NEW HAVEN, CONN.

# CONNECTICUT AGRICULTURAL EXPERIMENT STATION

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H. G. M. Jacobson, M.S., *Assistant Agronomist.*
Herbert A. Lunt, Ph.D., *Assistant in Forest Soils.*
Dwight B. Downs, *General Assistant.*

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Paul J. Anderson, Ph.D., *Pathologist in Charge.*
T. R. Swanback, M.S., *Agronomist.*
O. E. Street, Ph.D., *Plant Chemist.*
Miss Dorothy Lenard, *Secretary.*

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## LETTER OF TRANSMITTAL
AND
## REPORT OF THE BOARD OF CONTROL

*To His Excellency, John H. Trumbull, Governor of Connecticut:*

The Board of Control of the Connecticut Agricultural Experiment Station herewith submits its Fifty-Third Annual Report, for the year ending October 31, 1929. The financial reports covering the several appropriations appear on pages vii-xiii.

A general statement on the work of the year will be found in the Report of the Director (pages 749 to 771), which was issued as Bulletin 318.

The Report for this year consists of 17 bulletins, each dealing with a particular phase of the Station's activities. Of unusual interest are the "Fifty Years' Index" (Bulletin 309) prepared by Dr. Jenkins, and the Memorial to Dr. Thomas B. Osborne (Bulletin 312), in whose death on January 29, 1929, the Station suffered a great loss.

The General Assembly of 1929 made some small increases in the several Station appropriations. In the case of the Insect Pest Appropriation no increase was made, with the result that the Entomologist has been obliged to ask for certain special allotments to take care of the outbreaks of the Oriental peach moth, the Japanese beetle, and the European corn borer.

On February 13, 1929, occurred the death of Mr. Charles R. Treat, a member of this Board since 1919 and for several years its Vice-President. At its meeting on April 10, 1929, the Board adopted the following minute:

Mr. Charles R. Treat, a member of this Board, died at his home at Orange, Conn., on February 13, 1929, aged 57 years.

Born in Orange, he attended the public school there and later the New Haven High School, entered the Sheffield Scientific School of Yale University and graduated among the leaders of his class in 1894. He then took graduate study in civil and mining engineering at the same institution. The next two years were spent in Nevada in the mining industry. Then the call of the land brought him back to his home and to the development of the farm's resources; a business which he followed till his death. He was a leader in the production of seed sweet corn, successfully applying to it scientific method and experiment, in which he cooperated with this Station. His ability and power of leadership in agricultural affairs were quickly recognized. He was one of the organizers of the New Haven County Farm Bureau and continuously a director of it from 1915 till his death. He was a member of the State Board of Agriculture from 1917 till it was succeeded by a Commissioner. In 1917 and again in 1919 he was a member of the lower house of the General Assembly, in both terms a member of the committee on agriculture and in the second term its chairman. In 1921 he was elected to the Senate and was the chairman of its committee on agriculture. For

15 years he served on the school board of his native town. He also served as town treasurer, vice-president of the Home Bank and Trust Co. of Orange, and as a director of the Federal Land Bank of Springfield, Mass.

In 1919 Mr. Treat was appointed a member of the Board of Control of this Station and served as a member and as one of its executive committee until his death. To these duties he brought a wide acquaintance with agricultural problems and with the farmers of the state, experience in financial and legislative matters, and a clear common sense. He was interested and appreciative both of the research work of the Station and of its practical application to the work of the farm. His opinion and experience were invaluable to his associates, while his frankness, reasonableness and genial comradeship made him a most agreeable companion.

This Board here records their great appreciation of his public services, especially of his wise, helpful and unselfish services to this Station, and their deep sense of personal sorrow and of loss in his departure.

All of which is respectfully submitted,

GEORGE A. HOPSON,
*Secretary.*

## REPORT OF THE TREASURER

**July 1, 1928—June 30, 1929**

### RECEIPTS

| | | | |
|---|---|---|---|
| Balance on hand, July 1, 1928: | | | |
| State Appropriation | | ........ | $72.82 |
| State Appropriation (current expense) | | $53,000.00 | |
| " " (miscellaneous additions) | | 579.15 | |
| United States Appropriation (Hatch) | | 7,500.00 | |
| " " " (Adams) | | 7,500.00 | |
| " " " (Purnell) | | 25,000.00 | |
| " " " (Clarke-McNary) | | 1,504.21 | |
| Yale Soil Fund | | 850.00 | |
| Fertilizer analysis fees | | 13,500.00 | |
| Feed analysis fees | | 6,800.00 | |
| Lockwood Trust Fund | | 6,000.00 | 122,233.36 |
| | | | $122,306.18 |
| MISCELLANEOUS RECEIPTS: | | | |
| Balance on hand, July 1, 1928 | | $119.23 | |
| Sales of gasoline | $364.27 | | |
| Sales of automobile oil | 31.22 | | |
| Mileage for use of automobiles | 268.60 | | |
| Sale of waste and old paper | 7.07 | | |
| Sale of photographic enlargement | 5.00 | | |
| Interest on bank deposits | 112.98 | 789.14 | |
| | | $908.37 | |
| LESS MISCELLANEOUS RECEIPTS DEPOSITED WITH STATE TREASURER | | 686.61 | 221.76 |
| | | | $122,527.94 |

### DISBURSEMENTS

| | |
|---|---|
| Salaries | $75,237.49 |
| Labor | 20,024.91 |
| Stationery and office supplies | 1,070.91 |
| Scientific supplies (chemicals) | 1,395.51 |
| " " (other laboratory supplies) | 1,531.44 |
| " " (photographic supplies) | 222.06 |
| Feeding stuffs | 310.55 |
| Insecticides, etc. | 93.46 |
| Lumber and small hardware | 17.12 |
| Miscellaneous supplies | 928.43 |
| Automobile oil | 248.74 |
| Food and drug samples | 7.21 |
| Fertilizers | 906 71 |
| Telegraph and telephone | 401.25 |
| Postage | 435.96 |
| Travel expense (outlying investigations) | 1,253.68 |
| " " (meetings, conferences, etc.) | 1,527.94 |
| " " (gasoline for automobiles) | 977.55 |

| | | |
|---|---|---|
| Freight, express and parcel post | $ 230.99 | |
| Miscellaneous transportation charges | 59.80 | |
| Publications (reprints, etc.) | 279.42 | |
| Coal | 1,778.59 | |
| Gas and electricity | 2,173.19 | |
| Water | 242.65 | |
| Furniture and fixtures (new) | 970.25 | |
| " " " (repairs) | 84.97 | |
| Library (books and periodicals) | 1,046.19 | |
| " (binding) | 163.20 | |
| Scientific equipment (new) | 997.37 | |
| " " (repairs) | 103.92 | |
| Automobiles (new) | 490.00 | |
| " (repairs) | 385.76 | |
| Tools, machinery and appliances (new) | 590.47 | |
| " " " " (repairs) | 146.05 | |
| New buildings and structures | 3,083.50 | |
| Buildings (repairs and alterations) | 1,106.11 | |
| Grounds | 1.80 | |
| Insurance (fire, burglary and automobile) | 1,198.56 | |
| Miscellaneous contingent expenses | 214.00 | |
| Total disbursements | | $121,937.71 |
| Balance on hand June 30, 1929: | | |
| State General Appropriation (in hands of State Comptroller) | $368.47 | |
| Miscellaneous receipts (in hands of Station Treasurer) | 221.76 | 590.23 |
| | | $122,527.94 |

William L. Slate,
*Treasurer.*

REPORT OF

## WILLIAM L. SLATE, TREASURER

IN ACCOUNT WITH

## FOOD AND DRUG APPROPRIATION

**July 1, 1928—June 30, 1929**

RECEIPTS

| | |
|---|---|
| State Comptroller (Food and Drug Appropriation) | $7,500.00 |

EXPENDITURES

| | |
|---|---|
| Salaries | $7,500.00 |

REPORT OF

## WILLIAM L. SLATE, TREASURER

IN ACCOUNT WITH

## INSECT PEST APPROPRIATION

(Section 2109 of General Statutes, Revision of 1918)

**July 1, 1928—June 30, 1929**

RECEIPTS

| | | | |
|---|---|---|---|
| Insect Pest Appropriation | $30,000.00 | | |
| Deficiency appropriation | 15,000.00 | | |
| Refunds, etc. | 543.32 | | |
| | | $45,543.32 | |
| Charged to allotment for second year of fiscal period, July 1, 1928 | | 8,888.05 | |
| | | | $36,655.27 |

DISBURSEMENTS

| | | | |
|---|---|---|---|
| Salaries | $18,710.00 | | |
| Labor | 7,936.43 | | |
| Stationery and office supplies | 175.64 | | |
| Scientific supplies (chemicals) | 22.94 | | |
| " " (other laboratory supplies | 22.58 | | |
| " " (photographic supplies) | 95.11 | | |
| Insecticides, etc. | 804.11 | | |
| Lumber and small hardware | 3.40 | | |
| Miscellaneous supplies | 110.46 | | |
| Automobile oil | 144.53 | | |
| Fertilizer | 10.00 | | |
| Telegraph and telephone | 188.02 | | |
| Postage | 71.50 | | |
| Travel expense (outlying investigations) | 2,759.29 | | |
| " " (meetings, etc.) | 364.14 | | |
| " " (gasoline for automobiles) | 731.44 | | |
| Freight, express and parcel post | 38.98 | | |
| Electricity | 39.24 | | |
| Furniture and fixtures (new) | 491.19 | | |
| " " " (repairs) | 23.45 | | |
| Library (books and periodicals) | 89.44 | | |
| Scientific equipment (new) | 570.39 | | |
| " " (repairs) | 1.35 | | |
| Automobiles (new) | 581.00 | | |
| " (repairs) | 339.99 | | |
| Tools, machinery and appliances (new) | 145.49 | | |
| " " " " (repairs) | 2.25 | | |
| New buildings and structures | 709.69 | | |
| Buildings (repairs and alterations) | 15.15 | | |
| Rent of land and buildings | 58.75 | | |
| Insurance, automobile | 54.92 | | |
| Miscellaneous contingent expenses | 131.84 | | |
| Total disbursements | | $35,442.71 | |
| Balance on hand, June 30, 1929 | | 1,212.56 | |
| | | | $36,655.27 |

REPORT OF

## WILLIAM L. SLATE, DIRECTOR

IN ACCOUNT WITH

## MOSQUITO ELIMINATION APPROPRIATION

(Sections 2409 and 2410 of General Statutes, Revision of 1918; Amended by Chapter 68, Public Acts of 1923)

**July 1, 1928—June 30, 1929**

RECEIPTS

| | | | |
|---|---|---|---|
| State Appropriation | $7,500.00 | | |
| Deficiency Appropriation | 7,446.00 | | |
| Sale of tools and use of automobile | 60.05 | | |
| | | $15,006.05 | |
| Charged to allotment for second year of fiscal period, July 1, 1928 | | 777.40 | |
| | | | $14,228.65 |

DISBURSEMENTS

| | | |
|---|---|---|
| Salary | $2,500.00 | |
| Labor | 9,734.78 | |
| Stationery and office supplies | 52.85 | |
| Photographic supplies | 4.40 | |
| Miscellaneous supplies | 57.90 | |
| Automobile oil | 7.50 | |
| Telephone and telegraph | 8.55 | |
| Travel (outlying investigations) | 435.04 | |
| " (meetings and conferences) | 41.28 | |
| " (gasoline) | 197.28 | |
| Freight, express and parcel post | 7.87 | |
| Furniture and fixtures (new) | 4.95 | |
| Scientific equipment (new) | 19.48 | |
| Tools, machinery and appliances (new) | 210.54 | |
| " " " " (repairs) | 17.92 | |
| Automobile repairs and accessories | 297.06 | |
| Tidegates and culverts | 69.60 | |
| " " " (repairs) | 103.47 | |
| Insurance (automobile) | 49.49 | |
| | | $13,819.96 |
| Balance on hand, June 30, 1929 | | 408.69 |
| | | $14,228.65 |

REPORT OF

## WILLIAM L. SLATE, DIRECTOR

IN ACCOUNT WITH

## TOBACCO RESEARCH APPROPRIATION

(Public Acts, 1921, Chapter 184)

**July 1, 1928—June 30, 1929**

RECEIPTS

| | | | |
|---|---|---|---|
| State Appropriation | $15,000.00 | | |
| Sales of tobacco | 1,881.24 | | |
| Insurance rebate | 12.50 | | |
| | | $16,893.74 | |
| Charged to allotment for second year of fiscal period, July 1, 1928 | | 663.11 | |
| | | | $16,230.63 |

DISBURSEMENTS

| | | |
|---|---|---|
| Salaries | $9,860.00 | |
| Labor | 2,054.18 | |
| Stationery and office supplies | 68.81 | |
| Chemicals | 18.98 | |
| Laboratory supplies | 33.35 | |
| Photographic supplies | 37.18 | |
| Feeding stuffs | 19.50 | |
| Insecticides and fungicides | 12.20 | |
| Lumber and small hardware | 67.33 | |
| Miscellaneous supplies | 580.27 | |
| Automobile oil | 17.00 | |
| Fertilizer | 682.19 | |
| Telephone, telegraph and telegram | 59.49 | |
| Travel (outlying investigations) | 378.74 | |
| " (meetings, conferences, etc.) | 102.71 | |
| " (gasoline) | 82.40 | |
| Freight, cartage and express | 125 08 | |
| Coal | 673.65 | |
| Printing | 2.15 | |
| Electricity | 85.44 | |
| Water | 32.57 | |
| Furniture and fixtures (repairs) | 13.35 | |
| Books, periodicals and subscriptions | 26.50 | |
| Library (binding) | 6.75 | |
| Scientific apparatus (new) | 229.93 | |
| Automobiles (new) | 548.00 | |
| Automobiles (repairs) | 12.30 | |
| Tools, machinery and appliances (new) | 133 91 | |
| " " " " (repairs) | 13.06 | |
| Buildings (repairs and alterations) | 76.56 | |
| Rent of land | 75.00 | |
| Buildings and land (grounds) | 35.68 | |
| Insurance (automobile and tobacco) | 57.28 | |
| Contingent | 2.60 | |
| | | $16,224.14 |
| Balance on hand, June 30, 1929 | | 6.49 |
| | | $16,230.63 |

REPORT OF

## WILLIAM L. SLATE, DIRECTOR

IN ACCOUNT WITH

## WHITE PINE BLISTER RUST APPROPRIATION

(Section 2117 of General Statutes, Revision of 1918)

**July 1, 1928—June 30, 1929**

RECEIPTS

| | | | |
|---|---|---|---|
| State Appropriation | $7,500.00 | | |
| Refund for labor | 2,863.08 | | |
| | | $10,363.08 | |
| Charged to allotment for second year of fiscal period, July 1, 1928 | | 2,548.92 | |
| | | | $7,814.16 |

EXPENDITURES

| | | | |
|---|---|---|---|
| By the State Comptroller on vouchers submitted by William L. Slate, *Director* | | | |
| Salaries | $600.00 | | |
| Labor | 6,383.03 | | |
| Lumber and small hardware | 31.18 | | |
| Miscellaneous supplies | 4.85 | | |
| Telegraph and telephone | 25.36 | | |
| Travel (outlying investigations) | 366.54 | | |
| " (meetings, conferences, etc.) | 27.30 | | |
| Automobiles (repairs) | 65.65 | | |
| Insurance (automobile) | 153.46 | | |
| Miscellaneous contingent expenses | 155.79 | | |
| Total disbursements | | $7,813.16 | |
| Balance on hand, June 30, 1929 | | 1.00 | |
| | | | $7,814.16 |

Connecticut Agricultural Experiment Station
New Haven

# REPORT ON INSPECTION
## OF
# COMMERCIAL FERTILIZERS FOR 1929

E. M. BAILEY, *Chemist in Charge of the Analytical Laboratory.*

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**The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.**

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

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Miss Dorothy Lenard, *Secretary.*

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY, NEW HAVEN, CONN.

# INSPECTION OF COMMERCIAL FERTILIZERS 1929

E. M. Bailey,*
*Chemist in Charge, Analytical Laboratory.*

## THE FERTILIZER LAW.

The provisions of the Connecticut fertilizer law have been discussed in previous reports but for more ready reference its essential features may be mentioned here.

### Significance of the Term "Commercial Fertilizers."

Explaining what is meant by the term "commercial fertilizers" the law says:

"The term 'commercial fertilizers' shall be construed to mean any and every substance imported, manufactured, prepared or sold for fertilizing or manuring or soil amendment purposes, except barnyard manure and stable manure which have not been artificially treated or manipulated, marl and lime. Cottonseed meal, rapeseed meal, castor pomace and all other vegetable products used as fertilizers, including the ashes of cotton hulls and wood ashes, shall be included as fertilizers within the meaning of this act and separate analysis fees shall be paid on each different grade which is sold or offered for sale in the state. The person responsible for paying the fees above prescribed may deduct from the total tonnage sold such sales of cottonseed meal or other vegetable products as are made to anyone who gives a written certificate on a form supplied by the Connecticut Agricultural Experiment Station stating that the material bought by him was to be used exclusively for feed and not for fertilizer."

### Concerning Cottonseed Meal.

Cottonseed meal is a fertilizer within the meaning of the Statute but it is provided that when this product is sold for feeding purposes only, it shall be exempt from the tonnage tax. When sold as a feed, cottonseed meal is subject to registration under the terms of the feed law. By regulation, however, if it is sold exclusively as a fertilizer, or exclusively as a feed, it may be registered but once, and under that law which applies.

The status of cottonseed meal under the fertilizer law has been clearly stated in a bulletin[1] from this Station, from which the following may be quoted:

* Analyses were made by Messrs. Nolan, Mathis and Walden; microscopic examinations by Mr. Shepard and Miss Yale; inspection and sampling by Mr. Churchill; and the compilations largely by Mrs. Vosburgh.
[1] Bull. of Information No. 9, 1919.

*Registration and analysis fees.* "Each brand of cottonseed meal must be registered on forms provided by this Station and an analysis fee of ten dollars paid on it before it is sold, offered or exposed for sale, and on the first day of January annually thereafter."

"A distinctive name constitutes a distinct brand. If shipments have different guaranties of composition they are held to be different brands."

*Branding or tagging.* "Since nitrogen is the only fertilizer ingredient considered in the trade in cottonseed meal, no guaranty of phosphoric acid or potash is required. If either is guaranteed by the manufacturer, however, an additional fee of ten dollars must be paid on each element. The statement of composition now legal for feeds may be used hereafter if the percentage of nitrogen is stated."

"Note that the law regarding feeding stuffs forbids the use of metal in attaching tags and requires that each package shall be branded or tagged with the statement required by law."

*Duties of shippers.* "It is assumed from correspondence with shippers outside the state that they will register the brands which they sell in Connecticut, will pay analysis fees as has been done in the past by manufacturers of commercial fertilizers, and will semi-annually thereafter pay the tonnage fees.

"They will report to this Station their total sales and if they wish, may report what part has been sold for feed exclusively. From the reports of dealers within the state it will be possible to determine quite closely the amounts of each brand actually used as feed.

"In the case the jobber outside the state neglects or refuses to register a brand, the dealer who sells it within the state is responsible under the law."

*Duties of dealers.* "Dealers are required to file with the director of the Station on July first of each year and semi-annually thereafter a sworn statement of their total sales of each brand of cottonseed meal and the amount of each sold exclusively for feed, during the preceding six months."

## Requirements to be Complied with by Sellers of Commercial Fertilizers.

*The seller* is responsible for the proper labeling of each package, for the registration at the Station of every brand sold by him and for the payment of the analysis fee, before offering for sale, and annually thereafter on January 1st.

The law specifies the information which shall be given on the label as follows:

1. *Weight of each package in pounds.*
2. *Brand name or trade mark.*
3. *Analysis:*
   - (a) *Available phosphoric acid, per cent.*
   - (b) *Total phosphoric acid, per cent.*
   - (c) *Nitrogen, per cent.*
   - (d) *Equivalent ammonia, per cent.*
   - (e) *Potash soluble in water, per cent.*
4. *Name and address of the manufacturer or of the person who is responsible for the statement of the guaranty.*



In the case of bone meal, tankage or other organic products, and in basic slag and mineral phosphates in which a large percentage of the phosphoric acid is not available by laboratory methods, the phosphoric acid shall be claimed as total phosphoric acid unless it is desired to claim available phosphoric acid instead, in which case the guaranty shall take the form set forth above.

The label may be a tag attached to the package or a statement printed thereon. Percentages shall be minimum percentages only.

The presence of leather in its various forms, wool waste, hair, or any inert nitrogenous material shall be declared on the label unless, by processing, the activity of these materials has been rendered satisfactory as determined by official methods.

When potash is derived from sulphate or carbonate of potash it may be so claimed.

No claim or guaranty for less than 0.82 per cent of nitrogen or for less than 1 per cent of phosphoric acid, or for less than 1 per cent of potash shall be regarded in the registration or analysis of any commercial fertilizer.

The seller must also, on the 1st of January and July, report the tonnage of fertilizer sold within the preceding six months and pay to the director of the Station a tonnage fee of 6 cents per ton. On request, copies of the law and blanks for registration and for tonnage reports will be supplied by the Station.

*If, however, proper labeling, registration and payments have been provided for by the manufacturer of the brands or by another responsible person all sellers of such brands are released from the above mentioned requirements. The retailer, therefore, should assure himself that the requirements of the law have been met by the manufacturers of the brands which he handles, or himself be prepared to meet all these requirements.*

## Precautions to be Observed in Drawing Samples for Analysis.

The analysis of a fertilizer is of no value unless the sample analyzed represents as nearly as possible the stock from which the sample was drawn. The law prescribes the procedure to be followed by authorized agents of this Station when taking official samples for analysis as follows:

"When samples are taken from fertilizers in bags, a tube shall be used, and it shall be inserted at one end of the bag and shall pass substantially the entire length of the bag, so as to take a core of the material being sampled from substantially the entire length of the bag. Samples thus taken from individual bags shall be thoroughly mixed, and the official samples shall be taken from the mixture so drawn by the method known as 'quartering.' Samples of fertilizers taken as herein provided shall be taken from at least five per centum of the separate original unopened packages in the lot, for the mixture from which the official samples shall be taken. If less than one hundred bags are in the lot, at least five bags shall be sampled; if less than five bags, all shall be sampled. Broken packages shall not be sampled."

### Gratuitous Analyses.

Under the fertilizer law the Station is charged only with the analysis of samples drawn by its own agents. It does, however, each year analyze a considerable number of samples drawn by individuals, representing stock purchased by them for their own use. The object of the purchaser is to satisfy himself as to whether he has obtained goods of the grade represented and, perhaps, to obtain evidence upon which to base a claim for shortage should the materials not meet their guaranties. The Station assumes no responsibility for the sampling in case of such unofficial samples and can only vouch for the accuracy of the results obtained on the materials as submitted. Since a representative sample is as essential as an accurate analysis in judging the quality of a shipment of fertilizer, it is evident that a satisfactory adjustment will seldom be effected on the basis of an unofficial sample. Notwithstanding certain objections which may be raised to the practice of analyzing samples submitted by individuals, the Station is disposed to continue such work so long as there is evidence that it constitutes a useful service.



## DEFINITIONS AND STANDARDS FOR SOME FERTILIZER MATERIALS.

The Association of Official Agricultural Chemists upon the recommendation of its Committee on Definition of Terms and Interpretation of Results on Fertilizers has approved for final adoption as official, definitions and standards for the following materials:

1. *Limit of chlorine in mixed fertilizers in which potash is claimed as sulphate.* The chlorine in mixed fertilizers in which the potash is claimed as sulphate shall not exceed five-tenths of one per cent (0.5%) more than what is called for in the minimum potash content based on the definition for sulphate of potash as formulated by the committee. Calculate as follows: 0.05 times the percentage of potash found plus 0.5.

2. *Products obtained by heating calcium phosphate with alkali salts containing potash.* These products are *not* potassium phosphate. They may be called non-acid phosphates with potash.

3. *Muriate of potash.* For further consideration.

4. *Sulphate of potash.* Definition was proposed but not approved. For further consideration.

5. *Unleached wood ashes.* Unleached wood ashes are ashes that result from burning unleached wood, that have had no part of their plant food removed, and that contain four per cent (4%) or more of water-soluble potash ($K_2O$).

6. *Nitrate of Soda.* Nitrate of soda is commercial sodium nitrate containing not less than fifteen per cent (15%) of nitrogen, chiefly as sodium nitrate.

7. *Kainit.* Kainit is a potash salt containing potassium and sodium chlorides and sometimes sulphate of magnesia with not less than twelve per cent (12%) of potash ($K_2O$).

8. *Dried Blood.* Dried blood is the collected blood of slaughtered animals, dried and ground and containing not less than twelve per cent (12%) of nitrogen in organic forms.

9. *Fertilizer grade.* The grade of fertilizer shall represent the minimum guarantee of its plant food expressed in terms of nitrogen, available phosphoric acid, and water-soluble potash.

The following definitions have also been approved as tentative.

1. *Ground steamed bone.* Ground steamed bone is a product resulting from grinding animal bones that have been previously steamed under pressure.

2. *Ground raw bone.* Ground raw bone is a product resulting from drying and grinding animal bones that have not been previously steamed under pressure.

3. *Tankage.* This term (without qualification) shall be restricted to meat and bone tankage derived from the rendered, dried, and ground by-products from the slaughter of animals, or from carcasses of animals that have died otherwise than by slaughter.

4. *Fish tankage, fish scrap, dry ground fish.* Fish tankage, fish scrap, dry ground fish is the dried ground product derived from rendered or unrendered fish.

5. *Garbage tankage.* Garbage tankage is the rendered, dried, and ground product derived from waste household food materials.

6. *Crude, inert, or slow-acting nitrogenous materials.* Crude, inert, or slow-acting nitrogenous materials are unprocessed organic substances relatively high in nitrogen but having a very low value as plant food and showing a low activity by both the alkaline and neutral permanganate methods (below fifty per cent (50%) and eighty per cent (80%), respectively).

7. *Process tankage.* Process tankages are the products made from crude inert nitrogenous materials by processing under steam pressure, with or without the use of acids, for the purpose of increasing the activity of the nitrogen.

These products shall not be called "tankages" without proper qualification.

8. *Hoof and Horn Meal.* Hoof and horn meal is a product resulting from the processing, drying and grinding of hoofs and horns.

9. *Superphosphate.* Superphosphate is the ground product resulting from mixing finely ground rock phosphate and sulfuric acid or phosphoric acid. The grade should always be used as a prefix to the name. Example: 16% Superphosphate.

It is recommended that the use of the term "Acid Phosphate" be discontinued.

10. *Order of terms.* The order of terms in mixed fertilizers shall be nitrogen first, phosphoric acid second, and potash third.

11. *Statement of guaranties.* It is recommended and urged that the statement of guaranties of mixed fertilizers be given in whole numbers and without fractions.

12. *Acidulated fish tankage, fish scrap, dry ground fish.* Acidulated fish tankage, fish scrap, dry ground fish is the rendered, dried, and ground product derived from fish and with or without treatment with sulfuric acid.

13. *Significance of the name of a fertilizer material used as a brand name of a mixed fertilizer.* When the name of a material is used as a part of the brand name of a mixed fertilizer, as for example blood, or fish, the nitrogen or phosphoric acid shall be derived from or supplied entirely by the material named. When



the name of a material is used as a brand or as part of a brand the word "brand" shall follow the name of the material. Example: "Fish Brand Fertilizer."

14. *Ammoniated superphosphate.* Ammoniated superphosphate is that class of product containing both dissolved phosphate (superphosphate or dissolved bone) and nitrogenous compounds, but without the addition of potash.

15. *Activated sewerage products.* Activated sewerage products are made from sewage freed from grit and coarse solids and aerated after being inoculated with micro-organisms. The resulting flocculated organic matter is withdrawn from the tanks, filtered with or without the aid of coagulants, dried in rotary kilns, ground, and screened.

Other fertilizer materials and soil amendments under consideration by the Committee are: agricultural lime, quicklime, hydrated lime, air-slaked lime, ground limestone, ground shell lime, marl, by-product lime, calcium sulphate, available phosphoric acid, high-analysis fertilizer, soil amendment, peat, charred peat, sulphate of ammonia, urea, and cyanamide.

## REGISTRATIONS.

### Late Registrations for 1928.

To the brands registered for 1928 in our last report should be added:

**L. B. Lovitt & Company, Memphis, Tenn.**

"Lovit Brand" 36% Cottonseed Meal
"Lovit Brand" 41% Cottonseed Meal

**Memphis Cottonseed Products Company, Memphis, Tenn.**

Durham Brand 41% Protein Cottonseed Meal

### Registrations for 1929.

For 1929, 67 firms and individuals registered at this Station for sale in this State 422 brands of fertilizers. As required by Statute the brands so registered are listed as follows:

**American Agricultural Chemical Company, New Haven Sales Dept., New Haven, Conn.**

A.A.C. Acme Fertilizer
A.A.C. Aroostook Potato Manure
A.A.C. Castor Pomace
A.A.C. Complete General Fertilizer
A.A.C. Cotton Seed Meal
A.A.C. Double A Tobacco Fertilizer
A.A.C. Dry Ground Fish
A.A.C. Gladiator Fertilizer
A.A.C. Grass & Lawn Top Dressing
A.A.C. Ground Tankage
A.A.C. Hi-Grade Tobacco Manure
A.A.C. Monarch Fertilizer
A.A.C. Muriate of Potash
A.A.C. Nitrate of Soda
A.A.C. Pulverized Sheep & Goat Manure
A.A.C. Prolific 10% Potash Fertilizer
A.A.C. Special Grass Top Dressing
A.A.C. Special Ground Bone
A.A.C. Sulphate of Ammonia
A.A.C. Sulphate of Potash
A.A.C. 16% Superphosphate
A.A.C. Tobacco Starter
Agrico for Corn
Agrico for Potatoes
Agrico for Truck
Bowker's All Round Fertilizer
Bowker's Market Garden Fertilizer
Bowker's Potato & Vegetable Phosphate
Bowker's Stockbridge Early Crop Manure
Bowker's Stockbridge Hill & Drill Fertilizer
Bowker's Stockbridge Tobacco Manure
Bradley's Blood, Bone & Potash
Bradley's Complete Manure for Potatoes & Vegetables
Bradley's Complete Tobacco Manure
Bradley's Northland Potato Grower



Bradley's Potato Fertilizer
Bradley's Potato Manure
Bradley's XL Superphosphate of Lime
National Aroostook Special Fertilizer
National Complete Tobacco Fertilizer
National Market Garden Fertilizer
National Pine Tree State Potato Fertilizer
National Premier Potato Manure
Sanderson's Atlantic Coast Mixture
Sanderson's Complete Tobacco Grower
Sanderson's Corn Superphosphate
Sanderson's Formula A
Sanderson's Formula B
Sanderson's Potato Manure

**American Cyanamid Company, 535 Fifth Ave., New York City.**

Aero Brand Cyanamid
Ammo Phos B
Ammo-Phos-Ko No. 1
Ammo-Phos-Ko No. 2
Ammo-Phos-Ko No. 3

**Anglo-Chilean Nitrate Sales Corporation, 120 Broadway, New York City.**

Nitrate of Soda

**Apothecaries Hall Company, Waterbury, Conn.**

Acid Phosphate (Superphosphate)
Basic Slag Phosphate
Bone Meal 3-22
Bone Meal 4-20
Bone & Meat Tankage
Carbonate of Potash
Castor Pomace
Cotton Seed Meal
Dry Ground Fish
Lawn Fertilizer
Liberty Corn & All Crops 2-8-2
Liberty Corn, Fruit & All Crops, 2-12-4
Liberty Double Strength, 10-16-14
Liberty Fish, Bone & Potash, 3-8-3
Liberty High Grade Market Gardener's, 5-8-7
Liberty High Grade Tobacco Manure, 7-3-7
Liberty Onion Special (Potash as Sulphate) 4-8-7
Liberty Potato & General Crops, 4-8-10
Liberty Potato & Market Gardener's Special, 4-8-4
Liberty Potato & Vegetable, 2-8-10
Liberty Special Fertilizer for Fruit, 7-8-6
Liberty Tobacco Special (Cotton Seed Meal Base), 5-3-5
Liberty Top Dresser for Grass & Grain, 10-3½-8
Muriate of Potash
Nitrate of Soda
Nitrate of Soda & Potash
Precipitated Bone
Sulphate of Ammonia
Sulphate of Potash
Sulphate of Potash & Magnesia
Tankage

**Armour Fertilizer Works, 50 Broad St., New York City.**
- Armour Big Crop Bone Meal 3-48
- Armour Big Crop Fertilizer 2-12-4
- Armour Big Crop Fertilizer 3-8-4
- Armour Big Crop Fertilizer 4-6-10
- Armour Big Crop Fertilizer 4-8-4
- Armour Big Crop Fertilizer 4-8-7
- Armour Big Crop Fertilizer 4-16-4
- Armour Big Crop Fertilizer 5-8-7
- Armour Big Crop Fertilizer 5-15-5
- Armour Big Crop Fertilizer 7-11-10
- Armour Big Crop Fertilizer 7-12-7
- Armour Big Crop Fertilizer 8-6-6
- Armour Big Crop Tobacco Fertilizer 7-3-7
- Armour Big Crop Tobacco Special 5-3-5
- Armour Big Crop Super Phosphate 16%
- Armour Big Crop Super Phosphate 20%
- Armour Lawn & Garden Grower 6-8-6
- Castor Pomace
- Cotton Seed Meal
- Ground Tankage
- Muriate of Potash
- Nitrate of Soda
- NPK 9-18-18
- NPK 9-27-9
- Sheep & Goat Manure
- Sulphate of Ammonia
- Sulphate of Potash

**Ashcraft-Wilkinson Company, Atlanta, Ga.**
- Helmet Brand Cottonseed Meal
- Monarch Brand Cottonseed Meal
- Paramount Brand Cottonseed Meal

**Associated Seed Growers, Inc., New Haven, Conn.**
- Nitrate of Soda
- 16% Acid Phosphate
- Special Mixture for General Use
- Special Mixture with 6% Potash
- Tip Top Brand

**Baker Castor Oil Company, 120 Broadway, New York City.**
- Castor Pomace

**Barrett Company, 40 Rector St., New York City.**
- Arcadian Nitrate of Soda
- Arcadian Sulphate of Ammonia
- Sulphate of Ammonia

**F. A. Bartlett Tree Expert Company, Stamford, Conn.**
- Bartlett Green Tree Food

**The Berkshire Chemical Company, Bridgeport, Conn.**
- Berkshire Castor Pomace
- Berkshire Complete Fertilizer
- Berkshire Complete Tobacco Fertilizer
- Berkshire Dry Ground Fish



- Berkshire Economical Grass Fertilizer
- Berkshire Fine Ground Bone
- Berkshire Grass Special Fertilizer
- Berkshire Long Island Special Fertilizer
- Berkshire Market Garden Fertilizer
- Berkshire Sheep Manure
- Berkshire Super Phosphate
- Berkshire Tobacco Special Fertilizer
- Berkshire Tobacco Starter Fertilizer
- Berkshire Truck Fertilizer
- High Grade Sulphate Potash
- Muriate of Potash
- Nitrate of Soda

**Amos D. Bridge's Sons, Inc., Hazardville, Conn.**
- Corn, Onion, Potato and General Purpose
- Special Tobacco Fertilizer

**F. W. Brode Corporation, Memphis, Tenn.**
- Owl Brand 41% Prime Cottonseed Meal

**A. H. Case & Company, Inc., 965 William St., Buffalo, N. Y.**
- Par Plus Brand Reinforced Sheep Manure

**The E. D. Chittenden Company, Bridgeport, Conn.**
- Castor Pomace
- Chittenden's Complete Tobacco & Onion Grower
- Chittenden's High Grade Potato
- Chittenden's Potato Special
- Chittenden's Tobacco Special

**Conn. Fat Rendering & Fertilizer Corporation, West Haven, Conn.**
- Tankage

**Consolidated By-Product Company, 30th and Race Sts., Philadelphia, Pa.**
- Consolidated Bone Meal

**Consolidated Rendering Company, Boston, Mass.**
- Castor Pomace
- Corenco Sheep Manure
- Dry Ground Fish
- Ground Bone
- Muriate of Potash
- Nitrate of Soda
- Sulphate of Ammonia
- Sulphate of Potash
- Superphosphate (Acid Phos. 16%)
- Superphosphate (Acid Phos. 20%)
- Tankage 6-30
- Tankage 9-20

**C & R Sales Company, Worcester, Mass.**
- C & R Lawn Shrub Fertilizer 5-6-5

**Davey Tree Expert Company, So. Water St., Kent, Ohio.**
Davey Shredded Cattle Manure
Davey Tree Food

**Eastern States Farmers' Exchange, Springfield, Mass.**
Eastern States Ammo-Phos
Eastern States Basic Slag
Eastern States Calurea
Eastern States Castor Pomace
Eastern States Dry Ground Fish
Eastern States Fine Bone Meal
Eastern States Ground Animal Tankage
Eastern States Muriate of Potash
Eastern States Nitrate of Potash
Eastern States Nitrate of Soda
Eastern States Nitrogenous Tankage
Eastern States Open Formula 0-14-6
Eastern States Open Formula 4-8-8
Eastern States Open Formula 4-10-6
Eastern States Open Formula 4-12-4
Eastern States Open Formula 4-20-16
Eastern States Open Formula 6-8-6
Eastern States Open Formula 6-15-9
Eastern States Open Formula 6-18-6
Eastern States Open Formula 8-4-8
Eastern States Open Formula 8-16-16
Eastern States Open Formula 8-16-16 Potash from Sulphate
Eastern States Open Formula 10-5-10
Eastern States Precipitated Bone
Eastern States Sulphate of Ammonia
Eastern States Sulphate of Potash
Eastern States Sulphate of Potash Magnesia
Eastern States Superphosphate 16%

**Ed. Eggert, Hartford, Conn.**
Diamond "EE" Brand Cottonseed Hull Ashes

**Essex Fertilizer Company, Boston, Mass.**
Essex Complete Manure 5-8-7
Essex Fish Fertilizer for All Crops 3-8-4
Essex Market Garden 4-8-4
Essex Peerless Potato Manure 4-6-10
Essex Top Dressing 7-6-5

**Friedman Tobacco Products Corporation, 240 No. George St., York, Pa.**
Double Duty Tobacco Dust Fertilizer

**The L. T. Frisbie Company, New Haven, Conn.**
Frisbie's Corn & Grain Fertilizer 2-10-2
Frisbie's Fine Bone Meal
Frisbie's 5-8-7
Frisbie's 5-10-5
Frisbie's Market Garden 5-8-7
Frisbie's Special 3-8-4
Frisbie's Special Vegetable & Potato Grower 4-8-4
Frisbie's Tobacco Grower 7-3-7
Frisbie's Top Dresser 8-6-5



**Ford Motor Company, Fordson, Michigan.**
Ford Ammonium Sulphate

**The Grasselli Chemical Company, Cleveland, Ohio.**
Grasselli Odorless Plant Food

**Humphreys-Godwin Company, Memphis, Tenn.**
Bull Brand Cottonseed Meal
Danish Brand Cottonseed Feed
Dixie Brand Cottonseed Meal

**International Agricultural Corporation, 38 Chauncy St., Boston, Mass.**
Caribee Tobacco Fertilizer
Premium Tobacco Fertilizer

**John Joynt, Lucknow, Ontario, Canada.**
Joynt Brand "Canada Hardwood Ashes"

**Kelloggs & Miller, Inc., Amsterdam, N. Y.**
"K & M" Brand Pure Old Process Linseed Oil Meal

**Spencer Kellogg & Sons, Inc., Buffalo, N. Y.**
Castor Pomace
"Kellogg's Pure Old Process Linseed Meal" 5.14%
"Kellogg's Pure Old Process Linseed Meal" 6.22%

**L. B. Lovitt & Company, Memphis, Tenn.**
"Lovit Brand" 41% Cottonseed Meal

**Lowell Fertilizer Company, Boston, Mass.**
Lowell Animal Brand A High Grade Manure for All Crops 3-8-4
Lowell Bone Fertilizer 2-10-2
Lowell Corn and Vegetable 4-8-4
Lowell Market Garden Manure 5-8-7
Lowell Potato Grower 4-6-10
Lowell Tobacco Manure 5-3-5
Lowell Top Dressing 7-6-5

**Maine Farmers' Exchange, 801 Chapman Bldg., Portland, Me.**
M.F.E. "Produce-More" 3-10-3
M.F.E. "Produce-More" 4-8-5
M.F.E. "Produce-More" 5-8-7

**The Mapes Formula & Peruvian Guano Co., 270 Madison Ave., New York City.**
The Mapes Connecticut Valley Special
The Mapes Corn Manure
The Mapes General Tobacco Manure
The Mapes General Truck Manure
The Mapes General Use Manure
The Mapes Onion Manure
The Mapes Potato Manure
The Mapes Special Trucker

The Mapes Special Trucker "SP."
The Mapes Tobacco Ash Constituents
The Mapes Tobacco Ash & Starter
The Mapes Tobacco Manure, Wrapper Brand
The Mapes Tobacco Starter Improved
The Mapes Top Dressing
Castor Pomace
Nitrate of Soda
Pure Fine Ground Bone
Sulphate of Potash

**Marianna Sales Company, Memphis, Tenn.**
White Mule Brand Cotton Seed Meal

**A. G. Markham & Company, 20 Stockbridge St., Springfield, Mass.**
4-6-10
4-8-4
5-8-7

**Millane Tree Expert Company, Cromwell, Conn.**
Millane Shade Tree Food

**Natural Guano Company, Aurora, Ill.**
"Sheep's Head" Pulverized Sheep Manure

**New England Fertilizer Company, Boston, Mass.**
New England Complete Manure 4-6-10
New England Corn Phosphate 2-10-2
New England Market Garden Manure 5-8-7
New England Potato and Vegetable Manure 4-8-4
New England Super A High Grade Fertilizer For All Crops 3-8-4
New England Tobacco Manure 5-3-5

**Old Deerfield Fertilizer Company, Inc., South Deerfield, Mass.**
Old Deerfield Tobacco Starter, Bone & Potash
Special Tobacco Formula

**Olds & Whipple, Inc., Hartford, Conn.**
High Grade Carbonate of Potash 96/98
High Grade Sulphate of Potash
O. & W. Acid Phosphate
O. & W. Blue Label Tobacco Fertilizer
O. & W. Castor Pomace
O. & W. Complete Market Garden Fertilizer
O. & W. Complete Tobacco Fertilizer
O. & W. Dry Ground Fish
O. & W. Favorite Sheep Manure
O. & W. Grass Fertilizer
O. & W. High Grade Potato & Vegetable Fertilizer
O. & W. High Grade Starter & Potash Compound
O. & W. High Grade Tobacco Starter
O. & W. Nitrate of Soda
O. & W. Nitrate of Potash 95%
O. & W. Precipitated Bone Meal
O. & W. Pure Bone Meal
O. & W. Sulphate of Ammonia



**Pacific Manure & Fertilizer Company, 429 Davis St., San Francisco, Cal.**
Groz-It Pulverized Sheep Manure

**Parmenter & Polsey Fertilizer Company, Boston, Mass.**
"P & P" Maine Potato Fertilizer 4-6-10
Parmenter & Polsey Top Dressing 7-6-5

**Piedmont-Mt. Airy Guano Company, Inc., Baltimore, Md.**
Harvest Brand 2-8-3
Harvest Brand 4-8-4
Harvest Brand 5-8-7
Nitrate of Soda

**Frank S. Platt Company, New Haven, Conn.**
Platt's Concentrated Lawn Fertilizer
Platco Special 5-8-7

**Premier Poultry Manure Company, 3-8 W. Washington St., Chicago, Ill.**
Premier Brand Poultry Manure
Premier Brand Sheep Manure

**Pulverized Manure Company, Chicago, Ill.**
Wizard Brand Cattle Manure
Wizard Brand Pulverized Sheep Manure

**Rackliffe Bros. Company, Inc., New Britain, Conn.**
Rackliffe Brand Corn Fertilizer 4-8-4
Rackliffe Brand Potato and Special Vegetable 5-8-7

**The Rogers & Hubbard Company, Portland, Conn.**
4-8-4 Fertilizer
5-8-7 Fertilizer
5-10-15 Fertilizer
Hubbard's "Bone Base" Fertilizer for Seeding Down
Hubbard's "Bone Base" Oats and Top Dressing
Hubbard's "Bone Base" Soluble Corn and General Crops Manure
Hubbard's "Bone Base" Soluble Potato Manure
Hubbard's "Bone Base" Soluble Tobacco Manure
Hubbard's Pure Raw Knuckle Bone Flour
Hubbard's Strictly Pure Fine Bone
Lawn Fertilizer
Nitrate of Soda
Rogers & Hubbard's All Soils-All Crops Fertilizer
Rogers & Hubbard's Climax Tobacco Brand
Rogers & Hubbard's Corn and Grain Fertilizer
Rogers & Hubbard's High Potash Fertilizer
Rogers & Hubbard's Potato Fertilizer
Rogers & Hubbard's Tobacco Grower, Vegetable Formula
Rogers & Hubbard's Tunaker Tobacco Brand
Superphosphate

**F. S. Royster Guano Company, Baltimore, Md.**
Royster's Connecticut Tobacco Guano
Royster's Curlew Guano
Royster's 5% Truck Guano

Royster's Gem Guano
Royster's Quality Trucker
Royster's Sheep and Goat Manure
Royster's 16% Super Phosphate
Royster's Top Dresser

**Ruhm Phosphate & Chemical Company, Mt. Pleasant, Tenn.**

Ruhm's Lime Phosphate (Phosphate Rock, washed and ground)

**Sewerage Commission of the City of Milwaukee, Milwaukee, Wis.**

Milorganite

**M. L. Shoemaker & Company, Inc., Philadelphia, Pa.**

Special Mixture of "Bantle's Wrapper Brand"
"Swift-Sure" Bone Meal 4½-47
"Swift-Sure" Potato Special 5-8-7
"Swift-Sure" Special Tobacco Formula 4-8-5
"Swift-Sure" Tobacco & General Use 3-10-3

**Springfield Rendering Company, Springfield, Mass.**

Springfield 3-8-4 Fertilizer
Springfield 4-8-4 Fertilizer
Springfield 4-8-7 Fertilizer
Springfield 5-8-7 Fertilizer
Springfield 5-3-5 Tobacco Special
Springfield 7-6-5 Top Dresser

**Standard Wholesale Phosphate & Acid Works, Inc., Baltimore, Md.**

5 x 4 x 5
5 x 10 x5
8 x 6 x 6
Animal Tankage 6%
Animal Tankage 9%
Animal Tankage 10%
Castor Pomace
Evergreen Fish Guano
Fish Bone & Potash
Fish Meal
Golden Rule Grower
Golden Rule Guano
Grain Grower
High Analysis
Ideal Potato Grower
Jersey Special
Mammoth Potato Grower
Muriate of Potash
Nitrate of Soda
Old Fertility
Raw Bone Meal
Steamed Bone Meal
Sulphate of Ammonia
Sulphate of Potash
Superphosphate 16%
Superphosphate 20%
Truckers Fish Guano



**Swift & Company Fertilizer Works, Baltimore, Md.**

Vigoro

**Synthetic Nitrogen Products Corporation, 285 Madison Ave., New York City.**

Calcium Nitrate Basf (Nitrate of Lime)
Calurea
Nitrophoska I
Nitrate of Potash
Urea Basf (Floranid)

**Tennessee Copper & Chemical Corporation, Lockland, Cincinnati, Ohio.**

Loma

**I. P. Thomas & Son Company, 1000 Drexel Bldg., Philadelphia, Pa.**

Castor Pomace
Dairymen's Special 0-10-10
Economy Fertilizer 3-12-3
I. P. Thomas 5-8-7
Long Island Special 4-8-7
Muriate of Potash
Nitrate of Soda
Pure Ground Bone
7% Guano 7-6-5
Sheep & Goat Manure
16% Superphosphate
Thomas' Tobacco Grower
Tip Top 3-10-6
Truckers High Grade Guano 4-8-4
Victor Potash Fertilizer 2-8-5

**Triton Oil and Fertilizer Company, 101 Beekman St., New York City.**

Nitrate of Soda
Triton 4-8-4 Fertilizer
Triton 5-8-7 Fertilizer

**Wessel, Duval & Company, 1 Broadway, New York City.**

Nitrate of Soda

**Wilcox Fertilizer Company, 56 West Main St., Mystic, Conn.**

Acid Phosphate
Castor Pomace
Ground Steamed Bone
Muriate of Potash
Nitrate of Soda Potash
Sulphate of Ammonia
Wilcox Corn Special 3-10-4
Wilcox Dry Ground Fish
Wilcox High Grade Fish & Potash 4-8-4
Wilcox Potato & Vegetable Phosphate 5-8-7
Wilcox Top Dresser 7-6-5

**Virginia-Carolina Chemical Corporation, Richmond, Va.**

Bloomaid
Fine Ground Bone
Nitrate of Soda

V-C Aroostook Potato Grower
V-C Fairway Fertilizer
V-C Fish & Potash Compound
V-C Phospho-Tobacco Dairy Absorbent
V-C 16% Superphosphate
V-C XXXX Fish & Potash

**S. D. Woodruff & Sons, Orange, Conn.**
Woodruff's Home Mixed Fertilizer

**Worcester Rendering Company, Auburn, Mass.**
Prosperity Brand Complete Dressing
Prosperity Brand Corn & Grain Fertilizer
Prosperity Brand Market Garden Fertilizer
Prosperity Brand Potato & Vegetable Fertilizer
Special Potato Fertilizer
Superior Top Dressing



## INSPECTION OF 1929.

The Station Agent has visited 93 towns and villages in the State and has drawn 480 official samples of fertilizer, including all of the registered brands which could be found. These, together with samples submitted by purchasers and others interested, are classified as follows:

CLASSIFICATION OF FERTILIZERS ANALYZED IN 1929.

| | No. of Samples | Page |
|---|---|---|
| I. *Containing Nitrogen as the chief active ingredient:* | | |
| Nitrate of Soda | 24 | 22 |
| Calcium Nitrate (Nitrate of Lime) | 1 | 22 |
| Calurea | 4 | 22 |
| Urea | 1 | 23 |
| Sulphate of Ammonia | 11 | 27 |
| Castor Pomace | 47 | 27 |
| Cottonseed Meal | 137 | 31 |
| Linseed Meal | 19 | 32 |
| II. *Containing Phosphoric Acid as the chief active ingredient:* | | |
| Precipitated Bone Phosphate | 12 | 39 |
| Superphosphate | 18 | 39 |
| Basic Slag | 1 | 39 |
| III. *Containing Potash as the chief ingredient:* | | |
| Carbonate of Potash | 25 | 44 |
| Muriate of Potash | 10 | 44 |
| Sulphate of Potash | 19 | 44 |
| Sulphate of Potash-Magnesia | 2 | 44 |
| Cotton Hull Ashes | 60 | 45 |
| IV. *Containing Nitrogen and Potash:* | | |
| Nitrate of Potash | 8 | 54 |
| Nitrate of Potash and Soda | 3 | 54 |
| V. *Containing Nitrogen and Phosphoric Acid:* | | |
| Dry Ground Fish | 38 | 56 |
| Tankage | 11 | 57 |
| Ground Bone | 35 | 57 |
| VI. *Mixed Fertilizer:* | | |
| Containing Nitrogen and Phosphoric Acid | 5 | 66 |
| Containing Phosphoric Acid and Potash | 2 | 66 |
| Containing Nitrogen and Potash | 1 | 66 |
| Containing Nitrogen, Phosphoric Acid and Potash | 248 | 67 |
| Special and Home Mixtures | 67 | 93 |
| VII. *Miscellaneous:* | | |
| Sheep Manure, etc. | 15 | 93 |
| Lime, etc. | 7 | 93 |
| Other miscellaneous materials | 40 | 93 |
| Collaborative check meals and fertilizers | 42 | 93 |
| Total | 913 | |

## RAW MATERIALS CHIEFLY VALUABLE FOR NITROGEN.

### NITRATE OF SODA.

Nitrate of Soda is a nitrogen salt containing not less than 15 percent of nitrogen, largely as sodium nitrate.[1] Ammonia equivalent to the nitrogen usually ranges from 18.2 to 19.5 percent, which represents 91 to 97 percent of nitrate of soda.

This raw material is obtained from the west coast of South America, chiefly from Chile, where large deposits of the crude salt are found. Until recently this has been practically the sole source of this form of agricultural nitrogen, but it now finds competition from nitrate made in Europe from synthetic nitric acid and soda. However, natural deposits of nitrate are not likely to be exhausted for many years to come and improvement in methods of refining will probably enable the natural product to maintain an important place in the fertilizer market.

Twenty-four samples were analyzed and the average nitrogen content found to be 15.53 per cent. All equalled or exceeded guaranties, except in two instances, one of which was negligible. The other involved a shortage of 0.3 per cent.

Eleven price quotations ranged from $65 to $80 a ton and averaged $70. Nitrogen from this source was bought at an average of about 25 cents a pound.

Analyses are given in Table I.

### CALCIUM NITRATE.

This material is now being produced in quantity in Europe, where nitrogen of the air is converted into nitric acid and then combined with limestone to form calcium nitrate. It readily absorbs moisture and is shipped in drums or in paper lined bags to protect it from moisture.

The commercial article as offered in the fertilizer trade usually contains about 15.5 per cent of nitrogen. The one sample examined this year was guaranteed 15 per cent and 15.28 per cent was found.

Analysis appears in Table I.

### CALUREA.

Calurea is a trade name for one of the synthetic ammoniates and is a combination of urea and calcium nitrate. About one-fifth of its nitrogen is derived from nitrate and the remainder is in organic form. It is generally guaranteed to contain 34 per cent of total nitrogen which is equivalent to 41.3 per cent of ammonia.

Four samples were examined this year, two of which were somewhat under the guaranty of 34 per cent. The deficiencies were 0.32 and 0.48 per cent, respectively.

Analyses are given in Table I.

[1] A.O.A.C. definition.



### UREA.

This product is now made synthetically in considerable quantities in Europe from synthetic ammonia and carbon dioxide. It furnishes organic nitrogen in water soluble form. The usual guaranty is 46 per cent of nitrogen and the one sample examined this year fully met that specification. No price quotation was given, but nitrogen from this source may be valued at about 15 cents a pound.

Analysis appears in Table I.

TABELE I. ANALYSES OF NITRATE OF SODA, ETC.

| Station No. | Manufacturer or Jobber. | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Nitrate of Soda.** | | | |
| 1379 | American Agricultural Chemical Co., New York | Station agent. Stock of S. P. Strople, New Britain | 15.40 | 15.22 |
| 1405 | Apothecaries Hall Co., Waterbury, Conn. | Station agent. Stock of J. A Glasnapp, West Cheshire | 15.46 | 14.80 |
| 947 | Apothecaries Hall Co., Waterbury, Conn. | Hatheway & Steane, Inc., Hartford | 15.88 | 14.80 |
| 948 | Apothecaries Hall Co., Waterbury, Conn. | Hatheway & Steane, Inc., Hartford | 15.64 | 14.80 |
| 1271 | Apothecaries Hall Co., Waterbury, Conn. | Hatheway & Steane, Inc., Hartford | 15.60 | 14.80 |
| 1662 | Apothecaries Hall Co., Waterbury, Conn. | Hatheway & Steane, Inc., Hartford | 15.42 | 14.80 |
| 1720 | Apothecaries Hall Co., Waterbury, Conn. | A. N. Shepard & Son., Hartford | 15.74 | 14.80 |
| 1561 | Armour Fertilizer Works New York | Station agent. Stock of Raven's Hardware Co., Meriden | 15.66 | 14.81 |
| 1584 | Associated Seed Growers, New Haven, Conn. | Station agent. Stock of Associated Seed Growers, Milford | 15.82 | 15.00 |
| 1449 | The Barrett Co., New York | Station agent. Stock of W. S. Eaton, Plainville | 16.16 | 16.25 |
| 682 | Berkshire Chemical Co. Bridgeport, Conn. | American Sumatra Tobacco Co., Bloomfield | 15.28 | 15.00 |
| 683 | Berkshire Chemical Co. Bridgeport, Conn. | American Sumatra Tobacco Co., Bloomfield | 15.52 | 15.00 |
| 684 | Berkshire Chemical Co. Bridgeport, Conn. | American Sumatra Tobacco Co., Bloomfield | 15.48 | 15.00 |
| 763 | Berkshire Chemical Co., Bridgeport, Conn. | American Sumatra Tobacco Co., Bloomfield | 15.46 | 15.00 |
| 998 | Berkshire Chemical Co. Bridgeport, Conn. | James T. Burgess, Thompsonville | 15.58 | 15.00 |
| 1375 | Berkshire Chemical Co. Bridgeport, Conn. | Station agent. Stock of J. A. Smith, Hamden | 16.08 | 15.00 |
| 1369 | Consolidated Rendering Co. Boston, Mass. | Station agent. Stock of H. D. Peters, Highwood | 15.48 | 15.22 |
| 1443 | Eastern States Farmers' Exchange, Springfield, Mass. | Station agent. Stock of Hoyt's Nurseries, New Canaan | 15.68 | 15.00 |
| 1476 | Olds & Whipple, Inc., Hartford, Conn. | Sation agent. Stock of F. T. Blish Hardware Co., So. Manchester | 15.86 | 15.00 |
| 1415 | The Rogers & Hubbard Co., Portland, Conn. | Station agent. Stock of Cadwell & Jones, Hartford | 14.50 | 14.80 |
| 1399 | Standard Phosphate & Acid Works, Baltimore, Md. | Station agent. Stock of Peter Aldo, Milford | 15.08 | 15.00 |



TABLE I. ANALYSES OF NITRATE OF SODA, ETC.—*Concluded.*

| Station No. | Manufacturer or Jobber. | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Nitrate of Soda.** | | | |
| 1618 | I. P. Thomas & Son, Philadelphia, Pa. | Station agent. Stock of Ira W. Beers, Hamden | 15.36 | 15.00 |
| 1675 | Triton Oil & Fertilizer Co. New York | Station agent. Stock of F. H. Woodruff & Son, Milford | 15.48 | 14.80 |
| 1630 | Virginia-Carolina Chemical Co., New York | Station agent. Stock of Stanley Svea Coal Co., New Britain | 15.12 | 14.80 |
| | **Calcium Nitrate. (Nitrate of Lime)** | | | |
| 1615 | Synthetic Nitrogen Products Co., New York | Station agent. Stock of Olds & Whipple, Inc., Hartford | 15.28 | 15.00 |
| | **Calurea.** | | | |
| 1704 | Synthetic Nitrogen Products Co., New York | L. Wetstone & Sons, Hartford | 34.00 | 34.00 |
| 1613 | Synthetic Nitrogen Products Co., New York | Station agent. Stock of Olds & Whipple, Inc., Hartford | 33.68 | 34.00 |
| 1902 | Synthetic Nitrogen Products Co., New York | Station agent. Stock of John Richards, So. Glastonbury | 34.08 | 34.00 |
| 2031 | Synthetic Nitrogen Products Co., New York | Chas. D. Lewis, Hartford | 33.52 | 34.00 |
| | **Urea.** | | | |
| 1614 | Synthetic Nitrogen Products Co., New York | Station agent. Stock of Olds & Whipple, Inc., Hartford | 46.04 | 46.00 |

TABLE II. ANALYSES OF SULPHATE OF AMMONIA.

| Station No. | Manufacturer or Jobber. | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| 1389 | American Agricultural Chemical Co., New York | Station agent. Stock of S. P. Strople, New Britain | 20.68 | 20.56 |
| 1564 | Armour's Fertilizer Works New York | Station agent. Stock of F. A. Bartlett Tree Expert Co., Stamford | 20.80 | 20.56 |
| 1409 | Apothecaries Hall Co., Waterbury, Conn. | Station agent at factory | 21.10 | 20.58 |
| 1403 | The Barrett Co., New York | Station agent. Stock of Berkshire Chemical Co., Bridgeport | 21.04 | 20.75 |
| 1402 | The Barrett Co., New York | Station agent. Stock of Berkshire Chemical Co., Bridgeport | 20.68 | 20.50 |
| 1423 | Consolidated Rendering Co., Boston, Mass. | Station agent. Stock of L. T. Frisbie Co., New Haven | 20.58 | 20.50 |
| 1794 | Eastern States Farmers' Exchange, Springfield, Mass. | Station agent. Stock of C. D. Prentice, North Haven | 20.64 | 20.50 |
| 1876 | Ford Motor Co., Detroit Mich. | Station agent. Stock of J. N. Adams, Willimantic | 20.96 | 20.80 |
| 1469 | Olds & Whipple, Inc., Hartford, Conn. | Station agent at factory | 20.72 | 20.58 |
| 1397 | Standard Phosphate & Acid Works, Baltimore, Md. | Station agent. Stock of Geo. S. Jennings, Southport | 19.92 | 20.56 |
| 1641 | Wilcox Fertilizer Co., Mystic, Conn. | Station agent at factory | 20.76 | 20.56 |



## SULPHATE OF AMMONIA.

In this country sulphate of ammonia is made almost entirely from sulphate acid and ammonia obtained in the production of coke and illuminating gas. In Europe it is now made on a large scale from synthetic ammonia, gypsum and carbon dioxide.

So called "Arcadian" sulphate of ammonia is specially treated, dried and screened to remove lumps and insure good mechanical condition.

The grade offered for fertilizer purposes will contain about 20.5 per cent of nitrogen and is generally so guaranteed. All of the eleven samples examined this year met or exceeded guarantees with the exception of No. 1397, which was deficient by about 0.6 per cent. The average nitrogen content for all samples was 20.71 per cent. Ton price quotations were so few and variable that average cost to the purchaser cannot be fairly estimated, but a fair valuation for nitrogen from this source may be taken at about 14.5 cents a pound.

Analyses are given in Table II.

## CASTOR POMACE.

Castor Pomace is the ground residue left after removal of the oil from castor beans. It should be stored where farm animals will not have access, as it is poisonous if eaten.

This raw material is chiefly valuable as a fertilizer for its nitrogen, although it also contains small amounts of phosphoric acid and potash.

Forty-seven samples were examined, all sold under guaranties of about 4.5 per cent nitrogen. The average nitrogen found was 4.75 per cent and only five samples failed to meet guaranties by amounts greater than 0.1 per cent. There has been some impression that castor pomace was of rather poorer quality than usual this year, but our figures show no significant variation in quality. Averages for nitrogen for the past three years, according to our records are 4.75, 5.10 and 4.80 per cent as compared with 4.75 this year.

The prevailing ton price, so far as prices were quoted to our agent, has been $30, and the average is $30.15. With no allowance for phosphoric acid and potash, nitrogen from this source has cost about 31.5 cents a pound. This compares with 30 cents last year and with 24 and 23.2 cents for the two years preceding.

Analyses are given in Table III.

TABLE III ANALYSES OF CASTOR POMACE.

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **The American Agricultural Chemical Co., New York City.** | | | |
| 1735 | ........................ | Station agent. Stock of E. J. Bantle, Glastonbury ......... | 4.58 | 4.52 |
| | **Apothecaries Hall Co., Waterbury, Conn.** | | | |
| 1406 | ........................ | Station agent. Stock of J. A. Glasnapp, West Cheshire ..... | 4.54 | 4.52 |
| 822 | Car No. 11645 ............ | Hatheway & Steane, Inc., Hartford ........ | 4.66 | 4.52 |
| 823 | Car No. 11264 ............ | Hatheway & Steane, Inc., Hartford ........ | 5.06 | 4.52 |
| 824 | Car No. 13716 ............ | Hatheway & Steane, Inc., Hart ford ........ | 5.24 | 4.52 |
| 825 | Car No. 570146 ............ | Hatheway & Steane, Inc., Hartford ........ | 4.46 | 4.52 |
| 826 | Car No. 203652 ............ | Hatheway & Steane, Inc., Hartford ........ | 5.32 | 4.52 |
| 857 | Car No. 17597 ............ | Hatheway & Steane, Inc., Hartford ........ | 5.10 | 4.52 |
| 949 | Car No. 515318 ............ | Hatheway & Steane, Inc., Hartford ........ | 5.00 | 4.52 |
| 950 | Car No. 533981 ............ | Hatheway & Steane, Inc., Hartford ........ | 4.10 | 4.52 |
| 951 | Car No. 41961 ............ | Hatheway & Steane, Inc., Hartford ........ | 4.49 | 4.52 |
| 1268 | Car No. 10133 ............ | Hatheway & Steane, Inc., Hartford ........ | 5.19 | 4.52 |
| 1657 | Truck No. 4791 ............ | Hatheway & Steane, Inc., Hartford ........ | 5.52 | 4.52 |
| 1722 | Car No. 17301 ............ | A. N. Shepard & Son., Hartford | 4.54 | 4.52 |
| | **Armour Fertilizer Works, New York City.** | | | |
| 1949 | ........................ | Station agent. Stock of James T. Caffrey, Cromwell .......... | 4.62 | 4.52 |
| | **Baker Castor Oil Co., New York City.** | | | |
| 895 | Car No. 10850 ............ | American Sumatra Tobacco Co. Bloomfield .............. | 4.88 | 4.50 |
| 896 | Car No. 35839 ............ | American Sumatra Tobacco Co. Bloomfield .............. | 5.24 | 4.50 |



TABLE III. ANALYSES OF CASTOR POMACE—*Continued.*

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Baker Castor Oil Co., New York City.** | | | |
| 897 | Car No. 17182 ............ | American Sumatra Tobacco Co. Bloomfield .............. | 4.77 | 4.50 |
| 1230 | Car No. 17911 ............ | American Sumatra Tobacco Co. Bloomfield .............. | 4.50 | 4.50 |
| 1448 | ........................ | Station agent. Stock of Olds & Whipple, Inc., Hartford ....... | 4.98 | 4.50 |
| 1900 | ........................ | Station agent. Stock of John Richards, So. Glastonbury .... | 4.80 | 4.50 |
| | **Berkshire Chemical Co., Bridgeport, Conn.** | | | |
| 1258 | Car No. 171163 ............ | Station agent. Stock of Cullman Bros. Hartford ............ | 4.34 | 4.52 |
| 1260 | ........................ | Station agent. Stock of James T Burgess, Thompsonville ....... | 4.58 | 4.52 |
| 1905 | ........................ | Station agent. Stock of Lester W Lloyd, Suffield ............ | 4.43 | 4.52 |
| 1944 | ........................ | Station agent. Stock of G. A. Peckham, Suffield ........... | 4.50 | 4.52 |
| 879 | Car N. H. 167387 .......... | Cullman Bros., Hartford ........ | 4.59 | 4.52 |
| 886 | Car B. & M. 70062 .......... | Cullman Bros., Hartford ........ | 4.66 | 4.52 |
| 1001 | ........................ | James T. Burgess, Thompsonville | 4.21 | 4.52 |
| 1023 | Car No. 171163 ............ | Cullman Bros., Hartford ........ | 4.15 | 4.52 |
| 1024 | Car No. 163194 N. H. ........ | Cullman Bros., Hartford ........ | 4.26 | 4.52 |
| 1025 | Car N. H. 150236 .......... | Cullman Bros., Hartford ........ | 4.90 | 4.52 |
| 1026 | Car N. H. 164131 .......... | Cullman Bros., Hartford ........ | 4.84 | 4.52 |
| 1027 | Car N. H. 164215 .......... | Cullman Bros., Hartford ........ | 5.00 | 4.52 |
| 1028 | Car C. of N. J. 30208 ........ | Cullman Bros., Hartford ........ | 4.70 | 4.52 |
| 1853 | Car P. R. R. 516474 ........ | Spencer Bros., Inc., Suffield ..... | 4.81 | 4.52 |
| 1855 | Car N. Y. 71365 .......... | Spencer Bros., Inc., Suffield ..... | 4.76 | 4.52 |
| | **E. D. Chittenden Co., Bridgeport, Conn.** | | | |
| 2041 | ........................ | Station agent. Stock of J. P. Norton, Broad Brook ......... | 4.58 | 4.50 |
| | **Consolidated Rendering Co., Boston, Mass.** | | | |
| 1419 | ........................ | Station agent. Stock of L. T. Frisbie Co., New Haven ...... | 4.95 | 4.52 |
| | **Spencer Kellogg & Sons, Buffalo, N. Y.** | | | |
| 1455 | ........................ | Station agent. Stock of S. D. Woodruff & Sons, Orange .... | 4.62 | 4.52 |

TABLE III. ANALYSES OF CASTOR POMACE—*Concluded.*

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Mapes Formula & Peruvian Guano Co., New York City.** | | | |
| 1414 | ............................ | Station agent. Stock of Mapes Branch, Hartford ............ | 4.76 | 4.52 |
| 1285 | Car C. N. J. 21191 ......... | John P. Cranouski, Poquonock .. | 4.61 | 4.52 |
| | **Olds & Whipple, Inc., Hartford, Conn.** | | | |
| 2065 | ............................ | Station agent at factory ......... | 4.53 | 4.53 |
| 1687 | ............................ | Silberman & Kahn, Hartford .... | 5.35 | 4.53 |
| 1707 | Car 98792 .................. | L. Wetstone & Sons, Hartford .. | 4.86 | 4.53 |
| 1780 | Car P. R. R. 38403 .......... | Silberman & Kahn, Hartford .... | 4.77 | 4.53 |
| | **Standard Wholesale Phosphate & Acid Works, Baltimore, Md.** | | | |
| 1921 | ............................ | Station agent. Stock of H. H. McKnight, Ellington ......... | 5.36 | 4.52 |
| | **Wilcox Fertilizer Co., Mystic, Conn.** | | | |
| 2045 | ............................ | Station agent. Stock of Patrick Foram, East Hartford ........ | 4.56 | 4.52 |



## COTTONSEED MEAL.

In Connecticut, cottonseed meal is largely used for fertilizer purposes, particularly in mixtures for tobacco. It is sold, however, under classifications as laid down by the Association of Feed Control Officials of the United States, which are as follows:

"*Cottonseed Meal* is a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil, provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 per cent of protein. Cottonseed meal shall be graded and classed as follows:

1. "*Cottonseed Meal, Prime Quality.* Cottonseed meal, prime quality, must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellowish, not brown or reddish, free from excessive lint, and shall contain not less than 36 per cent of protein. It shall be designated and sold according to its protein content. Cottonseed meal with 36 per cent of protein shall be termed '36 per cent Protein Cottonseed Meal, Prime Quality', and higher grades similarly designated (as '43 per cent Protein Cottonseed Meal, Prime Quality'), etc.

2. "*Cottonseed Meal, Off Quality.* Cottonseed meal not fulfilling the above requirements as to color, odor and texture shall be graded '36 per cent Protein Cottonseed Meal, Off Quality,' and higher grades similarly designated."

The grade chiefly used this year for fertilizer has been that containing 6.58 per cent nitrogen (41 per cent protein).

One hundred and thirty-seven samples have been analyzed, most of them submitted by purchasers. Such samples should be accompanied by complete information as to manufacturer and guaranty, but in some instances this information, although requested, is not obtained. Thus thirteen samples appear in our summary without guaranties. About three-quarters of the total samples represented the 6.58 per cent nitrogen grade; there were 11 samples of the 6.88 per cent grade and 12 of the 5.75 per cent grade. The average nitrogen content for the groups in the order named was 6.60, 6.87 and 5.62 per cent.

Price quotations for the several grades, making no allowance for the phosphoric acid and potash per cent, show that nitrogen has cost 40.5 cents per pound in the 6.58 per cent meal; 40.8 cents per pound in the 5.75 per cent grade; and 40.7 cents in the 6.88 per cent grade.

Of one hundred and twenty-four samples with known guaranties, eighty substantially equalled or exceeded their guaranties and forty-four did not. That is to say that more than one-third of the samples fell below guaranty by more than 0.1 per cent of nitrogen. While purchasers are compensated by manufacturers and jobbers for shortages by means of rebates, the necessity for this appears to arise from attempting to grade this product too closely. Reference to the group averages noted above shows that the nitrogen found in meals of the several groups barely meets the requirements in two instances and in one fails to do so.

Analyses are given in Table IV.

LINSEED MEAL.

This product is also used in tobacco fertilizer mixtures in conjunction with, or as a substitute for, cottonseed meal to supply organic nitrogen. So-called "old process" meal is made by grinding the press cake left after removal of the oil from flaxseed by crushing, cooking and pressing. In "new process" meal the oil has been removed by the use of solvents.

Nineteen samples were examined this year, all submitted by purchasers. This material is generally guaranteed 5.5 per cent nitrogen. The average nitrogen found this year is 5.5 per cent. At the average of quoted prices nitrogen from this source has cost a little more than 50 cents a pound. Last year the cost was estimated from similar data at 48 cents.

Analyses are given in Table IV.



TABLE IV. ANALYSES OF COTTONSEED AND LINSEED MEALS.

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. | |
|---|---|---|---|---|
| | | | Found. | Guaranteed. |
| | **Apothecaries Hall Co., Waterbury, Conn.** | **Cottonseed Meal.** | | |
| 1744 | .......................... | Station agent at factory......... | 6.80 | 6.58 |
| 827 | Car No. 51081 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.70 | 6.58 |
| 828 | Car No. 50644 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.58 | 6.58 |
| 829 | Car No. 60166 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.54 | 6.58 |
| 830 | Car No. 55816 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.82 | 6.58 |
| 831 | Car No. 519348 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.33 | 6.58 |
| 832 | Car No. 174494 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.32 | 6.58 |
| 833 | Car No. 55314 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.58 | 6.58 |
| 834 | Car No. 55922 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.47 | 6.58 |
| 835 | Car No. 7415 ................ | Hatheway & Steane, Inc., Hartford .......................... | 6.59 | 6.58 |
| 861 | Car No. 58471 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.14 | 6.58 |
| 862 | Car No. 55496 .............. | Hatheway & Steane, Inc., Hartford .......................... | 6.53 | 6.58 |
| 1209 | Car No. 311306 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.64 | 6.58 |
| 1210 | Car No. 166052 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.62 | 6.58 |
| 1211 | Car No. 409603 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.48 | 6.58 |
| 1212 | Car No. 167589 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.71 | 6.58 |
| 1213 | Car No. 170331 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.54 | 6.58 |
| 1214 | Car No. 163137 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.50 | 6.58 |
| 1262 | Car No. 405457 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.58 | 6.58 |
| 1269 | Car No. 160009 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.58 | 6.58 |
| 1502 | Car No. 162958 ............ | Hatheway & Steane, Inc., Hartford .......................... | 6.66 | 6.58 |

TABLE IV. ANALYSES OF COTTONSEED AND LINSEED MEALS—*Continued.*

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Apothecaries Hall Co., Waterbury, Conn.** | | | |
| 1503 | Car No. 162120 | Hatheway & Steane, Inc., Hartford | 6.53 | 6.58 |
| 1504 | Car No. 161055 | Hatheway & Steane, Inc., Hartford | 6.42 | 6.58 |
| 1505 | Car No. 47379 | Hatheway & Steane, Inc., Hartford | 6.72 | 6.58 |
| 1625 | Car No. 15341 | Hatheway & Steane, Inc., Hart ford | 6.33 | 6.58 |
| 8820 | Car No. 156920 | Hatheway & Steane, Inc., Hart ford | 6.66 | 6.58 |
| 8828 | Car No. 7611 | Hatheway & Steane, Inc., Hartford | 6.66 | 6.58 |
| 8829 | Car No. 158940 | Hatheway & Steane, Inc., Hart ford | 6.73 | 6.58 |
| 8830 | Car No. 55363 | Hatheway & Steane, Inc., Hartford | 6.73 | 6.58 |
| | **Ashcraft-Wilkinson Co., Atlanta, Ga.** | | | |
| 1951 | Paramount | Station agent. Stock of Amos D. Bridge's Sons, Hazardville | 5.65 | 5.76 |
| 876 | Car N. H. 167451 | Cullman Bros., Hartford | 6.92 | .... |
| 877 | Car N. H. 71784 | Cullman Bros., Hartford | 6.05 | .... |
| 878 | Car N. H. 165813 | Cullman Bros., Hartford | 6.83 | .... |
| 881 | Helmet, Car L & N. 15890 | Cullman Bros., Hartford | 6.67 | 6.56 |
| 882 | Helmet, Car.B. & O. 194016 | Cullman Bros., Hartford | 6.78 | 6.56 |
| 883 | Helmet, Car L. & N. 14274 | Cullman Bros., Hartford | 6.83 | 6.56 |
| 884 | Helmet, Car N. H. 168439 | Cullman Bros., Hartford | 6.74 | 6.56 |
| 885 | Helmet, Car No. 150244 | Cullman Bros., Hartford | 6.56 | 6.56 |
| 1029 | Helmet, Car N. H. 169671 | Cullman Bros., Hartford | 6.60 | 6.56 |
| 1286 | Helmet, Car No. 163490 | I. Kaffenburgh & Sons, Inc., Hartford | 6.70 | 6.56 |
| 1287 | Helmet, Car No. 231485 | I. Kaffenburgh & Sons, Inc., Hartford | 6.55 | 6.56 |
| 1288 | Helmet, Car No. 30347 | I. Kaffenburgh & Sons, Inc., Hartford | 6.45 | 6.56 |
| 1289 | Helmet, Car No. 162083 | I. Kaffenburgh & Sons, Inc., Hartford | 6.68 | 6.56 |
| 1290 | Helmet, Car No. 342072 | I. Kaffenburgh & Sons, Inc., Hartford | 6.20 | 6.56 |
| 1291 | Helmet, Car No. 62951 | I. Kaffenburgh & Sons, Inc., Hartford | 6.17 | 6.56 |
| 1292 | Helmet, Car No. 166275 | I. Kaffenburgh & Sons, Inc., Hartford | 6.48 | 6.56 |



TABLE IV. ANALYSES OF COTTONSEED AND LINSEED MEALS—*Continued.*

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Ashcraft-Wilkinson Co., Atlanta, Ga.** | | | |
| 1293 | Helmet, Car No. 160890 | I. Kaffenburgh & Sons, Inc., Hartford | 6.59 | 6.56 |
| 1294 | Helmet, Car C. N. 428278 | I. Kaffenburgh & Sons, Inc., Hartford | 6.57 | 6.56 |
| 1295 | Car C. N. 409048 | I. Kaffenburgh & Sons, Inc., Hartford | 6.56 | 6.56 |
| 1626 | Helmet, Car C. N. E. 10559 | I. Kaffenburgh & Sons, Inc., Hartford | 6.56 | 6.56 |
| 1246 | Monarch, Car N. Y. 84844 and M. L. & T. 53287 | Spencer Bros., Inc., Suffield | 6.94 | 6.88 |
| 1712 | Monarch, Car C. of Ga. 58030 | Spencer Bros., Inc., Suffield | 6.90 | 6.88 |
| 1713 | Monarch, Car N. Y. 166393 and 25254 | Spencer Bros., Inc., Suffield | 7.02 | 6.88 |
| 1714 | Helmet, Car Pa. 572583 | Spencer Bros., Inc., Suffield | 6.49 | 6.56 |
| 1715 | Paramount, Car R. I. 46524 | Spencer Bros., Inc., Suffield | 5.32 | 5.76 |
| 1716 | Helmet, Car W. of A. 959 | Spencer Bros., Inc., Suffield | 6.53 | 6.56 |
| 1717 | Monarch, Car N. Y. 160303 and 37727 | Spencer Bros., Inc., Suffield | 7.08 | 6.88 |
| 1849 | Helmet, Car I. C. 340224 | Spencer Bros., Inc., Suffield | 6.71 | 6.56 |
| 1850 | Helmet, Car I. C. 159550 | Spencer Bros., Inc., Suffield | 6.56 | 6.56 |
| 1851 | Monarch, Car N. Y. 163385 and INO 53564 | Spencer Bros., Inc., Suffield | 7.02 | 6.88 |
| 1852 | Monarch, Car B. & O. 192375 | Spencer Bros., Inc., Suffield | 6.90 | 6.88 |
| | **F. W. Brode Corp., Memphis, Tenn.** | | | |
| 1916 | Owl Brand 41% | Station agent. Stock of F. N. Buckland, So. Manchester | 6.28 | 6.56 |
| 1598 | Owl Brand 43% | Geo. T. Soule Co., New Milford | 6.60 | 6.88 |
| 1770 | Owl Brand 43% | Geo. T. Soule Co., New Milford | 6.54 | 6.88 |
| 1829 | Owl Brand 43% | Geo. T. Soule Co., New Milford | 6.70 | 6.88 |
| | **Humphreys-Godwin Co., Memphis, Tenn.** | | | |
| 1543 | Dixie | Station agent. Stock of C. S. Barnum, Danbury | 6.66 | 6.58 |
| 1681 | Dixie | Station agent. Stock of Frank Ford, Suffield | 6.58 | 6.58 |
| 1792 | Bull | Station agent. Stock of Bloomfield Farmers' Exchange, Bloomfield | 6.86 | 6.88 |
| 1877 | Danish | Station agent. Stock of Geo. S. Phelps, Thompsonville | 5.78 | 5.75 |

TABLE IV. ANALYSES OF COTTONSEED AND LINSEED MEALS—*Continued.*

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Humphreys-Godwin Co., Memphis, Tenn.** | | | |
| 1899 | Dixie | Station agent. Stock of John Richards, So. Glastonbury | 6.37 | 6.56 |
| 1297 | Dixie, Car No. 164145 | J. Bermant, Ellington | 6.48 | 6.58 |
| 1298 | Dixie, Car No. 168084 | J. Bermant, Ellington | 6.69 | 6.58 |
| 1299 | Dixie, Car No. 35114 | J. Bermant, Ellington | 6.39 | 6.58 |
| 1330 | Bull, Car N. H. 71512 | Cullman Bros., Inc., Hartford | 7.02 | 6.88 |
| 873 | Dixie, Car N. H. 169423 | Cullman Bros., Inc., Hartford | 6.41 | 6.58 |
| 874 | Dixie, Car N. H. 163452 | Cullman Bros., Inc., Hartford | 6.58 | 6.58 |
| 875 | Dixie, Car No. 160484 | Cullman Bros., Inc., Hartford | 6.45 | 6.58 |
| 1331 | Dixie, Car N.H. 90428 | Cullman Bros., Inc., Hartford | 6.67 | 6.58 |
| 1332 | Dixie, Car N. H. 160152 | Cullman Bros., Inc., Hartford | 6.66 | 6.58 |
| 1333 | Dixie, Car N. H. 87398 | Cullman Bros., Inc., Hartford | 6.58 | 6.58 |
| 1334 | Dixie, Car N. H. 79245 | Cullman Bros., Inc., Hartford | 6.54 | 6.58 |
| 1335 | Dixie, Car N.H. 164093 | Cullman Bros., Inc., Hartford | 6.62 | 6.58 |
| 1336 | Dixie, Car N. H. 158079 | Cullman Bros., Inc., Hartford | 6.60 | 6.58 |
| 1337 | Dixie, Car N. H. 160898 | Cullman Bros., Inc., Hartford | 6.68 | 6.58 |
| 1338 | Dixie, Car No. 162523 | Cullman Bros., Inc., Hartford | 6.58 | 6.58 |
| 1339 | Dixie, Car No. 89648 | Cullman Bros., Inc., Hartford | 6.58 | 6.58 |
| 1340 | Dixie, Car No. 76146 | Cullman Bros., Inc., Hartford | 6.59 | 6.58 |
| 1550 | .......... | J. R. Debone, East Hartford | 6.36 | .. |
| 980 | Dixie, Car No. 62046 | L. B. Haas & Co., Inc., Hartford | 6.39 | 6.58 |
| 981 | Dixie, Car No. 245109 | L. B. Haas & Co., Inc., Hartford | 6.83 | 6.58 |
| 982 | Dixie, Car No. 45358 | L. B. Haas & Co., Inc., Hartford | 6.50 | 6.58 |
| 983 | Dixie, Car No. 15145 | L. B. Haas & Co., Inc., Hartford | 6.42 | 6.58 |
| 984 | Dixie, Car No. 165952 | L. B. Haas & Co., Inc., Hartford | 6.45 | 6.58 |
| 985 | Dixie, Car No. 44183 | L. B. Haas & Co., Inc., Hartford | 6.32 | 6.58 |
| 1032 | Dixie, Car No. 421771 | L. B. Haas & Co., Inc., Hartford | 6.52 | 6.58 |
| 1033 | Dixie, Car No. 16441 | L. B. Haas & Co., Inc., Hartford | 6.44 | 6.58 |
| 1344 | Dixie, Car No. 171241 | L. B. Haas & Co., Inc., Hartford | 6.57 | 6.58 |
| 914 | Dixie | Huntington Bros., Windsor | 6.42 | 6.58 |
| 915 | Dixie | Huntington Bros., Windsor | 6.61 | 6.58 |
| 916 | Dixie | Huntington Bros., Windsor | 6.46 | 6.58 |
| 917 | Dixie | Huntington Bros., Windsor | 6.46 | 6.58 |
| 744 | Dixie | S. F. Holcomb & Son, West Granby | 6.40 | 6.58 |
| 901 | Dixie | S. F. Holcomb & Son, West Granby | 6.64 | 6.58 |
| 1906 | Dixie, Car No. 163938 | Max Lavitt, Ellington | 6.37 | 6.58 |
| 1907 | Dixie, Car No. 166562 | Max Lavitt, Ellington | 6.59 | 6.58 |
| 1908 | Dixie, Car No. 170190 | Max Lavitt, Ellington | 6.47 | 6.58 |
| 1284 | Dixie | H. C. Nelson, West Suffield | 6.58 | 6.58 |
| 906 | Dixie, Car C. G. A. 51140 | A. N. Shepard, Hartford | 6.61 | 6.58 |
| 1897 | Dixie, Car No. 1 | M. Silverberg, Ellington | 6.42 | 6.58 |



TABLE IV. ANALYSES OF COTTONSEED AND LINSEED MEALS—*Continued.*

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Humphreys-Godwin Co., Memphis, Tenn.** | | | |
| 1898 | Dixie, Car No. 2 | M. Silverberg, Ellington | 6.46 | 6.58 |
| 1854 | Danish, Car Southern 167164 | Spencer Bros., Inc., Suffield | 5.66 | 5.76 |
| 2006 | Danish, Car A. C. L. 50466 | Spencer Bros., Inc., Suffield | 5.63 | 5.76 |
| 2007 | Danish, Car C. M. St. P. 708260 | Spencer Bros., Inc., Suffield | 5.70 | 5.76 |
| 2008 | Danish, Car Southern 168634 | Spencer Bros., Inc., Suffield | 5.70 | 5.76 |
| 2009 | Danish, Car Southern 131844 | Spencer Bros., Inc., Suffield | 5.66 | 5.76 |
| 2010 | Danish, Car A. C. L. 30742 | Spencer Bros., Inc., Suffield | 5.73 | 5.76 |
| 2011 | Danish, Car A. C. L. 17430 | Spencer Bros., Inc., Suffield | 5.58 | 5.76 |
| 1428 | Car No. 1 | Henry E. Wells, Warehouse Point | 6.55 | .... |
| 1429 | Car No. 2 | Henry E. Wells, Warehouse Point | 6.65 | .... |
| 1694 | Dixie, Car No. 163226 | L. Wetstone & Sons, Hartford | 6.44 | 6.58 |
| 1695 | Dixie, Car No. 341534 | L. Wetstone & Sons, Hartford | 6.31 | 6.58 |
| 1696 | Dixie, Car No. 166772 | L. Wetstone & Sons, Hartford | 6.55 | 6.58 |
| 1697 | Dixie, Car No. 80678 | L. Wetstone & Sons, Hartford | 6.30 | 6.58 |
| 1698 | Dixie, Car No. 81014 | L. Wetstone & Sons, Hartford | 6.40 | 6.58 |
| 1699 | Dixie, Car S. P. 20654 | L. Wetstone & Sons, Hartford | 6.34 | 6.58 |
| | **International Agricultural Corp., Atlanta, Ga.** | | | |
| 1173 | Zenith | W. S. Pinney, Suffield | 6.66 | 6.56 |
| | **L. B. Lovitt Co., Memphis, Tenn.** | | | |
| 904 | "Lovit" 36%, Car I. C. 190247 | A. N. Shepard & Son, Hartford | 5.58 | 5.76 |
| 905 | "Lovit" 36%, Car I. C. 173354 | A. N. Shepard & Son, Hartford | 5.60 | 5.76 |
| | **Marianna Sales Co., Memphis, Tenn.** | | | |
| 1677 | White Mule | Charles J. Hartz, Burnside | 6.16 | 6.58 |
| | **Olds & Whipple, Inc., Hartford, Conn.** | | | |
| 1343 | Car No. 161099 | L. B. Haas & Co., Hartford | 6.53 | .... |
| 634 | .......... | The Hartman Tobacco Co., Hartford | 6.95 | .... |
| 665 | .......... | The Hartman Tobacco Co., Hartford | 7.13 | .... |
| 1690 | .......... | Silberman & Kahn, Hartford | 6.48 | .... |
| 1779 | Car No. 161306 | Silberman & Kahn, Hartford | 6.66 | .... |
| 1778 | Car No. 163813 | Silberman & Kahn, Hartford | 6.58 | .... |

TABLE IV. ANALYSES OF COTTONSEED AND LINSEED MEALS—*Concluded.*

| Station No. | Manufacturer or Jobber, Car No. or Mark | Purchased, Sampled or Sent by | Per cent. Nitrogen. Found. | Per cent. Nitrogen. Guaranteed. |
|---|---|---|---|---|
| | **Manufacturer Unknown.** | | | |
| 1549 | ........................... | J. R. Debone, East Hartford .... | 6.55 | .... |
| 2070 | ........................... | Karl C. Kulle, Suffield .......... | 6.43 | 6.56 |
| | **Archer-Daniels-Midland Co., Minneapolis, Minn.** | **Linseed Meal.** | | |
| 986 | Car No. 93172 .............. | L. B. Haas & Co., Inc., Hartford | 5.18 | 5.12 |
| 1345 | Car No. 170308 .............. | L. B. Haas & Co., Inc., Hartford | 5.18 | 5.12 |
| 8833 | Car No. 10432 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.64 | .... |
| 8822 | Car No. 94653 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.63 | .... |
| 8823 | Car No. 9027 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.64 | .... |
| 918 | ........................... | Huntington Bros., Windsor ..... | 5.25 | .... |
| 1703 | Car No. 161946 .............. | L. Wetstone & Sons, Hartford .. | 5.15 | 5.12 |
| | **Kellogg and Miller, Inc., Amsterdam, N. Y.** | | | |
| 863 | Car No. 95173 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.57 | 5.44 |
| 864 | Car No. 219843 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.52 | 5.44 |
| 940 | Car No. 33185 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.41 | 5.44 |
| 941 | Car No. 254108 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.48 | 5.44 |
| 942 | Car No. 48392 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.61 | 5.44 |
| 943 | Car No. 214525 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.59 | 5.44 |
| 944 | Car No. 220918 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.67 | 5.44 |
| 1661 | Truck No. 4791 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.25 | 5.44 |
| 1721 | Car No. 169078 .............. | A. N. Shepard & Sons, Hartford | 5.48 | 5.44 |
| 1178 | Car No. 180590 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.45 | 5.44 |
| 1179 | Car No. 35447 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.57 | 5.44 |
| 1180 | Car No. 229149 .............. | Hatheway & Steane, Inc., Hartford ........................ | 5.52 | 5.44 |



## II. RAW MATERIALS CHIEFLY VALUABLE FOR PHOSPHORIC ACID.

### PRECIPITATED BONE PHOSPHATE.

This material is a by-product obtained in the manufacture of gelatin and glue stock from bone. Bones are treated with hydrochloric acid and the acid solution then treated with lime or limestone to precipitate the phosphates. The term "precipitated phosphate" is generally used to designate the article derived from bone as here described; but it would be descriptive also of material of similar substance and quality derived from other sources. The terms "bone phosphate" or "precipitated bone phosphate" are correctly applied only to those concentrated phosphates derived from bone.

Precipitated bone phosphate is valuable for its high available phosphoric acid, the guaranty for which is generally placed at 36 or 38 per cent.

Twelve samples were examined this year, three of which were sampled by the Station Agent and the others by purchasers. Guaranties, so far as given, were met with substantial margins of safety. There were three price quotations, all $45.00 a ton, at which available phosphoric acid has cost the purchaser 5.3 cents a pound.

Analyses are given in Table V.

### SUPERPHOSPHATE.

This important base material, formerly called "acid phosphate," is made by treating phosphate rock with sulphuric acid, which results in a mixture of mono-calcium phosphate and calcium sulphate or gypsum. The phosphoric acid is largely in available form and generally is guaranteed at 16 per cent.

Eighteen samples were analyzed, four of which fell below guaranties by amounts greater than 0.25 per cent. The deficiencies ranged from 0.3 to 1 per cent. The average of all samples is 16.65 per cent and the average of quoted prices is about $25.00 per ton, thus available phosphoric acid from this source has cost approximately 7.5 cents a pound this year.

Analyses are given in Table VI.

Sample 1629, Phospho Tobacco, is classed with the superphosphates, but it contains about 3 per cent less available phosphoric acid and is guaranteed accordingly.

### BASIC SLAG.

Basic slag is a by-product in the manufacture of steel from phosphatic iron ores. It should contain not less than 12 per cent of total phosphoric acid, of which not less than 80 per cent should be "available" by the Wagner method.[1]

One sample, **1956,** from stock of Apothecaries Hall Company, was analyzed. In contained 16.58 per cent of total phosphoric acid and 14.43 per cent available. The material meets the requirements for standard basic slag, but is about 0.5 per cent under the guaranty given by the seller.

[1] Assoc. of Official Agricultural Chemists, Proc. of Oct. 1925.



TABLE V. ANALYSES OF PRECIPITATED BONE PHOSPHATE.

| Station No. | Manufacturer or Wholesale Dealer. | Place of Sampling. | Citrate Insoluble. | Phosphoric Acid. Total. | "Available." Found. | "Available." Guaranteed. |
|---|---|---|---|---|---|---|
| | | | % | % | % | % |
| | *Sampled by Station.* | | | | | |
| 1410 | Apothecaries Hall Co., Waterbury | At factory | 0.57 | 39.10 | 38.53 | 36.00 |
| 1879 | Eastern States Farmers' Exchange, Springfield, Mass. | Frank V. Williams, Buckland | 0.05 | 45.53 | 45.48 | 38.00 |
| 1460 | Olds & Whipple, Inc., Hartford | At factory | 0.25 | 44.40 | 44.15 | 38.00 |
| | *Sampled by Purchaser.* | | | | | |
| 945 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 0.40 | 39.72 | 39.32 | 36.00 |
| 946 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 0.56 | 40.92 | 40.36 | 36.00 |
| 1175 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 0.75 | 39.25 | 38.50 | 36.00 |
| 1719 | Apothecaries Hall Co., Waterbury | A. N. Shepard & Son, Hartford | 0.42 | 39.10 | 38.68 | 36.00 |
| 920 | Olds & Whipple, Inc., Hartford | Huntington Bros., Windsor | 0.15 | 46.72 | 46.57 | 38.00 |
| 2030 | Olds & Whipple, Inc., Hartford | Lester Lloyd, Suffield | 0.30 | 46.10 | 45.80 | 38.00 |
| 1688 | Olds & Whipple, Inc., Hartford | Silberman & Kahn, Hartford | 0.30 | 46.10 | 46.50 | 38.00 |
| 1774 | Olds & Whipple, Inc., Hartford | Silberman & Kahn, Hartford | 0.30 | 45.78 | 45.48 | 38.00 |
| 1702 | Olds & Whipple, Inc., Hartford | L. Wetstone & Sons, Hartford | 0.60 | 39.50 | 38.90 | 38.00 |

TABLE VI. ANALYSES OF SUPERPHOSPHATE (ACID PHOSPHATE).

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Phosphoric Acid. Citrate Insoluble. | Phosphoric Acid. Total. | "Available." Found. | "Available." Guaranteed. |
|---|---|---|---|---|---|---|
| | *Sampled by Station.* | | % | % | % | % |
| 1496 | American Agricultural Chemical Co., New York City | New Canaan: Clap Board Hill Farm | 0.65 | 17.12 | 16.47 | 16.00 |
| 1446 | Apothecaries Hall Co., Waterbury | Waterbury: Templeton's Hardware Co. | 1.60 | 17.28 | 15.68 | 16.00 |
| 1568 | Armour Fertilizer Works, New York City | Stamford: F. A. Bartlett Tree Expert Co. | 0.48 | 20.50 | 20.02 | 20.00 |
| 1576 | Armour Fertilizer Works, New York City | Meriden: Raven's Hardware Co. | 0.69 | 17.16 | 16.47 | 16.00 |
| 1585 | Associated Seed Growers, New Haven | Milford: Associated Seed Growers | 0.43 | 17.25 | 16.82 | 16.00 |
| 1373 | Berkshire Chemical Co., Bridgeport | Hamden: J. A. Smith | 0.15 | 17.21 | 17.06 | 16.00 |
| 1368 | Consolidated Rendering Co., Boston, Mass. | Highwood: H. D. Peters | 0.10 | 19.80 | 19.70 | 20.00 |
| 1600 | Consolidated Rendering Co., Boston, Mass. | Wallingford: Laden Bros. | 1.53 | 17.60 | 16.07 | 16.00 |
| 1425 | Eastern States Farmers' Exchange, Springfield, Mass. | New Canaan: Hoyt's Nurseries | 0.76 | 16.73 | 15.97 | 16.00 |
| 1500 | Eastern States Farmers' Exchange, Springfield, Mass. | Southington: Julius Lewis | 0.43 | 16.60 | 16.17 | 16.00 |
| 1475 | Olds & Whipple, Inc., Hartford | So. Manchester: F. T. Blish Hardware Co. | 1.40 | 16.40 | 15.00 | 16.00 |
| 1472 | The Rogers & Hubbard Co., Portland | Sampled at factory | 0.15 | 17.76 | 17.61 | 16.00 |
| 1398 | Standard Phosphate & Acid Works, Baltimore, Md. | Southport: Geo. S. Jennings | 0.58 | 16.15 | 15.57 | 16.00 |



TABLE VI. ANALYSES OF SUPERPHOSPHATE (ACID PHOSPHATE)—*Concluded.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Phosphoric Acid. Citrate Insoluble. | Phosphoric Acid. Total. | "Available." Found. | "Available." Guaranteed. |
|---|---|---|---|---|---|---|
| | *Sampled by Station.* | | % | % | % | % |
| 1619 | I. P. Thomas & Son, Philadelphia, Pa. | Hamden: Ira W. Beers | 0.28 | 17.08 | 16.80 | 16.00 |
| 1633 | Virginia-Carolina Chemical Co., New York City | New Britain: Stanley Svea Coal Co. | 1.25 | 17.30 | 16.05 | 16.00 |
| 1634 | Wilcox Fertilizer Co., Mystic | Sampled at factory | 0.10 | 18.12 | 18.02 | 17.00 |
| | **Phospho Tobacco.** | | | | | |
| 1629 | Virginia-Carolina Chemical Co., New York City | New Britain: Stanley Svea Coal Co. | 0.78 | 13.89 | 13.11 | 13.00 |
| | *Sampled by Purchaser.* | | | | | |
| 2029 | United States Guano Co., Baltimore, Md. | Suffield: Lester Lloyd | 0.20 | 17.30 | 17.10 | 16.00 |

## III. RAW MATERIALS CHIEFLY VALUABLE FOR POTASH.

### CARBONATE OF POTASH.

This salt contains 68.2 per cent of potash ($K_2O$), when pure and dry, but commercial grades will contain from 60 to 65 per cent.

Twenty-five samples were examined. One sample was old stock held over from last year and had absorbed a good deal of moisture and another sample, **1433**, was low in potash, probably for the same reason. Sample **1775** was of good grade but somewhat under the guaranty given for it. All other samples were satisfactory, many exceeding 65 per cent. The average of all samples, excluding Nos. **1433** and **999**, is 65.54 per cent. Prices quoted ranged from $6.25 to $6.60 a hundred pounds, at which figures potash in a salt testing 65.5 per cent cost the purchaser from 9.5 to 10 cents a pound.

Analyses are given in Table VII.

### MURIATE OF POTASH.

The grades of this material which are used for fertilizer contain from 48 to 50 per cent of actual potash ($K_2O$), largely as chloride. Chlorides are detrimental to tobacco of the types grown in New England and hence muriate of potash is avoided for tobacco mixtures in this State.

Ten samples were examined and all of them exceeded guaranties. The average of all samples is 50.5 per cent potash and at $52.00 a ton potash costs 5.1 cents a pound.

Analyses are given in Table VII.

### SULPHATE OF POTASH.

This salt for fertilizer purposes should contain not less than 48 per cent of potash, and not more than 2.5 per cent of chlorine.[1]

Nineteen samples were analyzed. Most of them met guaranties with substantial averages. Nos. **1196** and **1458** showed shortages in potash approaching 1 per cent. The average potash content found is 49.3 per cent. Prices quoted ranged from $69.00 to $71.00 a ton and averaged $69.50, which makes the cost of potash from this source about seven cents a pound.

### SULPHATE OF POTASH-MAGNESIA.

This potash salt was formerly known as "double manure salt," a name which is now practically abandoned. It is a double sulphate of potash and magnesia containing 25 per cent or more of potash, and is fairly free from chlorine which should not be present in excess of 2.5 per cent.[1]

[1] Assoc. of Official Agricultural Chemists, Proc. of October, 1925.



"Manure salts" is a very different article seldom found in this State. This material contains 20 to 30 per cent of potash, which is chiefly in the form of chloride.

Only two samples of sulphate of potash-magnesia were analyzed this year. Both satisfied guaranties with substantial overruns.

### COTTONHULL ASHES.

This material is extremely variable in composition. Most or all of this fertilizer as sold in this State is screened and remixed by the jobber handling it and some improvement has been secured as regards uniformity. However, different shipments show wide variations, and different portions of the same lot may vary considerably in composition.

Sixty samples of these ashes have been examined this year and the results are given in Table VIII.

[1] Assoc. of Official Agricultural Chemists, Proc. of October, 1925.

TABLE VII. ANALYSES OF POTASH SALTS, ETC.

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Potash. Found. | Potash. Guaranteed. |
|---|---|---|---|---|
| | **Carbonate of Potash.** | | | |
| | *Sampled by Station.* | | % | % |
| 1954 | Apothecaries Hall Co., Waterbury, Conn. | Sampled at factory | 66.24 | 60.00 |
| 1463 | Olds & Whipple, Inc., Hartford, Conn. | Sampled at factory | 67.49 | 65.00 |
| | *Sampled by Purchaser.* | | | |
| 1181 | Apothecaries Hall Co., Waterbury, Conn., Car No. 3683 | Hatheway & Steane, Inc., Hartford | 61.13 | 60.00 |
| 1182 | Apothecaries Hall Co., Waterbury, Conn., Car No. 46112 | Hatheway & Steane, Inc., Hartford | 64.99 | 60.00 |
| 1183 | Apothecaries Hall Co., Waterbury Conn., Truck 1003 | Hatheway & Steane, Inc., Hartford | 65.10 | 60.00 |
| 1184 | Apothecaries Hall Co., Waterbury, Conn., Car No. 48305 | Hatheway & Steane, Inc., Hartford | 63.87 | 60.00 |
| 1266 | Apothecaries Hall Co., Waterbury, Conn., Car No. 400 | Hatheway & Steane, Inc., Hartford | 63.85 | 60.00 |
| 1659 | Apothecaries Hall Co., Waterbury, Conn., Truck 4791 | Hatheway & Steane, Inc., Hartford | 64.18 | 60.00 |
| 1723 | Apothecaries Hall Co., Waterbury, Conn., Car No. 416271 | A. N. Shepard & Son, Hartford | 63.10 | 60.00 |
| 999 | Berkshire Chemical Co., Bridgeport, Conn. | James T. Burgess, Thompsonville | 56.43[1] | ..... |
| 1228 | Harshaw, Fuller & Goodwin, New York, Car No. 16986 | American Sumatra Tobacco Co., Bloomfield | 66.52 | ..... |
| 1174 | International Agricultural Corp., Atlanta, Ga. | W. S. Pinney, Suffield | 66.18 | ..... |
| 725 | A. Klipstein Co., New York, Car No. 44552 | American Sumatra Tobacco Co., Bloomfield | 66.43 | ..... |
| 726 | A. Klipstein Co., New York, Car No. 165034 | American Sumatra Tobacco Co., Bloomfield | 65.53 | ..... |
| 727 | A. Klipstein Co., New York, Car No. 62255 | American Sumatra Tobacco Co., Bloomfield | 67.42 | ..... |
| 729 | A. Klipstein Co., New York, Car No. 342273 | American Sumatra Tobacco Co., Bloomfield | 66.97 | ..... |
| 730 | A. Klipstein Co., New York, Car No. 415088 | American Sumatra Tobacco Co., Bloomfield | 66.09 | ..... |

[1]Moisture, 16.20%. Last year's stock.



TABLE VII. ANALYSES OF POTASH SALTS, ETC.—*Continued.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Potash. Found. | Potash. Guaranteed. |
|---|---|---|---|---|
| | **Carbonate of Potash.** | | | |
| | *Sampled by Purchaser.* | | % | % |
| 893 | A. Klipstein Co., New York, Car No. 71236 | American Sumatra Tobacco Co., Bloomfield | 66.22 | ..... |
| 894 | A. Klipstein Co., New York, Car No. 571483 | American Sumatra Tobacco Co., Bloomfield | 67.29 | ..... |
| 1226 | A. Klipstein Co., New York, Car No. 23995 | American Sumatra Tobacco Co., Bloomfield | 65.94 | ..... |
| 1227 | A. Klipstein Co., New York, Car No. 19569 | American Sumatra Tobacco Co., Bloomfield | 65.56 | ..... |
| 1229 | A. Klipstein Co., New York, Car No. 85658 | American Sumatra Tobacco Co., Bloomfield | 66.12 | ..... |
| 1775 | Olds & Whipple, Inc., Hartford, Conn., Car N. H. 150075 | Silberman & Kahn, Hartford | 63.24 | 65.00 |
| 1685 | Olds & Whipple, Inc., Hartford, Conn. | Silberman & Kahn, Hartford | 60.20 | 65.00 |
| 1433 | Manufacturer unknown | P. J. Anderson, Windsor | 58.90 | ..... |
| | **Muriate of Potash.** | | | |
| | *Sampled by Station.* | | | |
| 1738 | American Agricultural Chemical Co., New York | Sampled at factory, West Haven | 51.78 | 50.00 |
| 1413 | Apothecaries Hall Co., Waterbury, Conn. | Sampled at factory | 51.64 | 50.00 |
| 1565 | Armour Fertilizer Works, New York | F. A. Bartlett Tree Expert Co., Stamford | 50.50 | 48.00 |
| 1394 | Berkshire Chemical Co., Bridgeport, Conn. | Sampled at factory | 50.20 | 50.00 |
| 1670 | Berkshire Chemical Co., Bridgeport, Conn. | Knowles-Lombard Co., Guilford | 50.65 | 50.00 |
| 1370 | Consolidated Rendering Co., Boston, Mass. | H. D. Peters, Highwood | 51.88 | 50.00 |
| 2158 | Eastern States Farmers' Exchange, Springfield, Mass. | F. W. Wooding, North Haven | 48.46 | 48.00 |
| 1608 | Standard Phosphate & Acid Works, Baltimore, Md. | Julius Lewis, Southington | 48.18 | 48.00 |

TABLE VII. ANALYSES OF POTASH SALTS, ETC.—*Continued.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Potash. Found. | Potash. Guaranteed. |
|---|---|---|---|---|
| | **Muriate of Potash.** | | | |
| | *Sampled by Station.* | | % | % |
| 1917 | I. P. Thomas & Son, Philadelphia, Pa. | J. C. Thompson, Unionville | 50.40 | 50.00 |
| 1635 | Wilcox Fertilizer Co., Mystic, Conn. | Sampled at factory | 51.70 | 50.00 |
| | **Sulphate of Potash.** | | | |
| | *Sampled by Station.* | | | |
| 1734 | American Agricultural Chemical Co., New York | E. J. Bantle, Glastonbury | 49.59 | 48.00 |
| 1758 | Apothecaries Hall Co., Waterbury, Conn. | Sampled at factory | 50.72 | 48.00 |
| 2148 | Armour Fertilizer Works, New York | James T. Caffrey, Cromwell | 49.53 | 48.00 |
| 1393 | Berkshire Chemical Co., Bridgeport, Conn. | Sampled at factory | 49.05 | 48.00 |
| 1422 | Consolidated Rendering Co., Boston, Mass. | L. T. Frisbie Co., New Haven | 49.87 | 48.00 |
| 1880 | Eastern States Farmers' Exchange, Springfield, Mass. | Frank V. Williams, Buckland | 49.46 | 48.00 |
| 1458 | Olds & Whipple, Inc., Hartford, Conn. | Sampled at factory | 47.80 | 48.65 |
| | *Sampled by Purchaser.* | | | |
| 1185 | Apothecaries Hall Co., Waterbury, Conn., Truck 1002 | Hatheway & Steane, Inc., Hartford | 49.54 | 48.00 |
| 1186 | Apothecaries Hall Co., Waterbury, Conn., Car No. 5430 | Hatheway & Steane, Inc., Hartford | 47.14 | 48.00 |
| 1267 | Apothecaries Hall Co., Waterbury, Conn., Car No. 402 | Hatheway & Steane, Inc., Hartford | 48.33 | 48.00 |
| 1658 | Apothecaries Hall Co., Waterbury, Conn., Truck 4791 | Hatheway & Steane, Inc., Hartford | 48.56 | 48.00 |
| 1727 | Apothecaries Hall Co., Waterbury, Conn., Car No. 166056 | A. N. Shepard & Son, Hartford | 48.98 | 48.00 |



TABLE VII. ANALYSES OF POTASH SALTS, ETC.—*Concluded.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Potash. Found. | Potash. Guaranteed. |
|---|---|---|---|---|
| | **Sulphate of Potash.** | | | |
| | *Sampled by Purchaser.* | | % | % |
| 997 | Berkshire Chemical Co., Bridgeport, Conn. | James T. Burgess, Thompsonville | 49.10 | 48.00 |
| 1986 | Berkshire Chemical Co., Bridgeport, Conn. | V. L. Hickey, Burnside | 49.25 | 48.00 |
| 728 | Harshaw, Fuller & Goodwin, New York, Car No. 184770 | American Sumatra Tobacco Co., Bloomfield | 50.56 | ..... |
| 2028 | Olds & Whipple, Inc., Hartford, Conn. | Lester Lloyd, Suffield | 51.33 | 48.65 |
| 1686 | Olds & Whipple, Inc., Hartford, Conn. | Silberman & Kahn, Hartford | 48.43 | 48.65 |
| 1777 | Olds & Whipple, Inc., Hartford, Conn., Car N. H. 150075 | Silberman & Kahn, Hartford | 49.60 | 48.65 |
| 1700 | Olds & Whipple, Inc., Hartford, Conn. | L. Wetstone & Sons, Hartford | 49.73 | 48.65 |
| | **Sulphate of Potash and Magnesia.** | | | |
| | *Sampled by Station.* | | | |
| 1408 | Apothecaries Hall Co., Waterbury, Conn. | Sampled at factory | 27.25 | 26.00 |
| 1968 | Eastern States Farmers' Exchange, Springfield, Mass. | Paul W. Caldwell, New Milford | 27.71 | 25.00 |

TABLE VIII. ANALYSES OF COTTON HULL ASHES.

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Moisture. | Phosphoric Acid. | Potash. |
|---|---|---|---|---|---|
| | *Sampled by Station.* | | % | % | % |
| 9852 | Ed. Eggert, Hartford, Conn., Car Rock Island 57595 ... | American Agricultural Chemical Co., West Haven .............................. | 15.77 | 2.55 | 14.65 |
| 9888 | Ed. Eggert, Hartford, Conn., Car N. H. 166696 ........ | American Agricultural Chemical Co., West Haven .............................. | 18.45 | 2.57 | 18.77 |
| 9889 | Ed. Eggert, Hartford, Conn., Car S. L. S. F. 147205 ... | American Agricultural Chemical Co., West Haven .............................. | 22.45 | 2.67 | 15.60 |
| 9890 | Ed. Eggert, Hartford, Conn., Car A. T. & S. F. 46228 .. | American Agricultural Chemical Co., West Haven .............................. | 19.25 | 4.77 | 23.69 |
| 303 | Ed. Eggert, Hartford, Conn., Lot No. 1 .............. | L. B. Haas & Co., Hartford .............. | 12.13 | 2.98 | 31.92 |
| 304 | Ed. Eggert, Hartford, Conn., Lot No. 2 .............. | L. B. Haas & Co., Hartford .............. | 13.20 | 4.71 | 29.13 |
| 407 | Ed. Eggert, Hartford, Conn. ......................... | L. B. Haas & Co., Hartford .............. | 14.33 | 4.26 | 27.95 |
| 1945 | Ed. Eggert, Hartford, Conn. ......................... | G. A. Peckham, Suffield .................. | ..... | 3.14 | 31.84 |
| 1324 | Ed. Eggert, Hartford, Conn. ......................... | J. E. Shepard, So. Windsor .............. | ..... | .... | 22.34 |
| 1322 | International Agricultural Corp., Boston, Mass. ........ | J. E. Shepard, So. Windsor .............. | ..... | 2.44 | 32.46 |
| 1323 | International Agricultural Corp., Boston, Mass. ........ | J. E. Shepard, So. Windsor .............. | ..... | 2.45 | 32.37 |
| | *Sampled by Purchaser.* | | | | |
| 2077 | F. W. Brode Corp., Memphis, Tenn., Car No. 37614 ... | The Otee Tobacco Corp., Hartford ....... | ..... | 2.65 | 21.18 |
| 2114 | F. W. Brode Corp., Memphis, Tenn., Car No. 128835 .. | The Otee Tobacco Corp., Hartford ....... | ..... | 2.73 | 31.15 |
| 2115 | F. W. Brode Corp., Memphis, Tenn., Car No. 28161 ... | The Otee Tobacco Corp., Hartford ....... | ..... | 1.83 | 15.47 |
| 2139 | F. W. Brode Corp., Memphis, Tenn., Car No. 46481 ... | The Otee Tobacco Corp., Hartford ....... | ..... | 3.65 | 25.95 |
| 2112 | F. W. Brode Corp., Memphis, Tenn., Car No. 156794 .. | J. B. Stewart, Windsor .................. | ..... | 2.94 | 27.04 |



TABLE VIII. ANALYSES OF COTTON HULL ASHES—*Continued.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Moisture. | Phosphoric Acid. | Potash. |
|---|---|---|---|---|---|
| | *Sampled by Purchaser.* | | % | % | % |
| 2113 | F. W. Brode Corp., Memphis, Tenn., Car No. 204733 .. | J. B. Stewart, Windsor .................. | ..... | 3.64 | 19.65 |
| 2117 | F. W. Brode Corp., Memphis, Tenn., Car No. 43268 ... | J. B. Stewart, Windsor .................. | ..... | 3.12[1] | 20.36 |
| 1679 | Ed. Eggert, Hartford, Conn., Car No. 46021 ........... | American Sumatra Tobacco Co., Bloomfield | ..... | 3.45 | 25.00 |
| 408 | Ed. Eggert, Hartford, Conn., Car C. M. & St. Paul 711241 ........................................ | P. J. Anderson, Windsor ................ | 14.98 | 2.93 | 12.03 |
| 409 | Ed. Eggert, Hartford, Conn., Car C. M. & St. Paul 711241 ........................................ | P. J. Anderson, Windsor ................ | 3.22 | 1.47 | 3.68 |
| 461 | Ed. Eggert, Hartford, Conn., Car S. F. 148880 ........ | P. J. Anderson, Windsor ................ | 6.48 | .... | 34.98 |
| 635 | Ed. Eggert, Hartford, Conn., Car St. L. 129233 ........ | P. J. Anderson, Windsor ................ | ..... | .... | 36.14 |
| 636 | Ed. Eggert, Hartford, Conn., Car R. I. 133611 ......... | P. J. Anderson, Windsor ................ | ..... | .... | 35.74 |
| 637 | Ed. Eggert, Hartford, Conn., Car C. R. I. & P. 156134.. | P. J. Anderson, Windsor ................ | ..... | .... | 37.34 |
| 638 | Ed. Eggert, Hartford, Conn., Car R. I. 57845 .......... | P. J. Anderson, Windsor ................ | ..... | .... | 32.60 |
| 639 | Ed. Eggert, Hartford, Conn., Car St. L. 161328 ........ | P. J. Anderson, Windsor ................ | ..... | .... | 31.45 |
| 640 | Ed. Eggert, Hartford, Conn., Car Frisco 122879 ....... | P. J. Anderson, Windsor ................ | ..... | .... | 37.42 |
| 693 | Ed. Eggert, Hartford, Conn., Car R. I. 350135 ......... | Edwards & Brewer, Hartford ............ | 8.75 | 3.51 | 25.08 |
| 694 | Ed. Eggert, Hartford, Conn., Car R. I. 350228 ......... | Edwards & Brewer, Hartford ............ | 12.08 | 4.45 | 28.58 |
| 695 | Ed. Eggert, Hartford, Conn., Car S. L. & S. F. 129344.. | Edwards & Brewer, Hartford ............ | 10.71 | 3.48 | 28.04 |
| 696 | Ed. Eggert, Hartford, Conn., Car S. L. & S. F. 128712.. | Edwards & Brewer, Hartford ............ | 12.05 | 4.20 | 27.64 |
| 993 | Ed. Eggert, Hartford, Conn., Car M. O. P. 31613 ...... | Edwards & Brewer, Hartford ............ | ..... | 2.97 | 22.52 |
| 1240 | Ed. Eggert, Hartford, Conn., Car R. I. 46687 .......... | Edwards & Brewer, Hartford ............ | ..... | 3.52 | 23.62 |
| 1241 | Ed. Eggert, Hartford, Conn., Car R. I. 46687 .......... | Edwards & Brewer, Hartford ............ | ..... | 2.68 | 21.54 |

[1] Moisture 14.4%.

TABLE VIII. ANALYSES OF COTTON HULL ASHES—*Continued.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Moisture. | Phosphoric Acid. | Potash. |
|---|---|---|---|---|---|
| | *Sampled by Purchaser.* | | % | % | % |
| 1596 | Ed. Eggert, Hartford, Conn., Car H. 46687 | Edwards & Brewer, Hartford | ..... | 2.33 | 33.98 |
| 1597 | Ed. Eggert, Hartford, Conn., Car S. L. & S. F. 122837 | Edwards & Brewer, Hartford | ..... | 3.23 | 24.78 |
| 1753 | Ed. Eggert, Hartford, Conn., Car CRIP 3299 | Edwards & Brewer, Hartford | ..... | 3.38 | 25.39 |
| 2023 | Ed. Eggert, Hartford, Conn., Lot XX | Edwards & Brewer, Hartford | ..... | 2.95 | 33.08 |
| 2024 | Ed. Eggert, Hartford, Conn., Lot No. 100 | Edwards & Brewer, Hartford | ..... | 4.20 | 21.65 |
| 229 | Ed. Eggert, Hartford, Conn., Car No. R. I. 350228 | Ed. Eggert, Hartford | 12.65 | 4.24 | 27.84 |
| 230 | Ed. Eggert, Hartford, Conn., Car No. St. L. & S. F. 128712 | Ed. Eggert, Hartford | 10.03 | 4.06 | 28.08 |
| 231 | Ed. Eggert, Hartford, Conn., Car No. 31613 | Ed. Eggert, Hartford | 9.78 | 3.19 | 22.74 |
| 747 | Ed. Eggert, Hartford, Conn., Lot No. 8 | Ed. Eggert, Hartford | ..... | 2.59 | 32.04 |
| 953 | Ed. Eggert, Hartford, Conn., Truck 5430 | Hatheway & Steane, Inc., Hartford | ..... | 4.27 | 25.20 |
| 1176 | Ed. Eggert, Hartford, Conn., Truck No. 3 | Hatheway & Steane, Inc., Hartford | ..... | 4.18 | 26.94 |
| 1177 | Ed. Eggert, Hartford, Conn., Car No. 37-989 | Hatheway & Steane, Inc., Hartford | ..... | 4.26 | 28.25 |
| 1624 | Ed. Eggert, Hartford, Conn., Car 5-203 | Hatheway & Steane, Inc., Hartford | ..... | 4.20 | 25.58 |
| 1726 | Ed. Eggert, Hartford, Conn. | A. N. Shepard & Son, Hartford | ..... | 2.24 | 28.51 |
| 2040 | Ed. Eggert, Hartford, Conn. | A. N. Shepard & Son, Hartford | ..... | 2.08 | 27.50 |
| 1485 | Ed. Eggert, Hartford, Conn. | J. E. Shepard, So. Windsor | ..... | 4.48 | 22.17 |
| 1486 | Ed. Eggert, Hartford, Conn. | J. E. Shepard, So. Windsor | ..... | 4.38 | 22.05 |
| 1771 | Ed. Eggert, Hartford, Conn. | Spencer Bros., Inc., Suffield | ..... | 3.41 | 12.89 |
| 994 | International Agricultural Corp., Boston, Mass. Car D. & H. 20826 | J. E. Shepard, So. Windsor | ..... | 2.88 | 33.66 |



TABLE VIII. ANALYSES OF COTTON HULL ASHES—*Concluded.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Moisture. | Phosphoric Acid. | Potash. |
|---|---|---|---|---|---|
| | *Sampled by Purchaser.* | | % | % | % |
| 995 | International Agricultural Corp., Boston, Mass., Car B. & M. 68094 | J. E. Shepard, So. Windsor | ..... | 2.76 | 36.34 |
| 1701 | Olds & Whipple, Inc., Hartford, Conn., Car No. 169164 | L. Wetstone & Sons, Hartford | ..... | 2.38 | 23.09 |
| 2016 | Ed. Eggert, Hartford, Conn., Car S. L. & S. F. 121723[1] | Edwards & Brewer, Hartford | ..... | 1.30 | 8.35 |
| 2017 | Ed. Eggert, Hartford, Conn., Car S. F. 147051[1] | Edwards & Brewer, Hartford | ..... | 1.75 | 8.35 |
| 2004 | Manufacturer unknown | Meyer & Mendelsohn, Inc., Hartford | ..... | 3.38 | 17.79 |
| 820 | Manufacturer unknown | American Sumatra Tobacco Co., Bloomfield | ..... | 2.32 | 40.16 |

[1] Bought for low grade ashes.

## IV. RAW MATERIALS CONTAINING NITROGEN AND POTASH.

### NITRATE OF POTASH AND NITRATE OF POTASH-SODA.

Potassium nitrate (salt peter), occurs naturally in small deposits in various parts of the world. It is also manufactured from nitrate of soda and muriate of potash. The salt should contain not less than 12 per cent of nitrogen and not less than 44 per cent of potash.

Nitrate of soda-potash is a mixture of about ¾ nitrate of soda and ¼ nitrate of potash. It occurs in Chile and yields about 14 per cent of nitrogen and 10 per cent or more of potash.

Both of these salts are used to some extent in mixtures for tobacco. Eight samples of potassium nitrate and three of nitrate of potash-soda were examined this year. All were of good grade and fully met guaranties in both elements of plant food.

Analyses are given in Table IX.



TABLE IX. ANALYSES OF NITRATE OF POTASH, ETC.

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Nitrogen. Found. | Nitrogen. Guaranteed. | Equivalent to Ammonia. Found. | Equivalent to Ammonia. Guaranteed. | Potash. Found. | Potash. Guaranteed. |
|---|---|---|---|---|---|---|---|---|
| | | | % | % | % | % | % | % |
| | **Nitrate of Potash.** *Sampled by Station.* | | | | | | | |
| 1969 | Eastern States Farmers' Exchange, Springfield, Mass. | Paul W. Caldwell, New Milford | 13.24 | 13.00 | 16.10 | 15.79 | 44.31 | 44.00 |
| 1459 | Olds & Whipple, Inc., Hartford | Sampled at factory | 13.28 | 12.55 | 16.15 | 15.00 | 45.65 | 44.00 |
| 1903 | Synthetic Nitrogen Products Co., New York | John Richards, So. Glastonbury | 13.28 | 13.00 | 16.15 | 15.70 | 44.50 | 44.00 |
| | *Sampled by Purchaser.* | | | | | | | |
| 1329 | Berkshire Chemical Co., Bridgeport, Conn., Car N. H. 171354 | Cullman Bros., Hartford | 14.22 | .... | 17.29 | .... | 43.09 | .... |
| 1892 | Eastern States Farmers' Exchange, Springfield, Mass. | Donald J. Grant, Buckland | 14.16 | 13.00 | 17.22 | 15.79 | 46.43 | 44.00 |
| 919 | Olds & Whipple, Inc., Hartford | Huntington Bros., Windsor | 13.16 | 12.55 | 16.00 | 15.00 | 45.81 | 44.00 |
| 1684 | Olds & Whipple, Inc., Hartford | Silberman & Kahn, Hartford | 13.26 | 12.55 | 16.12 | 15.00 | 45.40 | 44.00 |
| 1776 | Olds & Whipple, Inc., Hartford | Silberman & Kahn, Hartford | 13.16 | 12.55 | 16.00 | 15.00 | 45.61 | 44.00 |
| | **Nitrate of Soda and Potash.** *Sampled by Station.* | | | | | | | |
| 1411 | Apothecaries Hall Co., Waterbury | Sampled at factory | 14.86 | 14.80 | 18.07 | 18.00 | 14.55 | 10.00 |
| 988 | W. R. Grace & Co., New York Car No. 65037 | L. B. Haas & Co., Hartford | 14.40 | .... | 17.51 | .... | 16.55 | .... |
| 1992 | Wilcox Fertilizer Co., Mystic | J. R. Haley, Groton | 15.06 | 14.80 | 18.31 | 18.00 | 12.25 | 12.00 |

# V. RAW MATERIAL CONTAINING NITROGEN AND PHOSPHORIC ACID.

## DRY GROUND FISH.

Dry ground fish, also known as fish scrap and fish tankage, is made from non-edible fish and offal from fish canneries. Oil is removed by steaming and pressing and the residue is then dried and ground. Fish may also be acidulated to prevent decomposition.

Fish scrap is generally sold on a guaranty of 8.20 per cent of nitrogen and 5 to 6 per cent of phosphoric acid. The nitrogen is organic and fairly valued at 45 to 47 cents a pound this year.

Last year a considerable quantity of fish scrap, in which inorganic nitrogen was largely substituted for fish nitrogen, came into this State. Examination of all samples this year has failed to show any evidence of adulteration of this sort. Although microscopically a number of samples were found to contain crystals of ammonium sulphate, the amounts did not appear to be considerable, and determinations of ammonia nitrogen did not show significant quantities. In two samples considerably decomposed, somewhat more than 1 per cent of nitrogen as ammonia was found, but no evidence of ammonium sulphate was found by microscopic examination. We have not found ammonium sulphate this year in any quantity which could not reasonably be explained on the basis of accidental contamination.

Another substance which we have noted in a considerable number of cases is superphosphate. The explanation given us is that the nitrogen content of fish is sometimes standardized by means of the addition of superphosphate. While it might be argued that a mixture of dry ground fish and superphosphate is not dry ground fish, nevertheless such an addition does not lessen the value of the material provided the nitrogen guaranty is met. The almost uniform guaranty of 8.22 per cent nitrogen suggests that the product is standardized by some means. There appeared to be no excessive amounts of superphosphate in the samples examined and moreover those samples showing deficiencies in nitrogen were not always identical with those containing superphosphate. In some cases samples showing less than the guaranteed amount of nitrogen showed no evidence of superphosphate; and in other cases where superphosphate was present the nitrogen found was considerable above that guaranteed.

Thirty-eight samples were examined this year. If we accept 47 cents a pound as a fair valuation for the nitrogen in fish, then commercial deficiencies greater than $1.00 a ton (equivalent to a shortage of 0.11 per cent in nitrogen), are shown in samples **1259**, **1878**, **1257** and **987**. Four other samples submitted without guaranties are also considerably deficient if the usual guaranty of 8.22 per cent nitrogen is assumed. In these calculations overages, if any, in phosphoric acid are not considered.

Analyses are given in Table X.



## TANKAGE.

This raw material is derived from refuse meat and bone. The refuse is treated with steam and then pressed to remove fat, after which the residue is dried and ground.

The composition of tankage with respect to nitrogen and phosphoric acid will depend upon the nature of the material; if meat predominates, nitrogen will be high and phosphoric acid relatively low, while the reverse will be true if there is a considerable excess of bone present.

Of the eleven samples examined this year Nos. **1407** and **1424** are essentially bone tankages as indicated by both analyses and guaranties. Four samples, **1760**, **1972**, **1607** and **1996** were considerably deficient in nitrogen. Of these, **1760** **1972** and **1607** also were low in phosphoric acid.

Analyses are given in Table XI.

## GROUND BONE.

Raw bone meal or raw ground bone is the product made by drying and grinding animal bones which have not been previously steamed under pressure.

Steamed bone meal or steamed ground bone is the product made by steaming bones under pressure, after which they are dried and ground.

Steamed bone will contain considerably less nitrogen than raw bone.

Thirty-five samples were examined and so far as guaranties were given, there were only two deficiencies in nitrogen and two in phosphoric acid. The nitrogen shortages were both less than 0.2 per cent and, in general, the character of this material this year was very satisfactory. Last year a number of samples of bone were found to contain notable quantities of inorganic ammoniates, or mineral phosphates, or both, but in only four samples this year was any evidence of these materials found and in no case were the amounts considerable.

Analyses are given in Table XII.

TABLE X. ANALYSES OF DRY GROUND FISH.

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Nitrogen: Total found. | Nitrogen: Total guaranteed. | Ammonia equivalent to total nitrogen. | Phosphoric Acid: Total found. | Phosphoric Acid: Total guaranteed. | Station No. |
|---|---|---|---|---|---|---|---|---|
| | *Sampled by Station.* | | % | % | % | % | % | |
| 1499 | American Agricultural Chemical Co., New York City | F. S. Bidwell Co., Windsor Locks | 8.12 | 8.23 | 9.87 | 18.55 | 6.00 | 1499 |
| 1957 | Apothecaries Hall Co., Waterbury | Jos. P. Norton, Broad Brook | 9.61 | 8.20 | 11.68 | 6.26 | 5.00 | 1957 |
| 1259 | Berkshire Chemical Co., Bridgeport | L. B. Haas & Co., Hartford | 7.86 | 8.22 | 9.56 | 6.77 | 6.00 | 1259 |
| 1878 | Eastern States Farmers' Exchange, Springfield, Mass. | Frank V. Williams, Buckland | 7.39 | 9.00 | 8.98 | 6.91 | 6.90 | 1878 |
| 1468 | Olds & Whipple, Inc., Hartford | Sampled at factory | 9.28 | 8.23 | 11.28 | 7.65 | 5.00 | 1468 |
| 1610 | Standard Phosphate & Acid Works, Baltimore, Md. | E. O. Chapman, No. Haven | 8.66 | 8.22 | 10.53 | 6.68 | 6.00 | 1610 |
| 1257 | Wilcox Fertilizer Co., Mystic | J. E. Shepard, So. Windsor | 8.03 | 8.23 | 9.76 | 6.67 | 6.00 | 1257 |
| | *Sampled by Purchaser.* | | | | | | | |
| 821 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 9.73 | 8.20 | 11.83 | 6.66 | 5.00 | 821 |
| 858 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 9.86 | 8.20 | 11.99 | 7.46 | 5.00 | 858 |
| 859 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 9.94 | 8.20 | 12.09 | 7.16 | 5.00 | 859 |
| 1270 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 10.03 | 8.20 | 12.19 | 6.76 | 5.00 | 1270 |
| 1656 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 9.19 | 8.20 | 11.17 | 6.71 | 5.00 | 1656 |
| 1261 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 9.92 | 8.20 | 12.06 | 7.41 | 5.00 | 1261 |
| 1725 | Apothecaries Hall Co., Waterbury | A. N. Shepard & Son, Hartford | 9.18 | 8.20 | 11.16 | 6.98 | 5.00 | 1725 |



TABLE X. ANALYSES OF DRY GROUND FISH—*Continued.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Nitrogen: Total found. | Nitrogen: Total guaranteed. | Ammonia equivalent to total nitrogen. | Phosphoric Acid: Total found. | Phosphoric Acid: Total guaranteed. | Station No. |
|---|---|---|---|---|---|---|---|---|
| | *Sampled by Purchaser.* | | % | % | % | % | % | |
| 737 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 7.80 | 8.22 | 9.48 | 6.80 | 6.00 | 737 |
| 738 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 8.70 | 8.22 | 10.58 | 7.11 | 6.00 | 738 |
| 739 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 8.26 | 8.22 | 10.04 | 6.76 | 6.00 | 739 |
| 740 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 8.13 | 8.22 | 9.88 | 6.88 | 6.00 | 740 |
| 741 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 7.96 | 8.22 | 9.68 | 7.16 | 6.00 | 741 |
| 758 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 7.97 | 8.22 | 9.69 | 6.95 | 6.00 | 758 |
| 759 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 8.22 | 8.22 | 9.99 | 7.14 | 6.00 | 759 |
| 760 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 8.17 | 8.22 | 9.93 | 6.37 | 6.00 | 760 |
| 761 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 8.67 | 8.22 | 10.54 | 6.84 | 6.00 | 761 |
| 762 | Berkshire Chemical Co., Bridgeport | American Sumatra Tobacco Co., Bloomfield | 8.54 | 8.22 | 10.38 | 6.02 | 6.00 | 762 |

TABLE X. ANALYSES OF DRY GROUND FISH—*Concluded.*

| Station No. | Manufacturer or Wholesale Dealer. | Dealer or Purchaser. | Nitrogen. Total found. | Nitrogen. Total guaranteed. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Total found. | Phosphoric Acid. Total guaranteed. | Station No. |
|---|---|---|---|---|---|---|---|---|
| | *Sampled by Purchaser.* | | % | % | % | % | % | |
| 996 | Berkshire Chemical Co., Bridgeport .... | James T. Burgess, Thompsonville .. | 8.63 | 8.22 | 10.49 | 5.96 | 6.00 | 996 |
| 880 | Berkshire Chemical Co., Bridgeport .... | Cullman Bros., Hartford .......... | 9.46 | 8.22 | 11.50 | 7.60 | 6.00 | 880 |
| 1030 | Berkshire Chemical Co., Bridgeport .... | Cullman Bros., Hartford .......... | 9.42 | 9.46 | 11.45 | 7.11 | 6.00 | 1030 |
| 1031 | Berkshire Chemical Co., Bridgeport .... | Cullman Bros., Hartford .......... | 9.40 | 9.46 | 11.43 | 7.18 | 6.00 | 1031 |
| 987 | Berkshire Chemical Co., Bridgeport .... | L. B. Haas & Co., Inc., Hartford ... | 8.02 | 8.22 | 9.75 | 6.44 | 6.00 | 987 |
| 1342 | Berkshire Chemical Co., Bridgeport .... | L. B. Haas & Co., Inc., Hartford ... | 8.72 | 8.22 | 10.60 | 6.39 | 6.00 | 1342 |
| 921 | Olds & Whipple, Inc., Hartford ....... | Huntington Bros., Windsor ........ | 8.65 | 8.23 | 10.52 | 6.30 | 5.00 | 921 |
| 1689 | Olds & Whipple, Inc., Hartford ....... | Silberman & Kahn, Hartford ....... | 9.74 | 8.23 | 11.84 | 8.00 | 5.00 | 1689 |
| 1781 | Olds & Whipple, Inc., Hartford ....... | Silberman & Kahn, Hartford ....... | 9.68 | 8.23 | 11.77 | 7.85 | 5.00 | 1781 |
| 1705 | Olds & Whipple, Inc., Hartford ....... | L. Wetstone & Sons, Hartford ..... | 8.62 | 8.23 | 10.48 | 8.25 | 5.00 | 1705 |
| 1706 | Olds & Whipple, Inc., Hartford ....... | L. Wetstone & Sons, Hartford ..... | 8.14 | 8.23 | 9.90 | 8.23 | 5.00 | 1706 |
| 1891 | Wilcox Fertilizer Co., Mystic ......... | V. L. Hickey, Burnside ............ | 8.19 | 8.22 | 9.96 | 7.30 | 6.00 | 1891 |
| 899 | Wilcox Fertilizer Co., Mystic ......... | J. E. Shepard, So. Windsor ........ | 8.29 | 8.22 | 10.08 | 6.72 | 6.00 | 899 |
| 900 | Wilcox Fertilizer Co., Mystic ......... | J. E. Shepard, So. Windsor ........ | 8.05 | 8.22 | 9.79 | 7.21 | 6.00 | 900 |



TABLE XI. ANALYSES OF TANKAGE.

| Station No. | Manufacturer. | Dealer or Purchaser. | Nitrogen. Total found. | Nitrogen. Total guaranteed. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Total found. | Phosphoric Acid. Total guaranteed. | Mechanical Analysis. Finer than 1–50 inch. | Mechanical Analysis. Coarser than 1–50 inch. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Station.* | | % | % | % | % | % | % | % | |
| 1407 | Apothecaries Hall Co., Waterbury .. | J. A. Glasnapp, West Cheshire .. | 3.75 | 3.29 | 4.56 | 20.60 | 20.00 | 53.5 | 46.5 | 1407 |
| 1569 | Apothecaries Hall Co., Waterbury .. | J. B. McArdle, Greenwich ...... | 7.48 | 7.40 | 9.09 | 11.45 | 3.00 | 43.5 | 56.5 | 1569 |
| 1760 | Armour Fertilizer Works, New York City .......................... | A. R. Jones, Wallingford ....... | 6.94 | 7.40 | 8.44 | 5.59 | 6.87 | 38.0 | 62.0 | 1760 |
| 1372 | Berkshire Chemical Co., Bridgeport.. | J. A. Smith, Hamden ........... | 7.76 | 7.40 | 9.43 | 7.65 | 6.86 | 40.5 | 59.5 | 1372 |
| 1424 | Conn. Fat Rendering & Fertilizer Corp., New Haven .............. | Sampled at factory ............. | 3.60 | 3.29 | 4.38 | 21.80 | ..... | 41.0 | 59.0 | 1424 |
| 1371 | Consolidated Rendering Co., Boston, Mass. ......................... | H. D. Peters, Highwood ........ | 7.84 | 7.41 | 9.53 | 10.64 | 9.15 | 33.0 | 67.0 | 1371 |
| 1421 | Consolidated Rendering Co., Boston, Mass. ......................... | L. T. Frisbie Co., New Haven .. | 5.18 | 4.92 | 6.30 | 16.14 | 14.00 | 35.5 | 64.5 | 1421 |
| 1972 | Eastern States Farmers' Exchange Springfield, Mass. ............... | Harold Brundage, Danbury ..... | 7.18 | 7.50 | 8.73 | 8.75 | 9.20 | 34.0 | 66.0 | 1972 |
| 1396 | Standard Phosphate & Acid Works, Baltimore, Md. ................. | Geo. S Jennings, Southport ..... | 7.46 | 7.40 | 9.07 | 4.98 | ..... | 26.5 | 73.5 | 1396 |
| 1607 | Standard Phosphate & Acid Works, Baltimore, Md. ................. | Julius Lewis, Southington ....... | 6.60 | 7.40 | 8.02 | 7.78 | 9.15 | 29.5 | 70.5 | 1607 |
| 1996 | Standard Phosphate & Acid Works, Baltimore, Md. ................. | Rand & Christensen, Wilson .... | 7.88 | 8.22 | 9.58 | 4.66 | 4.57 | 25.5 | 74.5 | 1996 |

TABLE XII. ANALYSES OF GROUND BONE.

| Station No. | Manufacturer. | Dealer or Purchaser. | Nitrogen. | | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | Mechanical Analysis. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total found. | Total guaranteed. | | Total found. | Total guaranteed. | Finer than 1–50 inch. | Coarser than 1–50 inch. | |
| | *Sampled by Station.* | | % | % | % | % | % | % | % | |
| 1390 | American Agricultural Chemical Co., New York City | S. P. Strople, New Britain | 2.48 | 2.47 | 3.02 | 25.95 | 22.88 | 43.5 | 56.5 | 1390 |
| 1412 | Apothecaries Hall Co., Waterbury | Sampled at factory | 3.64 | 3.29 | 4.43 | 23.25 | 20.00 | 50.5 | 49.5 | 1412 |
| 1447 | Apothecaries Hall Co., Waterbury | Templeton Hardware Co., Waterbury | 2.78 | 2.46 | 3.38 | 24.18 | 22.00 | 59.0 | 41.0 | 1447 |
| 1562 | Armour Fertilizer Works, New York City | Raven's Hardware Co., Meriden | 2.51 | 2.47 | 3.05 | 23.45 | 22.00 | 65.5 | 34.5 | 1562 |
| 1395 | Berkshire Chemical Co., Bridgeport | C. Buckingham & Co., Southport | 1.95 | 2.06 | 2.37 | 26.85 | 23.00 | 50.5 | 49.5 | 1395 |
| 1420 | Consolidated Rendering Co., Boston, Mass. | Lightbourn & Pond Co., New Haven | 3.86 | 2.46 | 4.69 | 21.18 | 22.90 | 33.0 | 67.0 | 1420 |
| 1962 | Eastern States Farmers' Exchange, Springfield, Mass. | Hoyt's Nurseries, New Canaan | 2.59 | 2.50 | 3.15 | 26.60 | 23.00 | 59.5 | 40.5 | 1962 |
| 1467 | Olds & Whipple, Inc., Hartford | Rackliffe Bros. Co., New Britain | 2.84 | 2.50 | 3.45 | 22.80 | 22.00 | 61.5 | 38.5 | 1467 |
| 1901 | Olds & Whipple, Inc., Hartford | John Richards, So. Glastonbury | 2.74 | 2.50 | 3.33 | 24.42 | 22.00 | 60.5 | 39.5 | 1901 |
| 1537 | The Rogers & Hubbard Co., Portland | Cadwell & Jones, Hartford | 3.45 | 3.29 | 4.19 | 20.00 | 20.50 | 52.0 | 48.0 | 1537 |
| 1538 | The Rogers & Hubbard Co., Portland | Cadwell & Jones, Hartford | 3.52 | 3.69 | 4.28 | 26.60 | 24.70 | 70.5 | 29.5 | 1538 |
| 1923 | The Rogers & Hubbard Co., Portland | Sampled at factory | 3.86 | 3.69 | 4.69 | 25.85 | 24.70 | 73.0 | 27.0 | 1923 |
| 1644 | M. L. Shoemaker & Co., Philadelphia, Pa. | Geo. T. Soule Co., New Milford | 4.00 | 3.69 | 4.86 | 21.58 | 21.51 | 34.0 | 66.0 | 1644 |



TABLE XII. ANALYSES OF GROUND BONE—*Continued.*

| Station No. | Manufacturer. | Dealer or Purchaser. | Nitrogen. | | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | Mechanical Analysis. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total found. | Total guaranteed. | | Total found. | Total guaranteed. | Finer than 1–50 inch. | Coarser than 1–50 inch. | |
| | *Sampled by Station.* | | % | % | % | % | % | % | % | |
| 1601 | Standard Phosphate & Acid Works, Baltimore, Md. | Eldridge Hardware Co., Norwich | 3.39 | 2.47 | 4.12 | 26.97 | 22.00 | 31.5 | 68.5 | 1601 |
| 2001 | Standard Phosphate & Acid Works, Baltimore, Md. | Morris L. Burr, Southport | 3.42 | 3.30 | 4.16 | 25.67 | 18.30 | 30.5 | 69.5 | 2001 |
| 1631 | Virginia-Carolina Chemical Co., New York City | Stanley Svea Coal Co., New Britain | 2.52 | 2.47 | 3.06 | 22.50 | 22.50 | 69.5 | 30.5 | 1631 |
| 1616 | I. P. Thomas & Son, Philadelphia, Pa. | W. S. Eaton, Plainville | 2.49 | 2.45 | 3.03 | 23.40 | 23.00 | 59.5 | 40.5 | 1616 |
| 1642 | Wilcox Fertilizer Co., Mystic | Sampled at factory | 2.68 | 2.46 | 3.26 | 25.35 | 22.00 | 77.0 | 23.0 | 1642 |
| | *Sampled by Purchaser.* | | | | | | | | | |
| 860 | Apothecaries Hall Co., Waterbury | Hatheway & Steane, Inc., Hartford | 4.39 | .... | 5.34 | 21.86 | ..... | .... | .... | 860 |
| 1215 | Apothecaries Hall Co., Waterbury, Car No. 161901 | Hatheway & Steane, Inc., Hartford | 2.99 | .... | 3.64 | 26.00 | ..... | .... | .... | 1215 |
| 1263 | Apothecaries Hall Co., Waterbury, Car No. 405 | Hatheway & Steane, Inc., Hartford | 4.00 | 3.29 | 4.86 | 21.50 | 20.00 | 41.8 | 58.2 | 1263 |
| 1264 | Apothecaries Hall Co., Waterbury, Car No. 81547 | Hatheway & Steane, Inc., Hartford | 4.39 | .... | 5.34 | 22.16 | ..... | 60.4 | 39.6 | 1264 |

TABLE XII. ANALYSES OF GROUND BONE—*Continued.*

| Station No. | Manufacturer. | Dealer or Purchaser. | Nitrogen. Total found. | Nitrogen. Total guaranteed. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Total found. | Phosphoric Acid. Total guaranteed. | Mechanical Analysis. Finer than 1–50 inch. | Mechanical Analysis. Coarser than 1–50 inch. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Purchaser.* | | % | % | % | % | % | % | % | |
| 1265 | Apothecaries Hall Co., Waterbury, Car No. 168414 | Hatheway & Steane, Inc., Hartford | 5.05 | .... | 6.14 | 19.76 | ..... | 31.9 | 68.1 | 1265 |
| 1660 | Apothecaries Hall Co., Waterbury, Truck 4791 | Hatheway & Steane, Inc., Hartford | 4.23 | .... | 5.14 | 22.14 | ..... | 63.2 | 36.8 | 1660 |
| 1724 | Apothecaries Hall Co., Waterbury, Car No. 169078 | A. N. Shepard & Son, Hartford | 3.74 | .... | 4.55 | 21.22 | ..... | 39.5 | 60.5 | 1724 |
| 1000 | Berkshire Fertilizer Co., Bridgeport | James T. Burgess, Thompsonville | 2.21 | 2.06 | 2.69 | 28.12 | 23.00 | .... | .... | 1000 |
| 1773 | L. T. Frisbie Co., New Haven | Allen H. Treat, Hudson, N. Y. | 3.76 | .... | 4.57 | 22.90 | ..... | .... | .... | 1773 |
| 657 | Harshaw, Fuller, Goodwin Co., New York, Car No. 163619 | American Sumatra Tobacco Co., Bloomfield | 2.75 | .... | 3.34 | 24.84 | ..... | .... | .... | 657 |
| 658 | Harshaw, Fuller, Goodwin Co., New York, Car No. 160305 | American Sumatra Tobacco Co., Bloomfield | 2.89 | .... | 3.51 | 24.98 | ..... | .... | .... | 658 |
| 685 | Harshaw, Fuller, Goodwin Co., New York, Car No. 425345 | American Sumatra Tobacco Co., Bloomfield | 2.64 | .... | 3.21 | 25.94 | ..... | .... | .... | 685 |
| 686 | Harshaw, Fuller, Goodwin Co., New York, Car No. 78208 | American Sumatra Tobacco Co., Bloomfield | 2.66 | .... | 3.23 | 25.08 | ..... | .... | .... | 686 |
| 764 | Harshaw, Fuller, Goodwin Co., New York, Car No. 23344 | American Sumatra Tobacco Co., Bloomfield | 2.79 | .... | 3.39 | 25.56 | ..... | .... | .... | 764 |



TABLE XII. ANALYSES OF GROUND BONE—*Concluded.*

| Station No. | Manufacturer. | Dealer or Purchaser. | Nitrogen. Total found. | Nitrogen. Total guaranteed. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Total found. | Phosphoric Acid. Total guaranteed. | Mechanical Analysis. Finer than 1–50 inch. | Mechanical Analysis. Coarser than 1–50 inch. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Purchaser.* | | % | % | % | % | % | % | % | |
| 765 | Harshaw, Fuller, Goodwin Co., New York, Car No. 3989 | American Sumatra Tobacco Co., Bloomfield | 3.15 | .... | 3.83 | 25.02 | ..... | .... | .... | 765 |
| 891 | Harshaw, Fuller, Goodwin Co., New York, Car No. 12199 | American Sumatra Tobacco Co., Bloomfield | 2.78 | .... | 3.38 | 27.22 | ..... | .... | .... | 891 |
| 892 | Harshaw, Fuller, Goodwin Co., New York, Car No. 11165 | American Sumatra Tobacco Co., Bloomfield | 2.83 | .... | 3.44 | 26.22 | ..... | .... | .... | 892 |

# VI. MIXED FERTILIZERS.

## MIXTURES CONTAINING ONLY NITROGEN AND PHOSPHORIC ACID.

Five samples of this group of materials were analyzed.

**1875.** Lawn Fertilizer. Apothecaries Hall Co., Waterbury. Sampled by Station agent from stock of Yantic Grain & Products Co., Norwich, Conn.

**1952.** Tobacco Starter. Apothecaries Hall Co., Waterbury. Sampled by Station agent at factory.

**1980.** O & W High Grade Tobacco Starter. Olds & Whipple, Inc., Hartford. Sampled by Station agent from stock of Julius Ident, South Windsor, Conn.

**1995.** Milorganite. Sewerage Commission, Milwaukee, Wis. Sampled by Station agent from stock of T. S. Griswold, West Hartford, Conn.

**1665.** Swift-Sure Tobacco Starter. M. L. Shoemaker & Co., Philadelphia, Pa. Sampled by Station agent from stock of A. D. Bridge's Sons, Hazardville, Conn.

| | 1875 | 1952 | 1980 | 1995 | 1665 |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| Nitrogen, found | 4.16 | 3.81 | 8.11 | 4.94 | 3.25 |
| guaranteed | 3.29 | 3.29 | 8.23 | 5.00 | 3.28 |
| Ammonia, equivalent to nitrogen | 5.06 | 4.63 | 9.86 | 6.01 | 3.95 |
| Phosphoric acid, total | 11.50 | 10.88 | 5.16 | 2.40 | 10.93 |
| available found | 6.82 | 9.65 | 4.14 | 2.05 | 10.53 |
| guaranteed | 4.00 | 10.00 | 3.00 | 2.00 | 10.00 |

## MIXTURES CONTAINING ONLY PHOSPHORIC ACID AND POTASH.

Only two samples of this group were analyzed.

**2160.** Eastern States Open Formula 0-14-6. Eastern States Farmers' Exchange, Springfield, Mass. Sampled by Station agent from stock of H. H. McKnight, Ellington.

It contained 14.83 per cent total and 14.32 per cent available phosphoric acid, and 6.38 per cent of potash.

**2224.** Dairymen's Special, 0-10-10. I. P. Thomas & Son, Philadelphia. Sampled from stock of H. A. Costello, Mgr., Simsbury.

It contained 10.11 per cent of available phosphoric acid and 10.05 per cent of potash.

## MIXTURES CONTAINING ONLY NITROGEN AND POTASH.

**2049.** Special Tobacco Formula, 9-0-7. Old Deerfield Fertilizer Co., South Deerfield, Mass.

It contained 7.28 per cent of nitrogen (equivalent to 8.85 per cent of ammonia), 1.85 per cent of available phosphoric acid and 8.08 per cent of potash. It was somewhat deficient in ammonia and contained about 2 per cent of phosphoric acid, although none was guaranteed.



## MIXTURES CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH.

In this group there are 239 official samples and 9 which were sampled by purchasers, a total of 248. Analyses are given in Table XIII. The following tabulated statement summarizes the results of the inspection.

| | | |
|---|---|---|
| Total number of official samples analyzed | | 239 |
| Samples considerably deficient in | | |
| one item | 61 | |
| two items | 5 | |
| three items | 0 | 66 |
| Total items of plant food guaranteed (239 x 3) | | 717 |
| Total items found deficient: | | |
| ammonia | 21 | |
| available phosphoric acid | 25 | |
| potash | 25 | 71 |
| Total guaranties substantially met or exceeded | | 646 |
| Per cent of guaranties substantially met or exceeded | | 90 |
| Samples showing approximate commercial deficiencies exceeding $1.00 per ton | | 9 |

### Deficient Samples.

The number of samples found to be substantially below guaranties in one or more items of plant food is less than for several years past. In considering deficiencies those shortages which are within the limits of reasonable analytical variation have been disregarded. Very few of the samples were short in more than one of the guaranteed constituents; and the most expensive element of plant food (nitrogen) showed the fewest deficiencies.

In estimating the approximate value represented by the shortages found, it is our practice to balance such shortages against any overages found. This plan may be open to the objection that a purchaser who, for example, receives less nitrogen than is guaranteed him is not properly compensated by receiving an extra supply of phosphoric acid, or of potash, or of both. However, we are attempting to arrive at a balance of commercial values and not of agricultural values and, moreover, it is not clear that measurable effects of the shortages and overages of such magnitudes as are generally involved in the case of mixed fertilizers can be noted in the field. In the instance of certain raw materials, fish for example, which is purchased chiefly for its nitrogen, the consideration may be somewhat different.

The number of samples showing commercial deficiencies in excess of $1.00 a ton is nine this year, or less than 4 per cent of the total number of official samples examined. In computing these values ammonia has been reckoned at 20 cents a pound, available phosphoric acid at 5½ cents, and potash at 5 cents. Similar data compiled for a nine-year period shows that of more than 2,000 samples examined, 93 per cent of them have substantially equalled or exceeded commercial values as represented by guaranties; and for the past year the corresponding percentage is 96.

The distribution of deficiencies and the summary of commercial deficiencies are given in Tables XIV, XV and XVI.

## Grades and Guaranties.

In recent years, there has been an increasing practice of branding mixed fertilizers to show the percentages of plant food which they contain, such percentages being given generally in whole numbers, for example 4-8-4, and representing in the Northeastern States ammonia, available phosphoric acid and potash in the order named. This order does not prevail in all sections of the country, however, the chief variation from it being that available phosphoric is sometimes stated first. Thus using the above example, the statement would be 8-4-4. For some time there has been an effort made to have designations of grade made in a uniform manner and the Association of Official Agricultural Chemists has approved of the statement of grade giving the nitrogenous element first and giving it in terms of nitrogen instead of ammonia. The American Fertilizer Association agrees to this plan as do also agronomists who have, in fact, been largely responsible for the reversion to the plan of stating nitrogenous constituents in terms of the element nitrogen.

There has been very little inclination on the part of manufacturers to adopt the new plan this year. Of all the firms registering mixed fertilizers in this State all but three have adhered to the old plan. It is gratifying to observe that where the new plan has been followed nitrogen has been stated in whole numbers, allowing the fractions to fall on the ammonia equivalent.

In Table XIII, which gives analyses of mixed fertilizers, the column headed "grade" has the usual significance, that is, the first figure denotes ammonia. The few departures from this plan are indicated by foot notes.

## Quality of the Organic Nitrogen.

The usual laboratory methods for evaluating the activity of the insoluble organic nitrogen in fertilizer materials indicated organic ammoniates of inferior character in only two instances. In one of these, however, the water soluble nitrogen practically equalled the total nitrogen guaranteed and the sample was passed, without question. In the other, **1845,** Standard Wholesale Acid and Phosphate Works 5-4-5, the total nitrogen found was much short of the guaranty and the activity of the insoluble organic-nitrogen was found to be 31.6 per cent by the alkaline method and 59.4 per cent by the neutral method. Values of less than 50 and 80 by these respective methods are taken to indicate the presence of ammoniates of inferior quality.

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH.

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. | | | | | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | | Potash. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | In Nitrates. | In Ammonia. | Organic water-soluble. | Organic water-insoluble. | Total. | | Citrate-insoluble. | Total. | So-called "Available." | As Muriate. | Total. | |
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* **American Agricultural Chemical Co., New York City.** | | | | | | | | | | | | | | |
| 1733 | AAC Acme Fertilizer | 1-9-4 | Meriden | 0.04 | 0.24 | 0.49 | 0.23 | 1.00 | 1.22 | 0.25 | 9.15 | 8.90 | 4.02 | 4.02 | 1733 |
| 1489 | AAC Aroostook Potato Manure | 5-8-7 | Plantsville | 0.62 | 2.52 | 0.43 | 0.36 | 3.93 | 4.78 | 0.46 | 8.65 | 8.19 | 6.38 | 6.38 | 1489 |
| 1827 | AAC Aroostook Potato Manure | 5-8-7 | Bristol | 0.56 | 2.68 | 0.45 | 0.42 | 4.11 | 5.00 | 0.60 | 8.60 | 8.00 | 6.69 | 6.69 | 1827 |
| 1741 | AAC Complete General Fertilizer | 3-8-4 | Norfolk | 0.00 | 1.58 | 0.52 | 0.38 | 2.48 | 3.02 | 0.18 | 8.25 | 8.07 | 4.19 | 4.19 | 1741 |
| 1842 | AAC Double A Tobacco Fertilizer | 5-3-5 | West Suffield | 0.38 | 1.34 | 0.30 | 2.21 | 4.23 | 5.14 | 0.15 | 3.44 | 3.29 | 0.62 | 4.60 | 1842 |
| 1493 | AAC Gladiator Fertilizer | 4-8-7 | New Britain | 0.34 | 2.02 | 0.56 | 0.45 | 3.37 | 4.10 | 0.13 | 8.25 | 8.12 | 7.15 | 7.15 | 1493 |
| 1491 | AAC Grass & Lawn Top Dressing | 6-6-4 | Farmington | 0.54 | 3.80 | 0.19 | 0.46 | 4.99 | 6.07 | 0.16 | 6.65 | 6.49 | 4.22 | 4.22 | 1491 |
| 1846 | AAC Hi Grade Tobacco Manure | 7-3-7 | Glastonbury | 0.32 | 1.18 | 0.77 | 3.49 | 5.76 | 7.00 | 0.21 | 3.90 | 3.69 | 0.69 | 8.26 | 1846 |
| 1490 | AAC Monarch Fertilizer | 4-8-4 | Plantsville | 0.36 | 2.04 | 0.55 | 0.37 | 3.32 | 4.04 | 0.47 | 8.60 | 8.13 | 3.96 | 3.96 | 1490 |
| 1737 | AAC Prolific 10% Potash Fertilizer | 2-8-10 | North Haven | 0.00 | 0.90 | 0.52 | 0.32 | 1.74 | 2.11 | 0.30 | 8.60 | 8.30 | 9.26 | 9.26 | 1737 |
| 2128 | AAC Prolific 10% Potash Fertilizer | 2-8-10 | Canaan | 0.22 | 0.88 | 0.35 | 0.26 | 1.71 | 2.08 | 0.15 | 8.35 | 8.20 | 9.94 | 9.94 | 2128 |
| 2126 | AAC Prolific 10% Potash Fertilizer | 2-8-10 | North Haven | 0.00 | 1.02 | 0.42 | 0.30 | 1.74 | 2.11 | 0.28 | 8.30 | 8.02 | 9.97 | 9.97 | 2126 |
| 1497 | AAC Special Grass Top Dressing | 8-6-6 | Simsbury | 0.94 | 4.78 | 0.17 | 0.70 | 6.59 | 8.01 | 0.20 | 6.75 | 6.55 | 5.97 | 5.97 | 1497 |
| 1495 | Agrico for Corn | 3-10-6 | New Canaan | 0.12 | 1.52 | 0.51 | 0.35 | 2.50 | 3.04 | 0.28 | 10.25 | 9.97 | 6.17 | 6.17 | 1495 |
| 1498 | Agrico for Potatoes | 4-8-6 | Simsbury | 0.24 | 2.08 | 0.53 | 0.51 | 3.36 | 4.09 | 0.15 | 7.95 | 7.80 | 6.00 | 6.00 | 1498 |
| 1492 | Agrico for Truck | 5-10-5 | Farmington | 0.46 | 2.54 | 0.54 | 0.52 | 4.06 | 4.94 | 0.58 | 10.24 | 9.66 | 5.12 | 5.12 | 1492 |
| 1826 | Agrico for Truck | 5-10-5 | Farmington | 0.50 | 2.52 | 0.47 | 0.46 | 3.95 | 4.80 | 0.67 | 10.52 | 9.85 | 5.30 | 5.30 | 1826 |
| 1513 | Bowker's All Round Fertilizer | 3-8-4 | New Canaan | 0.00 | 1.60 | 0.47 | 0.40 | 2.47 | 3.00 | 0.23 | 8.15 | 7.92 | 4.23 | 4.23 | 1513 |
| 1512 | Bowker's Market Garden Fertilizer | 4-8-4 | New Canaan | 0.32 | 2.00 | 0.61 | 0.43 | 3.36 | 4.09 | 0.50 | 8.50 | 8.00 | 4.02 | 4.02 | 1512 |
| 1736 | Bowker's Potato and Vegetable Phosphate | 2-9-3 | Portland | 0.04 | 0.92 | 0.41 | 0.35 | 1.72 | 2.09 | 0.25 | 8.95 | 8.70 | 3.09 | 3.09 | 1736 |
| 1516 | Bowker's Stockbridge Hill and Drill Fertilizer | 4-8-7 | Bristol | 0.26 | 1.96 | 0.56 | 0.57 | 3.35 | 4.07 | 0.30 | 8.23 | 7.93 | 7.33 | 7.33 | 1516 |
| 1840 | Bowker's Stockbridge Tobacco Manure | 5-3-5 | Thompsonville | 0.46 | 1.12 | 0.38 | 2.09 | 4.05 | 4.92 | 0.15 | 3.35 | 3.20 | 0.43 | 5.41 | 1840 |
| 1515 | Bradley's Blood, Bone and Potash | 5-8-7 | Simsbury | 0.48 | 2.72 | 0.40 | 0.51 | 4.11 | 5.00 | 0.45 | 8.50 | 8.05 | 7.03 | 7.03 | 1515 |
| 1571 | Bradley's Complete Manure for Potatoes and Vegetables | 4-8-7 | Broad Brook | 0.30 | 2.16 | 0.36 | 0.49 | 3.31 | 4.02 | 0.28 | 8.15 | 7.87 | 7.36 | 7.36 | 1571 |
| 1570 | Bradley's Complete Tobacco Manure | 5-3-5 | Broad Brook | 0.40 | 1.44 | 0.19 | 2.29 | 4.32 | 5.25 | 0.23 | 3.43 | 3.20 | 0.29 | 5.12 | 1570 |
| 1947 | Bradley's Northland Potato Grower | 4-8-4 | North Franklin | 0.38 | 2.00 | 0.47 | 0.42 | 3.27 | 3.98 | 0.48 | 8.50 | 8.02 | 4.03 | 4.03 | 1947 |
| 1948 | Bradley's Potato Fertilizer | 2-9-3 | Colchester | 0.00 | 0.90 | 0.51 | 0.27 | 1.68 | 2.04 | 0.20 | 8.78 | 8.58 | 4.76 | 4.76 | 1948 |
| 1510 | Bradley's Potato Manure | 3-8-4 | Meriden | 0.04 | 1.64 | 0.44 | 0.40 | 2.52 | 3.06 | 0.21 | 8.08 | 7.87 | 4.06 | 4.06 | 1510 |
| 1509 | Bradley's XL Superphosphate of Lime | 3-10-4 | Suffield | 0.06 | 1.58 | 0.53 | 0.38 | 2.55 | 3.10 | 0.30 | 10.38 | 10.08 | 4.02 | 4.02 | 1509 |
| 1572 | Bradley's XL Superphosphate of Lime | 3-10-4 | Broad Brook | 0.12 | 1.62 | 0.45 | 0.42 | 2.61 | 3.17 | 0.45 | 10.10 | 9.65 | 4.72 | 4.72 | 1572 |
| 1508 | National Aroostook Special Fertilizer | 5-8-7 | Farmington | 0.48 | 2.84 | 0.39 | 0.44 | 4.15 | 5.05 | 0.53 | 8.68 | 8.15 | 6.90 | 6.90 | 1508 |
| 1742 | National Complete Tobacco Fertilizer | 5-3-5 | Simsbury | 0.52 | 1.28 | 0.20 | 2.12 | 4.12 | 5.01 | 0.17 | 3.53 | 3.36 | 0.58 | 5.08 | 1742 |
| 1507 | National Market Garden Fertilizer | 3-8-4 | Farmington | 0.10 | 1.70 | 0.36 | 0.38 | 2.54 | 3.09 | 0.18 | 8.25 | 8.07 | 4.07 | 4.07 | 1507 |
| 1843 | National Pine Tree State Potato Fertilizer | 4-8-4 | Thompsonville | 0.36 | 2.00 | 0.49 | 0.42 | 3.27 | 3.98 | 0.41 | 8.90 | 8.49 | 4.03 | 4.03 | 1843 |
| 1514 | National Premier Potato Manure | 4-8-7 | Danbury | 0.40 | 1.96 | 0.39 | 0.48 | 3.23 | 3.93 | 0.30 | 8.53 | 8.23 | 7.06 | 7.06 | 1514 |
| 1841 | Sanderson's Atlantic Coast Mixture | 3-10-4 | Hamden | 0.00 | 1.84 | 0.49 | 0.45 | 2.78 | 3.38 | 0.25 | 9.90 | 9.65 | 5.45 | 5.45 | 1841 |
| 1844 | Sanderson's Complete Tobacco Grower | 5-3-5 | Warehouse Point | 0.18 | 1.34 | 0.50 | 2.12 | 4.14 | 5.03 | 0.15 | 3.48 | 3.33 | 0.57 | 5.23 | 1844 |
| 1740 | Sanderson's Corn Superphosphate | 2-9-3 | Canaan | 0.00 | 0.94 | 0.53 | 0.33 | 1.80 | 2.19 | 0.25 | 9.38 | 9.13 | 3.39 | 3.39 | 1740 |
| 1511 | Sanderson's Formula A | 4-8-4 | Guilford | 0.36 | 2.00 | 0.58 | 0.42 | 3.36 | 4.09 | 0.49 | 8.58 | 8.09 | 3.93 | 3.93 | 1511 |
| 1566 | Sanderson's Formula B | 4-8-7 | Glastonbury | 0.44 | 2.28 | 0.02 | 0.55 | 3.29 | 4.00 | 0.28 | 8.30 | 8.02 | 0.70 | 6.94 | 1566 |

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. | | | | | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | | Potash. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | In Nitrates. | In Ammonia. | Organic water-soluble. | Organic water-insoluble. | Total. | | Citrate-insoluble. | Total. | So-called "Available." | As Muriate. | Total. | |
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* **American Agricultural Chemical Co., New York City.** | | | | | | | | | | | | | | |
| 1739 | Sanderson's Formula B | 4-8-7 | Gaylordsville | 0.28 | 1.80 | 0.63 | 0.59 | 3.30 | 4.01 | 0.30 | 8.25 | 7.95 | 0.93 | 7.25 | 1739 |
| 1567 | Sanderson's Potato Manure | 3-8-4 | Derby | 0.14 | 1.62 | 0.30 | 0.37 | 2.43 | 2.95 | 0.25 | 8.18 | 7.93 | 3.88 | 3.88 | 1567 |
| 1942 | Sanderson's Potato Manure | 3-8-4 | Derby | 0.08 | 1.58 | 0.47 | 0.44 | 2.57 | 3.12 | 0.20 | 8.33 | 8.13 | 4.04 | 4.04 | 1942 |
| | **Apothecaries Hall Co., Waterbury, Conn.** | | | | | | | | | | | | | | |
| 1835 | Liberty Corn and All Crops 2-8-2 | 2-8-2 | Norwich | 0.06 | 1.22 | 0.29 | 0.64 | 2.21 | 2.69 | 1.40 | 8.93 | 7.53 | 2.73 | 2.73 | 1835 |
| 1755 | Liberty Corn, Fruit and All Crops 2-12-4 | 2-12-4 | Greenwich | 0.08 | 1.64 | 0.44 | 0.14 | 2.30 | 2.80 | 1.63 | 13.20 | 11.57 | 4.21 | 4.21 | 1755 |
| 1743 | Liberty Double Strength 10-16-14 | 10-16-14 | Sampled at factory | 1.00 | 3.24 | 3.00 | 0.44 | 7.68 | 9.34 | 0.48 | 16.49 | 16.01 | 13.72 | 13.72 | 1743 |
| 1517 | Liberty Fish, Bone and Potash 3-8-3 | 3-8-3 | North Haven | 0.00 | 1.08 | 0.31 | 1.64 | 3.03 | 3.68 | 1.25 | 8.93 | 7.68 | 3.46 | 3.46 | 1517 |
| 1520 | Liberty High Grade Market Gardener's 5-8-7 | 5-8-7 | West Cheshire | 0.80 | 2.96 | 0.34 | 0.16 | 4.26 | 5.18 | 1.05 | 8.90 | 7.85 | 7.07 | 7.07 | 1520 |
| 1953 | Liberty High Grade Tobacco Manure 7-3-7 | 7-3-7 | Sampled at factory | 0.00 | 1.88 | 0.43 | 3.72 | 6.03 | 7.33 | 0.78 | 4.74 | 3.96 | 0.86 | 8.31 | 1953 |
| 1759 | Liberty Onion Special 4-8-7 | 4-8-7 | Sampled at factory | 0.26 | 1.70 | 0.61 | 0.77 | 3.34 | 4.06 | 4.18 | 12.82 | 8.64 | 0.78 | 10.70 | 1759 |
| 1837 | Liberty Potato and General Crop 4-8-10 | 4-8-10 | Norwich | 1.50 | 1.06 | 0.50 | 0.44 | 3.50 | 4.26 | 0.83 | 8.65 | 7.82 | 11.02 | 11.02 | 1837 |
| 1506 | Liberty Potato and Market Gardener's Special 4-8-4 | 4-8-4 | West Cheshire | 0.00 | 2.04 | 0.50 | 0.81 | 3.35 | 4.07 | 1.13 | 9.35 | 8.22 | 4.13 | 4.13 | 1506 |
| 1836 | Liberty Potato and Vegetable 2-8-10 | 2-8-10 | Norwich | 0.18 | 0.98 | 0.44 | 0.54 | 2.14 | 2.60 | 0.75 | 8.02 | 7.27 | 11.27 | 11.27 | 1836 |
| 1756 | Liberty Special Fertilizer for Fruit 7-8-6 | 7-8-6 | Torrington | 2.96 | 2.04 | 0.25 | 0.59 | 5.84 | 7.10 | 1.43 | 9.38 | 7.95 | 6.17 | 6.17 | 1756 |
| 1955 | Liberty Tobacco Special C. S. M. Base 5-3-5 | 5-3-5 | Sampled at factory | 0.00 | 1.66 | 0.24 | 2.55 | 4.45 | 5.41 | 0.58 | 4.79 | 4.21 | 0.35 | 6.69 | 1955 |
| 1838 | Liberty Top Dresser for Grass and Grain 10-3½-8 | 10-3.5-8 | Norwich | 4.58 | 3.02 | 0.00 | 0.71 | 8.31 | 10.10 | 0.06 | 3.93 | 3.87 | 10.59 | 10.59 | 1838 |
| | **Armour Fertilizer Works, New York City.** | | | | | | | | | | | | | | |
| 1581 | Armour's Big Crop Fertilizer 2-12-4 | 2-12-4 | Wethersfield | 0.36 | 1.20 | 0.38 | 0.04 | 1.98 | 2.41 | 0.75 | 12.40 | 11.65 | 4.02 | 4.02 | 1581 |
| 1575 | Armour's Big Crop Fertilizer 3-8-4 | 3-8-4 | Meriden | 0.18 | 2.06 | 0.13 | 0.05 | 2.42 | 2.94 | 0.25 | 8.15 | 7.90 | 4.04 | 4.04 | 1575 |
| 1881 | Armour's Big Crop Fertilizer 4-6-10 | 4-6-10 | Granby | 0.52 | 2.40 | 0.30 | 0.05 | 3.27 | 3.98 | 0.30 | 6.64 | 6.34 | 9.69 | 9.69 | 1881 |
| 1761 | Armour's Big Crop Fertilizer 4-16-4 | 4-16-4 | Wallingford | 0.68 | 2.34 | 0.33 | 0.08 | 3.43 | 4.17 | 0.31 | 16.51 | 16.20 | 4.32 | 4.32 | 1761 |
| 1577 | Armour's Big Crop Fertilizer 4-8-4 | 4-8-4 | Danbury | 0.38 | 2.44 | 0.28 | 0.11 | 3.21 | 3.90 | 0.41 | 8.26 | 7.85 | 4.19 | 4.19 | 1577 |
| 1580 | Armour's Big Crop Fertilizer 5-8-7 | 5-8-7 | Wethersfield | 0.00 | 3.08 | 0.96 | 0.08 | 4.12 | 5.01 | 0.55 | 8.95 | 8.40 | 6.55 | 6.55 | 1580 |
| 1762 | Armour's Big Crop Fertilizer 7-11-10 | 7-11-10 | Wallingford | 1.32 | 4.12 | 0.19 | 0.04 | 5.67 | 6.89 | 0.14 | 11.63 | 11.49 | 10.22 | 10.22 | 1762 |
| 1578 | Armour's Big Crop Fertilizer 8-6-6 | 8-6-6 | Thompsonville | 1.06 | 5.00 | 0.28 | 0.07 | 6.41 | 7.79 | 0.35 | 6.79 | 6.44 | 6.01 | 6.01 | 1578 |
| 1769 | Armour's Big Crop Tobacco Special 5-3-5 | 5-3-5 | Enfield | 1.72 | 0.02 | 0.47 | 1.91 | 4.12 | 5.01 | 0.38 | 3.73 | 3.35 | 0.61 | 4.97 | 1769 |
| 1882 | Armour's Big Crop Tobacco Special 5-3-5 | 5-3-5 | Granby | 1.46 | 0.12 | 0.29 | 2.32 | 4.19 | 5.09 | 0.36 | 4.25 | 3.89 | 0.64 | 5.62 | 1882 |
| | **Associated Seed Growers, Inc., New Haven, Conn.** | | | | | | | | | | | | | | |
| 1528 | Tip Top Brand | 5-8-7 | Associated Seed Growers, Inc., Milford | 1.46 | 1.46 | 0.14 | 1.30 | 4.36 | 5.30 | 0.30 | 8.35 | 8.05 | 7.04 | 7.04 | 1528 |
| 1529 | Special Mixture for General Use | 4-8-4 | Associated Seed Growers, Inc., Milford | 0.92 | 1.48 | 0.17 | 0.93 | 3.50 | 4.26 | 0.25 | 8.35 | 8.10 | 6.96 | 6.96 | 1529 |

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. In Nitrates. | Nitrogen. In Ammonia. | Nitrogen. Organic water-soluble. | Nitrogen. Organic water-insoluble. | Nitrogen. Total. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* | | | | | | | | | | | | | | |
| | **Associated Seed Growers, Inc., New Haven, Conn.** | | | | | | | | | | | | | | |
| 1530 | Special Mixture 6% Potash | 4-8-6 | Associated Seed Growers, Inc., Milford | 0.92 | 1.36 | 0.22 | 1.00 | 3.50 | 4.26 | 0.30 | 8.23 | 7.93 | 7.40 | 7.40 | 1530 |
| | **F. A. Bartlett Tree Expert Co., Stamford, Conn.** | | | | | | | | | | | | | | |
| 1440 | Bartlett Green Tree Food | 6-7-4 | Sampled at factory | 0.28 | 4.26 | 0.00 | 0.86 | 5.40 | 6.57 | 2.18 | 10.20 | 8.02 | 5.22 | 5.22 | 1440 |
| | **Berkshire Chemical Co., Bridgeport, Conn.** | | | | | | | | | | | | | | |
| 1521 | Berkshire Complete Fertilizer | 2-9-3 | Southport | 0.04 | 0.90 | 0.39 | 0.67 | 2.00 | 2.43 | 2.63 | 11.79 | 9.16 | 3.91 | 3.91 | 1521 |
| 1883 | Berkshire Complete Tobacco Fertilizer | 5-3-5 | Granby | 1.02 | 0.00 | 0.46 | 2.54 | 4.02 | 4.89 | 0 08 | 4.23 | 4.15 | 0 84 | 5.69 | 1883 |
| 1574 | Berkshire Economical Grass Fertilizer | 10-3-8 | Sampled at factory | 7.24 | 0.00 | 0.29 | 0.48 | 8.01 | 9.74 | 1.06 | 9.03 | 7.97 | 1.55 | 8.81 | 1574 |
| 1920 | Berkshire Economical Grass Fertilizer | 10-3-8 | Ellington | 6.96 | 0.00 | 0.79 | 0.81 | 8.56 | 10.41 | 1.79 | 9 25 | 7.46 | 2.07 | 9.77 | 1920 |
| 1374 | Berkshire Grass Special Fertilizer | 7-6-5 | Hamden | 2.08 | 2.12 | 0.37 | 1.08 | 5.65 | 6.87 | 0 20 | 6.58 | 6.38 | 6.09 | 6.09 | 1374 |
| 1376 | Berkshire Long Island Special Fertilizer | 5-8-7 | Hamden | 0.20 | 2.52 | 0.41 | 0.90 | 4.03 | 4.90 | 0.10 | 8.08 | 7.98 | 8.96 | 8.96 | 1376 |
| 1377 | Berkshire Market Garden Fertilizer | 4-8-4 | Hamden | 1.24 | 1.40 | 0.32 | 0.69 | 3.65 | 4 44 | 0 27 | 8.60 | 8.33 | 5.09 | 5.09 | 1377 |
| 1884 | Berkshire Tobacco Special Fertilizer | 7-3-7 | Granby | 1.84 | 0.12 | 0.67 | 3.16 | 5.79 | 7.04 | 0.13 | 4.03 | 3.90 | 0.72 | 7.48 | 1884 |
| 1885 | Berkshire Tobacco Starter Fertilizer | 5-8-10 | Ellington | 2.02 | 1.34 | 0.47 | 0.72 | 4.55 | 5.53 | 0.18 | 9.23 | 9.05 | 0.74 | 9.38 | 1885 |
| 1583 | Berkshire Truck Fertilizer | 5-8-5 | North Haven | 0.00 | 2.62 | 0.40 | 1.02 | 4.04 | 4.91 | 0.20 | 7.95 | 7.75 | 6.79 | 6.79 | 1583 |
| | **Amos D. Bridge's Sons, Inc., Hazardville, Conn.** | | | | | | | | | | | | | | |
| 1673 | Corn, Onion, Potato and General Purpose | 4-8-4 | Sampled at factory | 0.84 | 1.86 | 0.00 | 0.60 | 3.30 | 4.01 | 1.10 | 9.25 | 8.15 | 4.51 | 4.51 | 1673 |
| 1950 | Special Tobacco Fertilizer | 5-3-5 | Sampled at factory | 0.94 | 0.00 | 0.41 | 3.00 | 4.35 | 5.29 | 0.47 | 4.50 | 4.03 | 0.36 | 5.85 | 1950 |
| | **E. D. Chittenden Co., Bridgeport, Conn.** | | | | | | | | | | | | | | |
| 2043 | Chittenden's Complete Tobacco and Onion Grower | 4-8-4 | Tolland | 0.00 | 2.80 | 0.08 | 0.36 | 3 24 | 3 94 | 0.30 | 8.19 | 7.89 | 2.27 | 4.59 | 2043 |
| 2042 | Chittenden's High Grade Potato 7% Potash | 5-8-7 | Tolland | 0.00 | 3.48 | 0.15 | 0.39 | 4.02 | 4.89 | 0 31 | 8.43 | 8.12 | 2.47 | 7 04 | 2042 |
| 2044 | Chittenden's Potato Special 4% Potash | 4-8-4 | Abington | 0.00 | 2.96 | 0.07 | 0.29 | 3.32 | 4 04 | 0.45 | 8.51 | 8.06 | 4.57 | 4.57 | 2044 |
| 2066 | Chittenden's Tobacco Special | 5-4-5 | Wapping | 0.00 | 2.60 | 0.30 | 1.27 | 4.17 | 5.07 | 0.23 | 5.29 | 5.06 | 1.28 | 5 50 | 2066 |
| | **C & R Sales Co., Worcester, Mass.** | | | | | | | | | | | | | | |
| 1958 | C & R Lawn and Shrub Fertilizer 5-6-5 | 5-6-5 | Putnam | 0.00 | 2.00 | 0.54 | 2.27 | 4.81 | 5.85 | 0.28 | 7.15 | 6.87 | 7.01 | 7.01 | 1958 |
| | **Davey Tree Expert Co., Inc., Kent, Ohio.** | | | | | | | | | | | | | | |
| 1441 | Davey Tree Food | 10-3-3 | Sound Beach | 0.00 | 5.38 | 1.01 | 2.00 | 8.39 | 10.20 | 3.63 | 8.45 | 4.82 | 3.14 | 3.14 | 1441 |

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. | | | | | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | | Potash. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | In Nitrates. | In Ammonia. | Organic water-soluble. | Organic water-insoluble. | Total. | | Citrate-insoluble. | Total. | So-called "Available." | As Muriate. | Total. | |
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* **Eastern States Farmers' Exchange, Springfield, Mass.**[1] | | | | | | | | | | | | | | |
| 1763 | Eastern States Open Formula 4-8-8 | 4-8-8 | North Haven | 0.94 | 2.28 | 0.79 | 0.24 | 4.25 | 5.17 | 0.31 | 9.73 | 9.42 | 7.47 | 7.47 | 1763 |
| 1582 | Eastern States Open Formula 4-10-6 | 4-10-6 | Ellington | 0.82 | 2.44 | 0.00 | 0.72 | 3.98 | 4.84 | 0.58 | 11.13 | 10.55 | 6.04 | 6.04 | 1582 |
| 1764 | Eastern States Open Formula 4-12-4 | 4-12-4 | North Haven | 1.62 | 2.00 | 0.26 | 0.24 | 4.12 | 5.01 | 0.44 | 12.85 | 12.41 | 4.56 | 4.56 | 1764 |
| 1765 | Eastern States Open Formula 4-20-16 | 4-20-16 | Clinton | 1.14 | 2.50 | 0.43 | 0.34 | 4.41 | 5.36 | 0.28 | 21.60 | 21.32 | 15.09 | 15.09 | 1765 |
| 1522 | Eastern States Open Formula 6-8-6 | 6-8-6 | North Haven | 2.14 | 3.08 | 0.29 | 0.85 | 6.36 | 7.73 | 0.23 | 8.40 | 8.17 | 6.41 | 6.41 | 1522 |
| 1531 | Eastern States Open Formula 6-15-9 | 6-15-9 | Meriden | 1.36 | 4.02 | 0.28 | 0.39 | 6.05 | 7.36 | 0.35 | 15.58 | 15.23 | 9.43 | 9.43 | 1531 |
| 1757 | Eastern States Open Formula 6-18-6 | 6-18-6 | West Simsbury | 1.02 | 4.16 | 0.57 | 0.68 | 6.43 | 7.82 | 0.55 | 19.50 | 18.95 | 6.59 | 6.59 | 1757 |
| 1970 | Eastern States Open Formula 8-4-8 | 8-4-8 | New Milford | 2.44 | 0.44 | 3.40 | 2.52 | 8.80 | 10.70 | 0.09 | 5.43 | 5.34 | 1.70 | 9.94 | 1970 |
| 1523 | Eastern States Open Formula 8-16-16 | 8-16-16 | North Haven | 1.50 | 5.88 | 0.15 | 0.80 | 8.33 | 10.13 | 0.40 | 20.15 | 19.75 | 13.45 | 13.45 | 1523 |
| 1966 | Eastern States Open Formula 8-16-16 | 8-16-16 | Buckland | 1.32 | 5.20 | 0.88 | 0.38 | 7.78 | 9.46 | 0.28 | 16.30 | 16.02 | 17.24 | 17.24 | 1966 |
| 1973 | Eastern States Open Formula 8-16-16 | 8-16-16 | Woodstock | 1.58 | 5.12 | 0.58 | 0.42 | 7.70 | 9.36 | 0.45 | 17.30 | 16.85 | 16.04 | 16.04 | 1973 |
| 1791 | Eastern States Open Formula 10-5-10 | 10-5-10 | West Simsbury | 3.42 | 0.56 | 5.18 | 2.11 | 11.27 | 13.70 | 0.15 | 5.54 | 5.39 | 1.86 | 10.52 | 1791 |
| | **Essex Fertilizer Co., Boston, Mass.** | | | | | | | | | | | | | | |
| 1525 | Essex Complete Manure 5-8-7 | 5-8-7 | Wallingford | 0.36 | 2.52 | 0.57 | 0.67 | 4.12 | 5.01 | 0.78 | 8.78 | 8.00 | 6.58 | 6.58 | 1525 |
| 1526 | Essex Fish Fertilizer for All Crops 3-8-4 | 3-8-4 | Wallingford | 0.00 | 0.67 | 1.11 | 0.64 | 2.42 | 2.94 | 1.18 | 8.30 | 7.12 | 4.06 | 4.06 | 1526 |
| 1943 | Essex Fish Fertilizer for All Crops 3-8-4 | 3-8-4 | Cromwell | 0.00 | 1.48 | 0.51 | 0.72 | 2.71 | 3.29 | 0.81 | 8.48 | 7.67 | 4.36 | 4.36 | 1943 |
| 1524 | Essex Market Garden 4-8-4 | 4-8-4 | Wallingford | 0.40 | 1.84 | 0.45 | 0.76 | 3.45 | 4.19 | 0.83 | 8.83 | 8.00 | 4.00 | 4.00 | 1524 |
| 1527 | Essex Peerless Potato Manure 4-6-10 | 4-6-10 | Wallingford | 0.40 | 1.88 | 0.35 | 0.76 | 3.39 | 4.12 | 0.38 | 6.70 | 6.32 | 10.08 | 10.08 | 1527 |
| 1786 | Essex Top Dressing | 7-6-5 | So. Manchester | 0.00 | 5.64 | 0.00 | 0.11 | 5.75 | 6.99 | 0.03 | 6.25 | 6.22 | 4.94 | 4.94 | 1786 |
| | **Friedman Tobacco Products Corp., York, Pa.**[1] | | | | | | | | | | | | | | |
| 1378 | Tobacco Dust Fertilizer | 2-4-2[2] | Hamden | 0.16 | 0.20 | 0.36 | 1.41 | 2.13 | 2.59 | 0.08 | 0.50 | 0.42 | 0.80 | 2.62 | 1378 |
| | **L. T. Frisbie Co., New Haven, Conn.** | | | | | | | | | | | | | | |
| 1445 | Frisbie's Corn and Grain Fertilizer 2-10-2 | 2-10-2 | Danbury | 0.08 | 0.58 | 0.50 | 0.59 | 1.75 | 2.13 | 0.55 | 10.16 | 9.61 | 2.12 | 2.12 | 1445 |
| 1784 | Frisbie's 5-8-7 | 5-8-7 | Wethersfield | 0.32 | 3.08 | 0.51 | 0.34 | 4.25 | 5.17 | 0.37 | 9.00 | 8.63 | 0.49 | 7.05 | 1784 |
| 1790 | Frisbie's 5-10-5 | 5-10-5 | Winsted | 0.30 | 3.20 | 0.42 | 0.35 | 4.27 | 5.19 | 0.64 | 10.76 | 10.12 | 5.41 | 5.41 | 1790 |
| 1438 | Frisbie's Market Garden 5-8-7 | 5-8-7 | Wethersfield | 0.24 | 3.16 | 0.57 | 0.33 | 4.30 | 5.23 | 0.48 | 8.90 | 8.42 | 6.83 | 6.83 | 1438 |
| 1787 | Frisbie's Special 3-8-4 | 3-8-4 | Waterbury | 0.10 | 1.52 | 0.37 | 0.65 | 2.64 | 3.21 | 0.57 | 8.74 | 8.17 | 4.17 | 4.17 | 1787 |
| 1439 | Frisbie's Special Vegetable and Potato Grower 4-8-4 | 4-8-4 | Guilford | 0.36 | 1.96 | 0.32 | 0.65 | 3.29 | 4.00 | 0.35 | 8.30 | 7.95 | 4.09 | 4.09 | 1439 |
| 1971 | Frisbie's Tobacco Grower 7-3-7 | 7-3-7 | Buckland | 1.56 | 0.14 | 0.03 | 4.00 | 5.73 | 6.97 | 0.13 | 4.60 | 4.47 | 1.08 | 7.91 | 1971 |
| 1444 | Frisbie's Top Dresser 8-6-6 | 8-6-6 | Danbury | 1.24 | 4.84 | 0.24 | 0.34 | 6.66 | 8.10 | 0.30 | 6.70 | 6.40 | 5.71 | 5.71 | 1444 |

[1] First figure in "grade" column represents "nitrogen," not ammonia.
[2] Total $P_2O_5$.

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. In Nitrates. | Nitrogen. In Ammonia. | Nitrogen. Organic water-soluble. | Nitrogen. Organic water-insoluble. | Nitrogen. Total. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* **Grasselli Chemical Co., Cleveland, Ohio.** | | | | | | | | | | | | | | |
| 1785 | Grasselli Odorless Plant Food | 5-13-4 | Fair Haven | 0.00 | 3.76 | 0.12 | 0.12 | 4.00 | 4.86 | 1.14 | 16.80 | 15.66 | 4.90 | 4.90 | 1785 |
| | **International Agricultural Corp., Boston, Mass.** | | | | | | | | | | | | | | |
| 2048 | I. A. C. Caribee Tobacco Fertilizer | 7-6-5 | West Suffield | 0.56 | 2.84 | 0.44 | 2.01 | 5.85 | 7.11 | 0.22 | 6.90 | 6.68 | 0.98 | 5.85 | 2048 |
| 1886 | Premium Tobacco Fertilizer | 7-9-8 | Hockanum | 0.00 | 2.54 | 0.95 | 2.38 | 5.87 | 7.14 | 0.20 | 9.00 | 8.80 | 0.70 | 8.21 | 1886 |
| | **Lowell Fertilizer Co., Boston, Mass.** | | | | | | | | | | | | | | |
| 1456 | Lowell Animal Brand, A High Grade Manure for All Crops, 3-8-4 | 3-8-4 | Southington | 0.00 | 1.36 | 0.53 | 0.70 | 2.59 | 3.15 | 1.15 | 8.88 | 7.73 | 4.14 | 4.14 | 1456 |
| 1788 | Lowell Bone Fertilizer 2-10-2 | 2-10-2 | Southbury | 0.00 | 0.92 | 0.39 | 0.35 | 1.66 | 2.02 | 1.21 | 11.31 | 10.10 | 2.24 | 2.24 | 1788 |
| 1457 | Lowell Corn and Vegetable 4-8-4 | 4-8-4 | Southington | 0.28 | 1.96 | 0.49 | 0.69 | 3.42 | 4.16 | 0.95 | 8.85 | 7.90 | 4.16 | 4.16 | 1457 |
| 1519 | Lowell Corn and Vegetable 4-8-4 | 4-8-4 | Cheshire | 0.36 | 1.68 | 0.54 | 0.76 | 3.34 | 4.06 | 0.70 | 8.50 | 7.80 | 3.97 | 3.97 | 1519 |
| 1462 | Lowell Market Garden 5-8-7 | 5-8-7 | Cheshire | 0.64 | 2.90 | 0.05 | 0.48 | 4.07 | 4.95 | 0.80 | 8.65 | 7.85 | 6.89 | 6.89 | 1462 |
| 1789 | Lowell Potato Grower 4-6-10 | 4-6-10 | Southbury | 0.42 | 1.92 | 0.32 | 0.74 | 3.40 | 4.13 | 0.34 | 6.82 | 6.48 | 10.35 | 10.35 | 1789 |
| 2116 | Lowell Tobacco 5-3-5 | 5-3-5 | Warehouse Point | 0.80 | 0.00 | 0.57 | 2.74 | 4.11 | 5.00 | 0.24 | 4.38 | 4.14 | 0.93 | 5.81 | 2116 |
| 1461 | Lowell Top Dressing 7-6-5 | 7-6-5 | Cheshire | 0.14 | 5.50 | 0.00 | 0.00 | 5.64 | 6.86 | 0.13 | 5.50 | 5.37 | 5.14 | 5.14 | 1461 |
| | **Maine Farmers' Exchange, Portland, Me.** | | | | | | | | | | | | | | |
| 1963 | M. F. E. "Produce More" 3-10-3 | 3-10-3 | New Milford | 0.08 | 1.56 | 0.49 | 0.87 | 3.00 | 3.65 | 0.57 | 11.13 | 10.56 | 1.25 | 4.04 | 1963 |
| 1964 | M. F. E. "Produce More" 4-8-5 | 4-8-5 | New Milford | 0.34 | 1.80 | 1.12 | 1.02 | 4.28 | 5.20 | 0.45 | 9.41 | 8.96 | 1.69 | 5.40 | 1964 |
| 1965 | M. F. E. "Produce More" 5-8-7 | 5-8-7 | New Milford | 0.34 | 1.56 | 1.80 | 0.91 | 4.61 | 5.60 | 0.39 | 8.68 | 8.29 | 3.77 | 7.00 | 1965 |
| | **Mapes Formula and Peruvian Guano Co., New York City.** | | | | | | | | | | | | | | |
| 1807 | Mapes Conn. Valley Special | 6-4-7 | East Granby | 2.44 | 0.06 | 1.58 | 1.42 | 5.50 | 6.69 | 1.00 | 5.39 | 4.39 | 0.68 | 7.27 | 1807 |
| 1800 | Mapes Corn Manure | 3-8-3 | Windsor Locks | 0.26 | 1.02 | 1.13 | 0.48 | 2.89 | 3.51 | 1.24 | 10.75 | 9.51 | 2.72 | 3.06 | 1800 |
| 1808 | Mapes General Tobacco Manure | 5-4-5 | East Granby | 1.54 | 0.04 | 1.02 | 1.58 | 4.18 | 5.08 | 1.20 | 5.50 | 4.30 | 0.54 | 6.26 | 1808 |
| 1805 | Mapes General Truck Manure | 5-6-5 | Hartford | 0.38 | 3.80 | 0.00 | 0.51 | 4.69 | 5.70 | 0.93 | 8.74 | 7.81 | 3.71 | 4.56 | 1805 |
| 1801 | Mapes General Use Manure | 3-6-4 | Windsor Locks | 0.46 | 1.02 | 1.06 | 0.35 | 2.89 | 3.51 | 1.00 | 8.73 | 7.73 | 3.75 | 4.40 | 1801 |
| 1804 | Mapes Onion Manure | 4-6-4 | Hartford | 0.44 | 2.88 | 0.00 | 0.44 | 3.76 | 4.57 | 0.83 | 8.47 | 7.64 | 0.39 | 4.19 | 1804 |
| 1783 | Mapes Potato Manure | 4-7-5 | Windsor Locks | 0.26 | 2.34 | 0.30 | 0.42 | 3.32 | 4.04 | 0.74 | 8.45 | 7.71 | 4.93 | 5.07 | 1783 |
| 1802 | Mapes Special Trucker | 5-8-7 | Hartford | 0.36 | 1.72 | 1.74 | 0.60 | 4.42 | 5.37 | 1.07 | 10.85 | 9.78 | 7.09 | 7.09 | 1802 |
| 1806 | Mapes Special Trucker "SP" | 5-8-7 | Hartford | 0.38 | 3.40 | 0.10 | 0.51 | 4.39 | 5.34 | 0.95 | 10.33 | 9.38 | 0.60 | 7.47 | 1806 |
| 1918 | Mapes Tobacco Ash Constituents | 1-4-15 | West Suffield | 0.00 | 0.00 | 0.42 | 0.88 | 1.30 | 1.58 | 1.89 | 6.18 | 4.29 | 0.94 | 17.38 | 1918 |
| 1810 | Mapes Tobacco Ash and Starter | 4-6-15 | Hartford | 2.22 | 0.16 | 0.76 | 0.50 | 3.64 | 4.43 | 0.81 | 7.58 | 6.77 | 0.70 | 15.29 | 1810 |
| 1967 | Mapes Tobacco Manure Wrapper Brand | 7.5-2-10.5 | Windsor | 3.08 | 0.08 | 1.60 | 1.43 | 6.19 | 7.53 | 0.87 | 5.33 | 4.46 | 0.77 | 11.92 | 1967 |
| 1799 | Mapes Tobacco Starter Improved | 5-6-1 | Windsor Locks | 3.00 | 0.00 | 1.29 | 0.54 | 4.83 | 5.87 | 1.36 | 8.73 | 7.37 | 0.16 | 1.51 | 1799 |
| 1803 | Mapes Top Dresser | 10-4-2 | Hartford | 2.22 | 2.98 | 3.08 | 0.30 | 8.58 | 10.43 | 0.52 | 6.40 | 5.88 | 2.01 | 2.39 | 1803 |

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. | | | | | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | | Potash. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | In Nitrates. | In Ammonia. | Organic water-soluble. | Organic water-insoluble. | Total. | | Citrate-insoluble. | Total. | So-called "Available." | As Muriate. | Total. | |
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* **A. G. Markham & Co., Springfield, Mass.** | | | | | | | | | | | | | | |
| 1914 | 4-6-10 | 4-6-10 | Mansfield Depot | 0.56 | 2.20 | 0.28 | 0.32 | 3.36 | 4.09 | 0.22 | 6.38 | 6.16 | 9.57 | 9.57 | 1914 |
| 1913 | 4-8-4 | 4-8-4 | Mansfield Depot | 0.32 | 1.92 | 0.51 | 0.47 | 3.22 | 3.91 | 0.66 | 8.28 | 7.62 | 4.04 | 4.04 | 1913 |
| 1915 | 5-8-7 | 5-8-7 | Stafford Springs | 0.54 | 2.80 | 0.36 | 0.48 | 4.18 | 5.08 | 0.43 | 8.65 | 8.22 | 7.14 | 7.14 | 1915 |
| | **Millane Tree Expert Co., Cromwell, Conn.** | | | | | | | | | | | | | | |
| 2223 | Millane Shade Tree Food | 10-12-4 | Sampled at factory | 4.24 | 2.48 | 0.57 | 0.29 | 7.58 | 9.22 | 1.45 | 14.15 | 12.70 | 4.42 | 4.42 | 2223 |
| | **New England Fertilizer Co., Boston, Mass.** | | | | | | | | | | | | | | |
| 1809 | New England Complete Manure 4-6-10 | 4-6-10 | Unionville | 0.18 | 1.88 | 0.66 | 0.48 | 3.20 | 3.89 | 0.45 | 6.81 | 6.36 | 9.77 | 9.77 | 1809 |
| 1975 | New England Corn Phosphate 2-10-2 | 2-10-2 | Mansfield Depot | 0.00 | 1.00 | 0.46 | 0.37 | 1.83 | 2.22 | 0.36 | 10.53 | 10.17 | 2.40 | 2.40 | 1975 |
| 1919 | New England Market Garden Manure 5-8-7 | 5-8-7 | West Suffield | 0.36 | 3.10 | 0.44 | 0.37 | 4.27 | 5.19 | 0.52 | 8.85 | 8.33 | 7.22 | 7.22 | 1919 |
| 1465 | New England Potato and Vegetable Manure 4-8-4 | 4-8-4 | Meriden | 0.34 | 1.86 | 0.46 | 0.56 | 3.22 | 3.91 | 0.83 | 8.75 | 7.92 | 3.85 | 3.85 | 1465 |
| 1466 | New England Super, A High Grade Fertilizer for all Crops 3-8-4 | 3-8-4 | Meriden | 0.04 | 1.68 | 0.25 | 0.56 | 2.53 | 3.08 | 0.83 | 8.62 | 7.79 | 3.91 | 3.91 | 1466 |
| 1974 | New England Tobacco Manure 5-3-5 | 5-3-5 | Unionville | 0.94 | 0.20 | 0.40 | 2.64 | 4.18 | 5.08 | 0.28 | 4.70 | 4.42 | 1.12 | 6.23 | 1974 |
| | **Old Deerfield Fertilizer Co., South Deerfield, Mass.** | | | | | | | | | | | | | | |
| 1981 | Old Deerfield Tobacco Starter Bone and Potash | 6-8-12 | Suffield | 1.92 | 0.42 | 1.23 | 1.86 | 5.43 | 6.60 | 0.45 | 8.80 | 8.35 | 1.29 | 13.05 | 1981 |
| | **Olds & Whipple, Inc., Hartford, Conn.** | | | | | | | | | | | | | | |
| 1793 | O & W Blue Label Tobacco Fertilizer | 6-3-6 | Ellington | 1.08 | 0.00 | 0.53 | 3.56 | 5.17 | 6.29 | 0.38 | 4.12 | 3.74 | 0.36 | 6.51 | 1793 |
| 1541 | O & W Complete Market Garden Fertilizer | 4-8-4 | So. Manchester | 0.78 | 1.68 | 0.20 | 0.73 | 3.39 | 4.12 | 1.13 | 9.33 | 8.20 | 4.15 | 4.15 | 1541 |
| 2047 | O & W Complete Tobacco Fertilizer | 5-3-5 | So. Windsor | 0.74 | 0.00 | 0.51 | 2.97 | 4.22 | 5.13 | 0.42 | 3.99 | 3.57 | 0.44 | 5.95 | 2047 |
| 1474 | O & W Grass Fertilizer | 6-6-4 | So. Manchester | 2.30 | 1.70 | 0.29 | 0.70 | 4.99 | 6.07 | 0.71 | 7.00 | 6.29 | 4.12 | 4.12 | 1474 |
| 1473 | O & W High Grade Potato and Vegetable Fertilizer | 5-8-7 | So. Manchester | 1.06 | 2.00 | 0.18 | 0.91 | 4.15 | 5.05 | 0.99 | 9.25 | 8.26 | 7.55 | 7.55 | 1473 |
| 1977 | O & W High Grade Starter and Potash Compound | 5-4-15 | So. Windsor | 0.98 | 1.02 | 0.23 | 2.27 | 4.50 | 5.47 | 0.70 | 5.63 | 4.93 | 1.79 | 14.99 | 1977 |
| | **Parmenter & Polsey, Boston, Mass.** | | | | | | | | | | | | | | |
| 1822 | P & P Maine Potato Fertilizer 4-6-10 | 4-6-10 | Wallingford | 0.42 | 2.00 | 0.50 | 0.52 | 3.44 | 4.18 | 0.43 | 6.65 | 6.22 | 10.40 | 10.40 | 1822 |
| 1976 | Parmenter & Polsey Top Dressing 7-6-5 | 7-6-5 | Wallingford | 0.00 | 5.40 | 0.18 | 0.11 | 5.69 | 6.92 | 0.13 | 6.55 | 6.42 | 5.10 | 5.10 | 1976 |

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. In Nitrates. | Nitrogen. In Ammonia. | Nitrogen. Organic water-soluble. | Nitrogen. Organic water-insoluble. | Nitrogen. Total. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Station:* | | | % | % | % | % | % | % | % | % | % | % | % | |
| | **Piedmont Mt. Airy Guano Co., Baltimore, Md.** | | | | | | | | | | | | | | |
| 1984 | Harvest Brand 2-8-3 | 2-8-3 | Plantsville | 0.00 | 0.86 | 0.65 | 0.36 | 1.87 | 2.27 | 1.43 | 8.73 | 7.30 | 4.11 | 4.11 | 1984 |
| 1985 | Harvest Brand 4-8-4 | 4-8-4 | Plantsville | 0.00 | 2.26 | 0.58 | 0.25 | 3.09 | 3.76 | 0.66 | 8.69 | 8.03 | 4.35 | 4.35 | 1985 |
| 1983 | Harvest Brand 5-8-7 | 5-8-7 | Plantsville | 0.00 | 3.56 | 0.59 | 0.23 | 4.38 | 5.33 | 0.20 | 8.33 | 8.10 | 7.24 | 7.24 | 1983 |
| | **Frank S. Platt Co., New Haven, Conn.** | | | | | | | | | | | | | | |
| 1819 | Platt's Concentrated Lawn Fertilizer | 16-5-5 | Sampled at factory | 0.00 | 13.48 | 0.28 | 0.60 | 14.36 | 17.46 | 0.09 | 5.83 | 5.74 | 0.48 | 6.58 | 1819 |
| 1818 | Platco Special 5-8-7 | 5-8-7 | Sampled at factory | 0.22 | 3.08 | 0.52 | 0.46 | 4.28 | 5.20 | 0.56 | 8.90 | 8.34 | 7.10 | 7.10 | 1818 |
| | **Rackliffe Bros. Co., New Britain, Conn.** | | | | | | | | | | | | | | |
| 1535 | Rackliffe Brand Corn Fertilizer 4-8-4 | 4-8-4 | Sampled at factory | 0.38 | 1.94 | 0.38 | 0.58 | 3.28 | 3.99 | 0.39 | 8.55 | 8.16 | 4.21 | 4.21 | 1535 |
| 1536 | Rackliffe Brand Potato and Special Vegetable 5-8-7 | 5-8-7 | Sampled at factory | 0.34 | 3.04 | 0.44 | 0.40 | 4.22 | 5.13 | 0.53 | 8.55 | 8.02 | 7.09 | 7.09 | 1536 |
| | **The Rogers & Hubbard Co., Portland, Conn.** | | | | | | | | | | | | | | |
| 1470 | 4-8-4 Fertilizer | 4-8-4 | Hartford | 0.10 | 2.66 | 0.61 | 0.15 | 3.52 | 4.28 | 0.20 | 8.70 | 8.50 | 4.03 | 4.03 | 1470 |
| 1471 | 5-8-7 Fertilizer | 5-8-7 | Hartford | 0.18 | 3.52 | 0.30 | 0.12 | 4.12 | 5.01 | 0.18 | 8.87 | 8.59 | 6.84 | 6.84 | 1471 |
| 1540 | 5-10-5 Fertilizer | 5-10-5 | Sampled at factory | 0.12 | 3.42 | 0.62 | 0.24 | 4.40 | 5.35 | 0.20 | 10.61 | 10.41 | 5.31 | 5.31 | 1540 |
| 1539 | Hubbard's "Bone Base" Fertilizer for Seeding Down | 3-5-6 | Sampled at factory | 0.94 | 0.22 | 0.00 | 1.26 | 2.42 | 2.94 | 5.88 | 12.50 | 6.62 | 6.80 | 6.80 | 1539 |
| 1542 | Hubbard's "Bone Base" Oats and Top Dressing | 10-3-8 | Norwich | 7.68 | 0.16 | 0.02 | 0.29 | 8.15 | 9.91 | 2.13 | 8.71 | 6.58 | 3.96 | 8.62 | 1542 |
| 1922 | Hubbard's "Bone Base" Oats and Top Dressing | 10-3-8 | Sampled at factory | 7.70 | 0.00 | 0.39 | 0.18 | 8.27 | 10.05 | 2.05 | 8.58 | 6.53 | 2.87 | 8.30 | 1922 |
| 1544 | Hubbard's "Bone Base" Soluble Corn and General Crop Manure | 3-8-6 | Fair Haven | 0.40 | 0.50 | 1.12 | 0.44 | 2.46 | 2.99 | 1.43 | 9.73 | 8.30 | 5.77 | 6.07 | 1544 |
| 1816 | Hubbard's "Bone Base" Soluble Potato Manure | 6-8-5 | Higganum | 1.18 | 2.12 | 0.98 | 0.68 | 4.96 | 6.03 | 1.23 | 10.20 | 8.97 | 0.85 | 5.07 | 1816 |
| 1979 | Hubbard's "Bone Base" Soluble Tobacco Manure | 6-8-10 | So. Windsor | 0.96 | 2.24 | 1.25 | 0.53 | 4.98 | 6.05 | 1.33 | 10.01 | 8.68 | 0.78 | 10.44 | 1979 |
| 1815 | Lawn Fertilizer | 7.5-2-4.5 | New Britain | 3.96 | 0.00 | 0.45 | 2.30 | 6.71 | 8.16 | 0.54 | 4.58 | 4.04 | 2.71 | 5.70 | 1815 |
| 1817 | Rogers & Hubbard All Soils, All Crops Fertilizer | 4-10-4 | Higganum | 0.12 | 2.08 | 0.66 | 0.42 | 3.28 | 3.99 | 0.75 | 11.03 | 10.28 | 4.62 | 4.62 | 1817 |
| 1814 | Rogers & Hubbard's Corn and Grain Fertilizer | 1-10-3 | Willimantic | 0.06 | 0.16 | 0.51 | 0.13 | 0.86 | 1.05 | 0.59 | 11.05 | 10.46 | 3.41 | 3.41 | 1814 |
| 1824 | R & H Climax Tobacco Brand | 5-3-5 | Granby | 1.76 | 0.06 | 0.51 | 2.11 | 4.44 | 5.40 | 0.43 | 4.00 | 3.57 | 0.54 | 5.59 | 1824 |
| 1478 | R & H High Potash Fertilizer | 3-8-10 | New Britain | 0.16 | 1.44 | 0.74 | 0.40 | 2.74 | 3.33 | 0.88 | 8.50 | 7.62 | 10.31 | 10.31 | 1478 |
| 1825 | R & H High Potash Fertilizer | 3-8-10 | Branford | 0.28 | 1.10 | 1.02 | 0.32 | 2.72 | 3.31 | 0.63 | 8.65 | 8.02 | 9.86 | 9.86 | 1825 |
| 1813 | Rogers & Hubbard's Potato Fertilizer | 2-10-4 | Willimantic | 0.10 | 0.74 | 0.61 | 0.29 | 1.74 | 2.11 | 0.53 | 10.75 | 10.22 | 4.99 | 4.99 | 1813 |
| 1823 | R & H Tobacco Grower Vegetable Formula | 6-3-5 | Granby | 1.24 | 0.18 | 0.78 | 2.82 | 5.02 | 6.10 | 0.48 | 3.69 | 3.21 | 0.54 | 5.43 | 1823 |
| 1982 | R & H Tunaker for Tobacco | 10-4-10 | East Granby | 0.76 | 0.58 | 3.31 | 3.00 | 7.65 | 9.30 | 0.15 | 4.45 | 4.30 | 0.98 | 10.54 | 1982 |
| 2230 | R & H Tunaker for Tobacco | 10-4-10 | Sampled at factory | 1.34 | 0.16 | 3.13 | 2.89 | 7.52 | 9.14 | 0.15 | 4.10 | 3.95 | 0.70 | 10.93 | 2230 |

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. In Nitrates. | Nitrogen. In Ammonia. | Nitrogen. Organic water-soluble. | Nitrogen. Organic water-insoluble. | Nitrogen. Total. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* | | | | | | | | | | | | | | |
| | **F. S. Royster Guano Co., Baltimore, Md.** | | | | | | | | | | | | | | |
| 1993 | Royster's Conn. Tobacco Guano | 5-3-5 | Glastonbury | 0.32 | 0.88 | 0.21 | 2.45 | 3.86 | 4.69 | 0.21 | 3.50 | 3.29 | 0.27 | 5.33 | 1993 |
| 1646 | Royster's Curlew Guano | 3-10-6 | Waterbury | 0.12 | 1.66 | 0.33 | 0.48 | 2.59 | 3.15 | 1.18 | 11.33 | 10.15 | 5.41 | 5.41 | 1646 |
| 1645 | Royster's Quality Trucker | 4-8-7 | Waterbury | 0.10 | 2.04 | 0.55 | 0.64 | 3.33 | 4.05 | 1.19 | 8.90 | 7.71 | 7.28 | 7.28 | 1645 |
| 1994 | Royster's Truckers Delight | 4-8-4 | Glastonbury | 0.00 | 2.00 | 0.63 | 0.67 | 3.30 | 4.01 | 0.73 | 8.85 | 8.12 | 4.22 | 4.22 | 1994 |
| | **M. L. Shoemaker & Co., Philadelphia, Pa.** | | | | | | | | | | | | | | |
| 1671 | Special Mixture of Bantle's Wrapper Brand | 7-3-7 | Glastonbury | 1.56 | 0.34 | 0.71 | 3.02 | 5.63 | 6.84 | 0.85 | 5.15 | 4.30 | 1.34 | 8.49 | 1671 |
| 1668 | Swift-Sure Potato Special 5-8-7 | 5-8-7 | New Milford | 0.00 | 2.84 | 0.37 | 1.13 | 4.34 | 5.28 | 2.18 | 9.40 | 7.22 | 6.84 | 6.84 | 1668 |
| 1672 | Swift-Sure Special Tobacco Formula 4-8-5 | 4-8-5 | Glastonbury | 0.00 | 1.64 | 0.25 | 1.51 | 3.40 | 4.13 | 1.38 | 9.45 | 8.07 | 0.52 | 5.25 | 1672 |
| 1669 | Swift-Sure Tobacco and General Use 3-10-3 | 3-10-3 | New Milford | 0.00 | 0.87 | 1.08 | 0.74 | 2.69 | 3.27 | 1.50 | 11.50 | 10.00 | 0.44 | 3.13 | 1669 |
| | **Springfield Rendering Co., Springfield, Mass.** | | | | | | | | | | | | | | |
| 1820 | Springfield 3-8-4 Fertilizer | 3-8-4 | Stafford Springs | 0.00 | 1.76 | 0.52 | 0.32 | 2.60 | 3.16 | 0.30 | 8.70 | 8.40 | 4.28 | 4.28 | 1820 |
| 1821 | Springfield 4-8-4 Fertilizer | 4-8-4 | Stafford Springs | 0.26 | 1.98 | 0.56 | 0.50 | 3.30 | 4.01 | 0.60 | 8.58 | 7.98 | 4.06 | 4.06 | 1821 |
| 1839 | Springfield 5-8-7 Fertilizer | 5-8-7 | Stafford Springs | 0.44 | 2.64 | 0.49 | 0.53 | 4.10 | 4.98 | 0.55 | 8.80 | 8.25 | 7.21 | 7.21 | 1839 |
| 2067 | Springfield 5-3-5 Tobacco Special | 5-3-5 | West Springfield | 1.28 | 0.08 | 0.69 | 2.17 | 4.22 | 5.13 | 0.43 | 5.05 | 4.62 | 0.90 | 5.72 | 2067 |
| 1674 | Springfield 7-6-5 Top Dresser | 7-6-5 | Hazardville | 0.10 | 5.32 | 0.19 | 0.09 | 5.70 | 6.93 | 0.30 | 6.56 | 6.26 | 5.03 | 5.03 | 1674 |
| | **Standard Wholesale Phosphate & Acid Works, Baltimore, Md.** | | | | | | | | | | | | | | |
| 1845 | 5-4-5 | 5-4-5 | Ellington | 0.00 | 1.78 | 0.19 | 0.65 | 2.62 | 3.19 | 0.38 | 5.75 | 5.37 | 2.54 | 4.15 | 1845 |
| 1604 | 5-10-5 | 5-10-5 | Milford | 0.00 | 3.64 | 0.06 | 0.49 | 4.19 | 5.09 | 0.05 | 10.22 | 10.17 | 4.94 | 4.94 | 1604 |
| 1602 | 8-6-6 | 8-6-6 | Seymour | 0.54 | 5.28 | 0.24 | 0.33 | 6.39 | 7.77 | 0.70 | 8.17 | 7.47 | 6.09 | 6.09 | 1602 |
| 1606 | Evergreen Fish Guano | 4-8-4 | Norwalk | 0.00 | 2.58 | 0.29 | 0.57 | 3.44 | 4.18 | 1.29 | 9.38 | 8.09 | 4.29 | 4.29 | 1606 |
| 1603 | Golden Rule Guano | 4.11-6-10 | Seymour | 0.00 | 2.86 | 0.14 | 0.42 | 3.42 | 4.16 | 0.35 | 6.65 | 6.30 | 9.28 | 9.28 | 1603 |
| 1605 | Grain Grower | 2-8-2 | Norwalk | 0.26 | 0.58 | 0.37 | 0.62 | 1.83 | 2.22 | 1.75 | 9.16 | 7.41 | 2.32 | 2.32 | 1605 |
| 1999 | High Analysis | 4-16-4 | Seymour | 0.00 | 2.06 | 1.44 | 0.22 | 3.72 | 4.52 | 0.26 | 15.50 | 15.24 | 3.93 | 3.93 | 1999 |
| 2003 | Ideal Potato Grower | 4-8-6 | Silver Lane | 0.00 | 2.68 | 0.14 | 0.44 | 3.26 | 3.96 | 0.54 | 8.74 | 8.20 | 6.16 | 6.16 | 2003 |
| 1609 | Mammoth Potato Grower | 2-8-10 | North Haven | 0.00 | 2.10 | 0.18 | 0.40 | 2.68 | 3.26 | 0.80 | 8.83 | 8.03 | 8.67 | 8.67 | 1609 |
| 1400 | Standard U. S. Fish, Bone and Potash | 5-8-7 | Milford | 0.00 | 3.84 | 0.07 | 0.18 | 4.09 | 4.97 | 0.30 | 8.15 | 7.85 | 6.86 | 6.86 | 1400 |
| | **Swift & Co., Baltimore, Md.** | | | | | | | | | | | | | | |
| 1599 | Vigoro | 4-12-4 | Hartford | 0.34 | 2.58 | 0.08 | 0.39 | 3.39 | 4.12 | 0.75 | 12.95 | 12.20 | 4.37 | 4.37 | 1599 |

TABLE XIII. ANALYSES OF MIXED FERTILIZERS CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Continued.*

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. | Nitrogen. In Nitrates. | Nitrogen. In Ammonia. | Nitrogen. Organic water-soluble. | Nitrogen. Organic water-insoluble. | Nitrogen. Total. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | % | % | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station:* | | | | | | | | | | | | | | |
| | **Synthetic Nitrogen Products Co., New York City.**[1] | | | | | | | | | | | | | | |
| 1617 | Nitrophoska | 15-30-15 | North Haven | .... | .... | .... | .... | 15.14 | 18.41 | 0.01 | 30.65 | 30.64 | 14.27 | 14.27 | 1617 |
| | **Tenn. Copper & Chemical Corp., Lockland, Ohio.** | | | | | | | | | | | | | | |
| 1664 | Loma | 6-10-4 | Hamden | 0.18 | 3.78 | 0.50 | 0.41 | 4.87 | 5.92 | 0.79 | 10.99 | 10.20 | 4.03 | 4.03 | 1664 |
| | **I. P. Thomas & Son, Philadelphia, Pa.** | | | | | | | | | | | | | | |
| 1998 | Economy Fertilizer 3-12-3 | 3-12-3 | Clintonville | 0.28 | 1.40 | 0.31 | 0.48 | 2.47 | 3.00 | 1.08 | 13.15 | 12.07 | 3.44 | 4.26 | 1998 |
| 1620 | Long Island Special 4-8-7 | 4-8-7 | Hamden | 1.68 | 0.12 | 1.42 | 0.35 | 3.57 | 4.34 | 1.10 | 9.13 | 8.03 | 7.53 | 7.53 | 1620 |
| 1754 | I. P. Thomas 5-8-7 | 5-8-7 | Milford | 0.00 | 3.60 | 0.20 | 0.48 | 4.28 | 5.20 | 0.55 | 9.44 | 8.89 | 7.34 | 7.34 | 1754 |
| 1638 | Thomas Tobacco Grower | 5-4-5 | Unionville | 0.00 | 0.80 | 0.73 | 2.73 | 4.26 | 5.18 | 2.03 | 9.78 | 7.75 | 1.20 | 6.17 | 1638 |
| 1622 | Tip Top 3-10-6 | 3-10-6 | Unionville | 0.00 | 1.78 | 0.19 | 0.60 | 2.57 | 3.12 | 1.15 | 11.45 | 10.30 | 5.82 | 6.16 | 1622 |
| 1621 | Truckers High Grade Guano 4-8-4 | 4-8-4 | Milford | 0.00 | 2.86 | 0.21 | 0.43 | 3.50 | 4.26 | 1.13 | 9.25 | 8.12 | 3.55 | 4.37 | 1621 |
| 1611 | 7% Guano | 7-6-5 | Milford | 0.60 | 4.48 | 0.00 | 0.86 | 5.94 | 7.22 | 0.55 | 7.56 | 7.01 | 4.19 | 4.65 | 1611 |
| 1612 | 7% Guano | 7-6-5 | Highwood | 0.48 | 4.34 | 0.20 | 0.95 | 5.97 | 7.26 | 0.60 | 7.47 | 6.87 | 4.28 | 4.61 | 1612 |
| 1997 | Victor Potash Fertilizer 2-8-5 | 2-8-5 | Willimantic | 0.00 | 1.24 | 0.34 | 0.42 | 2.00 | 2.43 | 0.80 | 9.49 | 8.69 | 4.07 | 5.09 | 1997 |
| | **Triton Oil and Fertilizer Co., New York City.** | | | | | | | | | | | | | | |
| 1667 | Triton 4-8-4 Fertilizer | 4-8-4 | Milford | 1.46 | 0.80 | 0.50 | 0.74 | 3.50 | 4.26 | 0.75 | 9.43 | 8.68 | 3.97 | 3.97 | 1667 |
| 1666 | Triton 5-8-7 Fertilizer | 5-8-7 | Milford | 1.34 | 1.88 | 0.55 | 0.73 | 4.50 | 5.47 | 0.68 | 9.29 | 8.61 | 6.67 | 6.67 | 1666 |
| | **Virginia-Carolina Chemical Co., New York City.** | | | | | | | | | | | | | | |
| 1632 | V-C Aroostook Potato Grower | 5-8-7 | New Britain | 0.00 | 3.10 | 0.72 | 0.57 | 4.39 | 5.34 | 0.50 | 8.85 | 8.35 | 7.41 | 7.41 | 1632 |
| 1628 | V-C Fish and Potash Compound | 2-9-3 | New Britain | 0.00 | 0.94 | 0.60 | 0.32 | 1.86 | 2.26 | 1.00 | 10.13 | 9.13 | 3.07 | 3.07 | 1628 |
| 1637 | V-C XXXX Fish and Potash | 4-8-4 | Guilford | 0.00 | 2.34 | 0.62 | 0.28 | 3.24 | 3.94 | 0.95 | 8.61 | 7.66 | 4.12 | 4.12 | 1637 |
| | **Wilcox Fertilizer Co., Mystic, Conn.** | | | | | | | | | | | | | | |
| 1639 | Wilcox Corn Special 3-10-4 | 3-10-4 | Sampled at factory | 1.40 | 0.24 | 0.40 | 0.49 | 2.53 | 3.08 | 0.68 | 10.83 | 10.15 | 4.34 | 4.76 | 1639 |
| 1636 | Wilcox High Grade Fish and Potash 4-8-4 | 4-8-4 | Groton | 1.08 | 0.22 | 0.97 | 0.64 | 2.91 | 3.54 | 0.63 | 8.82 | 8.19 | 3.32 | 4.07 | 1636 |
| 2127 | Wilcox High Grade Fish and Potash 4-8-4 | 4-8-4 | Sampled at factory | 1.28 | 0.22 | 0.74 | 1.00 | 3.24 | 3.94 | 0.73 | 9.10 | 8.37 | 3.91 | 4.55 | 2127 |
| 1651 | Wilcox Potato and Vegetable Phosphate 5-8-7 | 5-8-7 | Norwich | 1.26 | 1.46 | 0.69 | 0.59 | 4.00 | 4.86 | 0.49 | 8.86 | 8.37 | 7.09 | 7.09 | 1651 |
| 1643 | Wilcox Top Dresser 7-6-5 | 7-6-5 | New London | 0.48 | 1.84 | 2.47 | 0.78 | 5.57 | 6.77 | 1.31 | 8.00 | 6.69 | 3.74 | 5.02 | 1643 |

[1] The first figure in the "grade" column represents "nitrogen," not ammonia.

TABLE XIII. ANALYSES OF MIXED FERTILIZERS

| Station No. | Manufacturer and Brand. | Grade. | Place of Sampling. |
|---|---|---|---|
| | *Sampled by Station:* | | |
| | **Worcester Rendering Co., Auburn, Mass.** | | |
| 1647 | Prosperity Brand Complete Dressing | 6-6-4 | Groton |
| 1648 | Prosperity Brand Corn and Grain Fertilizer | 2-10-2 | Groton |
| 1650 | Prosperity Brand Market Garden Fertilizer | 5-8-7 | Groton |
| 1649 | Prosperity Brand Potato and Vegetable Fertilizer | 4-8-4 | Groton |
| 2002 | Special Potato Fertilizer | 4-6-10 | Putnam |
| 1912 | Superior Top Dressing | 8-6-6 | Norwich |
| | *Sampled by Purchaser.* | | |
| | **Apothecaries Hall Co., Waterbury, Conn.** | | |
| 1711 | Liberty Special Fertilizer for Fruit 7-8-6 | 7-8-6 | Collinsville |
| | **Armour Fertilizer Works, New York City.** | | |
| 2018 | Armour's 5-8-7 Fertilizer | 5-8-7 | J. L. Futtner, Silver Lane |
| 2019 | Armour's 5-3-5 Fertilizer | 5-3-5 | J. L. Futtner, Silver Lane |
| | **Olds & Whipple, Inc., Hartford, Conn.** | | |
| 1708 | High Grade Potato and Vegetable Fertilizer | 5-8-7 | Hartford |
| 1709 | High Grade Potato and Vegetable Fertilizer | 5-8-7 | Hartford |
| | **The Rogers & Hubbard Co., Portland, Conn.** | | |
| 1483 | 5-8-7 Fertilizer | 5-8-7 | Beacon Falls |
| | **Standard Wholesale Phosphate & Acid Works, Baltimore, Md.** | | |
| 1768 | 4-8-4 | 4-8-4 | Branford |
| 1767 | 5-8-7 | 5-8-7 | Branford |
| 1766 | 5-10-5 | 5-10-5 | Branford |



CONTAINING NITROGEN, PHOSPHORIC ACID AND POTASH—*Concluded.*

| Nitrogen. | | | | | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | | Potash. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| In Nitrates. | In Ammonia. | Organic water-soluble. | Organic water-insoluble. | Total. | | Citrate-insoluble. | Total. | So-called "Available." | As Muriate. | Total. | |
| % | % | % | % | % | % | % | % | % | % | % | |
| 0.48 | 3.16 | 0.81 | 0.56 | 5.01 | 6.09 | 0.83 | 7.40 | 6.57 | 4.94 | 4.94 | 1647 |
| 0.18 | 1.00 | 0.51 | 0.58 | 2.27 | 2.76 | 1.25 | 10.78 | 9.53 | 3.48 | 3.48 | 1648 |
| 0.48 | 2.66 | 0.55 | 0.64 | 4.33 | 5.26 | 1.01 | 9.45 | 8.44 | 7.00 | 7.00 | 1650 |
| 0.44 | 1.88 | 0.33 | 0.58 | 3.23 | 3.93 | 0.80 | 9.23 | 8.43 | 4.06 | 4.06 | 1649 |
| 0.66 | 5.04 | 0.36 | 0.50 | 6.56 | 7.98 | 0.60 | 6.86 | 6.26 | 6.39 | 6.39 | 1912 |
| 0.38 | 1.98 | 0.36 | 0.60 | 3.32 | 4.04 | 0.89 | 7.15 | 6.26 | 10.64 | 10.64 | 2002 |
| .... | .... | .... | .... | 5.45 | 6.63 | 1.44 | 9.95 | 8.51 | 6.10 | 6.10 | 1711 |
| .... | .... | .... | .... | 4.08 | 4.96 | 0.39 | 8.80 | 8.41 | 7.06 | 7.06 | 2018 |
| .... | .... | .... | .... | 3.50 | 4.26 | 0.18 | 3.38 | 3.20 | 0.57 | 4.98 | 2019 |
| .... | .... | .... | .... | 4.26 | 5.18 | 0.93 | 9.10 | 8.17 | 0.49 | 7.64 | 1708 |
| .... | .... | .... | .... | 4.34 | 5.28 | 0.95 | 9.13 | 8.18 | 0.49 | 7.58 | 1709 |
| .... | .... | .... | .... | 4.34 | 5.28 | 0.15 | 8.90 | 8.75 | .... | 7.19 | 1483 |
| .... | .... | .... | .... | 3.28 | 3.99 | 0.75 | 9.48 | 8.73 | 4.29 | 4.29 | 1768 |
| .... | .... | .... | .... | 3.96 | 4.81 | 0.41 | 8.50 | 8.09 | 6.87 | 6.87 | 1767 |
| .... | .... | .... | .... | 4.26 | 5.18 | 0.35 | 10.88 | 10.53 | 4.95 | 4.95 | 1766 |

TABLE XIV. SUMMARY OF DEFICIENCIES.

| Manufacturer. | Number Samples. | Number Guaranties. | Number deficiencies in Ammonia. | Avail. $P_2O_5$ | Potash | Per cent of guaranties met. |
|---|---|---|---|---|---|---|
| American Agricultural Chemical Co. | 43 | 129 | 2 | 5 | 4 | 91 |
| Apothecaries Hall Co. | 13 | 39 | 1 | 4 | 1 | 85 |
| Armour Fertilizer Works | 10 | 30 | 1 | 1 | 2 | 87 |
| Associated Seed Growers, Inc. | 3 | 9 | 0 | 0 | 0 | 100 |
| Bartlett, F. A., Tree Expert Co. | 1 | 3 | 0 | 0 | 0 | 100 |
| Berkshire Chemical Co. | 10 | 30 | 2 | 0 | 1 | 90 |
| Bridge's Sons, Amos D., Inc. | 2 | 6 | 0 | 0 | 0 | 100 |
| Chittenden, E. D., Co. | 4 | 12 | 0 | 0 | 0 | 100 |
| C & R Sales Co. | 1 | 3 | 0 | 0 | 0 | 100 |
| Davey Tree Expert Co., Inc | 1 | 3 | 0 | 0 | 0 | 100 |
| Eastern States Farmers' Exchange | 12 | 36 | 2 | 0 | 3 | 86 |
| Essex Fertilizer Co. | 6 | 18 | 0 | 2 | 1 | 89 |
| Friedman Tobacco Products Corp. | 1 | 3 | 0 | 1[1] | 1 | 33 |
| Frisbie, L. T., Co. | 8 | 24 | 0 | 1 | 1 | 92 |
| Grasselli Chemical Co. | 1 | 3 | 1 | 0 | 0 | 67 |
| International Agricultural Corp. | 2 | 6 | 0 | 0 | 0 | 100 |
| Lowell Fertilizer Co. | 8 | 24 | 1 | 2 | 0 | 88 |
| Maine Farmers' Exchange | 3 | 9 | 0 | 0 | 0 | 100 |
| Mapes Formula and Peruvian Guano Co. | 14 | 42 | 0 | 0 | 1 | 98 |
| Markham, A. G., & Co. | 3 | 9 | 0 | 1 | 1 | 78 |
| Millane Tree Expert Co. | 1 | 3 | 1 | 0 | 0 | 67 |
| New England Fertilizer Co. | 6 | 18 | 0 | 0 | 1 | 94 |
| Old Deerfield Fertilizer Co. | 1 | 3 | 0 | 0 | 0 | 100 |
| Olds & Whipple, Inc. | 6 | 18 | 0 | 0 | 0 | 100 |
| Parmenter and Polsey | 2 | 6 | 0 | 0 | 0 | 100 |
| Piedmont Mt. Airy Guano Co. | 3 | 9 | 1 | 1 | 0 | 78 |
| Platt, Frank S., Co. | 2 | 6 | 0 | 0 | 0 | 100 |
| Rackliffe Bros. Co. | 2 | 6 | 0 | 0 | 0 | 100 |
| Rogers & Hubbard Co., The | 19 | 57 | 2 | 1 | 0 | 95 |

[1] Total $P_2O_5$.



TABLE XIV. SUMMARY OF DEFICIENCIES—*Concluded.*

| Manufacturer. | Number Samples. | Number Guaranties. | Number deficiencies in Ammonia. | Avail. $P_2O_5$ | Potash | Per cent of guaranties met. |
|---|---|---|---|---|---|---|
| Royster, F. S., Guano Co. | 4 | 12 | 1 | 1 | 1 | 75 |
| Shoemaker, M. L., & Co. | 4 | 12 | 1 | 1 | 0 | 83 |
| Springfield Rendering Co. | 5 | 15 | 0 | 0 | 0 | 100 |
| Standard Wholesale Phosphate and Acid Works | 10 | 30 | 2 | 2 | 3 | 77 |
| Swift & Co. | 1 | 3 | 0 | 0 | 0 | 100 |
| Synthetic Nitrogen Products | 1 | 3 | 0 | 0 | 1 | 67 |
| Tennessee Copper and Chemical Corp. | 1 | 3 | 0 | 0 | 0 | 100 |
| Thomas, I. P., & Sons | 9 | 27 | 0 | 0 | 2 | 93 |
| Triton Oil and Fertilizer Co. | 2 | 6 | 0 | 0 | 1 | 83 |
| Virginia-Carolina Chemical Co. | 3 | 9 | 0 | 1 | 0 | 89 |
| Wilcox Fertilizer Co. | 5 | 15 | 3 | 0 | 0 | 80 |
| Worcester Rendering Co. | 6 | 18 | 0 | 1 | 0 | 94 |
| Totals | 239 | 717 | 21 | 25 | 25 | 90 |

TABLE XV. SAMPLES SHOWING COMMERCIAL DEFICIENCIES.

| Sta. No. | Brand. | Approximate deficiency in money value per ton. |
|---|---|---|
| 1439 | A. A. C. Aroostook Potato Manure | $1.29[1] |
| 1743 | Apothecaries Hall Co. Liberty Double Strength | 2.91 |
| 1526 | Essex Fish Fertilizer for All Crops | 1.15[1] |
| 1378 | Friedman Tobacco Dust Fertilizer | 1.64 |
| 1451 | Lowell Top Dressing 7-6-5 | 1.11 |
| 2223 | Millane Shade Tree Food | 1.93 |
| 1982 | R & H Tunaker for Tobacco | 1.93 |
| 2230 | R & H Tunaker for Tobacco | 2.57 |
| 1845 | Standard Wholesale Acid and Phosphate Works, 5-4-5 | 6.58 |

[1] Second sample not deficient.

TABLE XVI. COMMERCIAL DEFICIENCIES FOR THE PERIOD 1921-1929.

| Manufacturer. | Total number of samples. | Number equaling or exceeding guaranties in money value. | Per cent for 9 yr. period. | No. of samples for 1929. | Per cent for 1929. |
|---|---|---|---|---|---|
| American Agricultural Chemical Co. | 390 | 375 | 96 | 43 | 98 |
| Apothecaries Hall Co. | 87 | 86 | 99 | 13 | 92 |
| Armour Fertilizer Works | 96 | 77 | 80 | 10 | 100 |
| Atlantic Packing Co. | 51 | 47 | 92[1] | 0 | 100 |
| Berkshire Chemical Co. | 79 | 79 | 100 | 10 | 100 |
| Bridge's, A. D., & Sons Co. | 19 | 19 | 100 | 2 | 100 |
| Chittenden, E. D., Co. | 56 | 51 | 91 | 4 | 100 |
| Clark, E. B., Seed Co. | 37 | 34 | 92[1] | 0 | ... |
| Eastern States Farmers' Exchange | 93 | 78 | 84 | 12 | 100 |
| Essex Fertilizer Co. | 59 | 56 | 95 | 6 | 83 |
| Frisbie, L. T., Co. | 89 | 79 | 89 | 8 | 100 |
| International Agricultural Corp. | 63 | 57 | 90 | 2 | 100 |
| Lowell Fertilizer Co. | 92 | 82 | 89 | 8 | 88 |
| Mapes Formula and Peruvian Guano Co. | 118 | 117 | 99 | 14 | 100 |
| New England Fertilizer Co. | 68 | 65 | 96 | 6 | 100 |
| Olds and Whipple, Inc. | 57 | 57 | 100 | 6 | 100 |
| Parmenter and Polsey | 30 | 29 | 97 | 2 | 100 |
| Piedmont-Mt. Airy Guano Co. | 34 | 25 | 74 | 3 | 100 |
| Rogers & Hubbard Co., The | 132 | 127 | 96 | 19 | 89 |
| Royster, F. S., Guano Co. | 67 | 54 | 81 | 4 | 100 |
| Shoemaker, M. L., & Co. | 26 | 26 | 100 | 4 | 100 |
| Springfield Rendering Co. | 37 | 35 | 95 | 5 | 100 |
| Standard Wholesale Acid and Phosphate Works | 18 | 17 | 94[2] | 10 | 90 |
| Thomas, I. P., & Sons | 41 | 41 | 100 | 9 | 100 |
| United States Guano Co. | 24 | 23 | 96 | 0 | ... |
| Virginia-Carolina Chemical Co. | 60 | 56 | 93 | 3 | 100 |
| Wilcox Fertilizer Co. | 65 | 61 | 94 | 5 | 100 |
| Worcester Rendering Co. | 38 | 34 | 89 | 6 | 100 |
| Totals | 2058 | 1916 | 93 | 212 | 96 |

[1] No samples in 1929.
[2] For two years.



## SPECIAL MIXTURES AND HOME MIXTURES.

Sixty-seven samples of mixed fertilizers have been examined for individuals, such samples in most cases being drawn by the persons interested. The Station is responsible only for the analyses of these materials as received.

Analyses are given in Table XVII.

# VIII. MISCELLANEOUS FERTILIZERS, AMENDMENTS, WASTE PRODUCTS, ETC.

## SHEEP MANURE, ETC.

Fifteen samples of Sheep manure and other farm manures were analyzed. All met or exceeded their guaranties for nitrogen, phosphoric acid and potash, except two which were slightly deficient in nitrogen. These shortages did not exceed 0.1 per cent.

Analyses are given in Table XVIII.

## LIME.

Seven samples of agricultural lime have been examined for purchasers and analyses are given in Table XIX.

## OTHER MISCELLANEOUS MATERIALS.

Analyses of various materials with remarks where necessary are given in Table XX.

## COLLABORATIVE WORK.

The laboratory has continued to participate in the check meal program of the American Oil Chemists Society and in the check fertilizer program sponsored by the F. S. Royster Guano Company. This work aims to compare and improve methods of analysis and has involved the examination of 45 samples.

TABLE XVII. ANALYSES OF SPECIAL AND HOME MIXTURES.

| Station No. | Manufacturer or Brand. | Place of Sampling. | Total Nitrogen. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Station:* | | % | % | % | % | % | % | % | |
| 1518 | Home Mixture for Tobacco | L. B. Haas & Co., Hazardville | 5.60 | 6.81 | 0.50 | 3.65 | 3.15 | 0.74 | 12.74 | 1518 |
| 1904 | Home Mixture for Corn | Lester W. Lloyd, Suffield | 3.84 | 4.67 | .... | 9.67 | .... | 4.88 | 4.88 | 1904 |
| 2161 | Special Formula B | F. C. Gould, Silver Lane | 4.77 | 5.80 | 4.10 | 12.60 | 8.50 | 0.78 | 6.28 | 2161 |
| 1640 | Woodruff Home Mixed Fertilizer | S. D. Woodruff & Sons, Orange | 3.07 | 3.73 | 0.30 | 8.40 | 8.10 | 7.12 | 7.12 | 1640 |
| | *Sampled by Purchaser:* | | | | | | | | | |
| 1235 | Formula A | American Sumatra Tobacco Co., Bloomfield | 6.02 | 7.32 | 0.92 | 5.18 | 4.26 | .... | 5.00 | 1235 |
| 1231 | "Drill" Fertilizer | American Sumatra Tobacco Co., Bloomfield | 9.79 | 11.90 | 0.62 | 3.64 | 3.02 | .... | 1.28 | 1231 |
| 1236 | F. E. Fertilizer | American Sumatra Tobacco Co., Bloomfield | 6.02 | 7.32 | 0.41 | 3.53 | 3.12 | .... | 5.87 | 1236 |
| 1237 | F. E. Fertilizer | American Sumatra Tobacco Co., Bloomfield | 5.86 | 7.12 | 0.49 | 3.71 | 3.22 | .... | 6.38 | 1237 |
| 1232 | F. A. G. Fertilizer | American Sumatra Tobacco Co., Bloomfield | 5.46 | 6.64 | 0.90 | 5.56 | 4.66 | .... | 4.11 | 1232 |
| 1234 | F. B. G. Fertilizer | American Sumatra Tobacco Co., Bloomfield | 5.16 | 6.27 | 0.88 | 5.64 | 4.76 | .... | 5.14 | 1234 |
| 1233 | F. C. G. Fertilizer | American Sumatra Tobacco Co., Bloomfield | 5.23 | 6.36 | 1.25 | 6.11 | 4.86 | .... | 7.65 | 1233 |

TABLE XVII. ANALYSES OF SPECIAL AND HOME MIXTURES—*Continued.*

| Station No. | Manufacturer or Brand. | Place of Sampling. | Total Nitrogen. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Purchaser:* | | % | % | % | % | % | % | % | |
| 889 | Formula A | American Sumatra Tobacco Co., Bloomfield | 6.08 | 7.39 | 1.17 | 5.36 | 4.19 | .... | 6.13 | 889 |
| 890 | Formula B | American Sumatra Tobacco Co., Bloomfield | 6.08 | 7.39 | 1.63 | 3.06 | 1.43 | .... | 7.57 | 890 |
| 9780 | Special High Grade Tobacco Starter | P. J. Anderson, Windsor | 7.90 | .... | 0.53 | 4.80 | 4.27 | .... | 0.80 | 9780 |
| 9781 | Special High Grade Tobacco Starter | P. J. Anderson, Windsor | 8.12 | .... | 0.63 | .... | .... | .... | 0.79 | 9781 |
| 9779 | Special Home Mixture | P. J. Anderson, Windsor | 4.88 | 5.93 | 0.33 | 4.05 | 3.72 | .... | 7.12 | 9779 |
| 1678 | Potato Fertilizer | Hatheway & Steane, Inc., Hartford | 5.59 | 6.80 | 0.53 | 10.38 | 9.85 | 0.69 | 9.56 | 1678 |
| 1307 | Special Tobacco Fertilizer, Hasting Farm | Consolidated Cigar Corp., Hartford | 6.07 | 7.38 | 0.53 | 4.13 | 3.60 | 0.08 | 4.18 | 1307 |
| 1306 | Special Tobacco Fertilizer, Hinsdale Farm | Consolidated Cigar Corp., Hartford | 6.10 | 7.42 | 0.60 | 4.36 | 3.76 | 0.11 | 4.43 | 1306 |
| 1305 | Special Tobacco Fertilizer, Huntting Farm | Consolidated Cigar Corp., Hartford | 6.09 | 7.40 | 0.50 | 3.80 | 3.30 | 0.11 | 4.66 | 1305 |
| 1303 | Special Tobacco Fertilizer, Kanter Farm | Consolidated Cigar Corp., Hartford | 6.15 | 7.48 | 0.48 | 4.07 | 3.59 | 0.08 | 4.14 | 1303 |
| 1304 | Special Tobacco Fertilizer, Myers Farm | Consolidated Cigar Corp., Hartford | 6.06 | 7.37 | 0.50 | 4.29 | 3.79 | 0.09 | 4.42 | 1304 |
| 1302 | Special Tobacco Fertilizer Shaker Farm | Consolidated Cigar Corp., Hartford | 6.08 | 7.39 | 0.50 | 4.48 | 3.98 | 0.07 | 4.34 | 1302 |

TABLE XVII. ANALYSES OF SPECIAL AND HOME MIXTURES—*Continued.*

| Station No. | Manufacturer or Brand. | Place of Sampling. | Total Nitrogen. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | | Potash. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Citrate-insoluble. | Total. | So-called "Available." | As Muriate. | Total. | |
| | *Sampled by Purchaser:* | | % | % | % | % | % | % | % | |
| 1426 | Special Tobacco Fertilizer, Spear Farm | Consolidated Cigar Corp., Hartford | 5.93 | 7.21 | .... | 4.00 | .... | .... | 4.20 | 1426 |
| 1427 | Special Tobacco Fertilizer, Warner Farm | Consolidated Cigar Corp., Hartford | 6.12 | 7.44 | .... | 4.11 | ..... | .... | 4.17 | 1427 |
| 1301 | Special Tobacco Fertilizer, Whitaker Farm | Consolidated Cigar Corp., Hartford | 5.96 | 7.25 | 0.49 | 4.20 | 3.71 | 0.13 | 4.78 | 1301 |
| 1309 | Special Tobacco Fertilizer, Winton Farm | Consolidated Cigar Corp., Hartford | 6.09 | 7.40 | 0.37 | 4.06 | 3.69 | 0.11 | 4.21 | 1309 |
| 1308 | Special Tobacco Fertilizer, Wolf Farm | Consolidated Cigar Corp., Hartford | 6.19 | 7.53 | 0.55 | 4.43 | 3.88 | 0.11 | 4.28 | 1308 |
| 2129 | Special Mixture Fertilizer, Higgins | Consolidated Cigar Corp., Hartford | 5.24 | 6.37 | 0.35 | 3.85 | 3.50 | 0.54 | 5.76 | 2129 |
| 2130 | Special Mixture Fertilizer, Stevenson | Consolidated Cigar Corp., Hartford | 5.06 | 6.15 | 0.38 | 3.23 | 2.85 | 0.42 | 5.38 | 2130 |
| 2131 | Special Mixture Fertilizer, Lata | Consolidated Cigar Corp., Hartford | 5.69 | 6.92 | 0.73 | 4.93 | 4.20 | 0.40 | 6.57 | 2131 |
| 2132 | Special Mixture Fertilizer, Bihl | Consolidated Cigar Corp., Hartford | 5.28 | 7.08 | 0.68 | 4.45 | 3.77 | 0.36 | 7.08 | 2132 |
| 2133 | Special Mixture Fertilizer, Jones | Consolidated Cigar Corp., Hartford | 6.10 | 7.42 | 1.92 | 6.90 | 4.98 | 0.74 | 8.37 | 2133 |
| 2134 | Special Mixture Fertilizer, Dickau | Consolidated Cigar Corp., Hartford | 5.89 | 7.16 | 0.31 | 3.88 | 3.57 | 0.47 | 8.31 | 2134 |



TABLE XVII. ANALYSES OF SPECIAL AND HOME MIXTURES—*Continued.*

| Station No. | Manufacturer or Brand. | Place of Sampling. | Total Nitrogen. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. | | | Potash. | | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Citrate-insoluble. | Total. | So-called "Available." | As Muriate. | Total. | |
| | *Sampled by Purchaser:* | | % | % | % | % | % | % | % | |
| 2135 | Special Mixture Fertilizer, House | Consolidated Cigar Corp., Hartford | 6.28 | 7.64 | 1.38 | 6.10 | 4.72 | 0.66 | 7.81 | 2135 |
| 2136 | Special Mixture Fertilizer, Keeney | Consolidated Cigar Corp., Hartford | 5.66 | 6.88 | 0.42 | 3.93 | 3.51 | 0.48 | 8.33 | 2136 |
| 9818 | Eastern States 12-24-12 | Eastern States Farmers' Exchange, Springfield, Mass. | 11.02 | 13.40 | 1.62 | 23.70 | 22.08 | 0.19 | 12.07 | 9818 |
| 9819 | Eastern States 10-20-15 | Eastern States Farmers' Exchange, Springfield, Mass. | 9.96 | 12.11 | 1.68 | 20.90 | 19.22 | 0.19 | 13.69 | 9819 |
| 9820 | Eastern States 10-30-10 | Eastern States Farmers' Exchange, Springfield, Mass. | 9.40 | 11.43 | 1.85 | 30.20 | 28.35 | 0.04 | 10.76 | 9820 |
| 1555 | Fertilizer | L. B. Haas & Co., Inc., Hazardville | 5.50 | 6.69 | .... | 3.65 | .... | 0.57 | 11.65 | 1555 |
| 1831 | Olds & Whipple Fertilizer, Form. No. 1 | I. Kaffenburgh & Sons, Inc., Hartford | 7.11 | 8.64 | 0.18 | 3.65 | 3.47 | 0.62 | 11.86 | 1831 |
| 1832 | Olds & Whipple Fertilizer Form. No. 2 | I. Kaffenburgh & Sons, Inc., Hartford | 7.73 | 9.40 | 0.33 | 3.73 | 3.40 | 0.70 | 14.31 | 1832 |
| 1833 | Olds & Whipple Fertilizer, Form. No. 3 | I. Kaffenburgh & Sons, Inc., Hartford | 6.30 | 7.66 | 0.38 | 3.28 | 2.90 | 0.62 | 10.47 | 1833 |
| 1834 | Olds & Whipple Fertilizer, Form. No. 4 | I. Kaffenburgh & Sons, Inc., Hartford | 6.60 | 8.02 | 0.33 | 3.40 | 3.07 | 0.56 | 11.89 | 1834 |

TABLE XVII. ANALYSES OF SPECIAL AND HOME MIXTURES—*Continued.*

| Station No. | Manufacturer or Brand. | Place of Sampling. | Total Nitrogen. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Purchaser:* | | % | % | % | % | % | % | % | |
| 1909 | Rogers & Hubbard R 4 Mixture | I. Kaffenburgh & Sons, Inc., Hartford | 6.22 | 7.56 | 0.33 | 7.99 | 7.66 | 1.02 | 20.49 | 1909 |
| 1910 | Rogers & Hubbard R 5 Mixture | I. Kaffenburgh & Sons, Inc., Hartford | 6.84 | 8.32 | 0.20 | 7.71 | 7.51 | 1.06 | 22.40 | 1910 |
| 2071 | Rogers & Hubbard Special Mixture | Karl C. Kulle, Suffield | 5.06 | 6.15 | 0.14 | 4.51 | 4.37 | 0.43 | 8.93 | 2071 |
| 842 | Consolidated Special Fertilizer | Olds & Whipple, Inc., Hartford | 6.27 | 7.62 | 0.63 | 4.67 | 4.04 | .... | 4.07 | 842 |
| 888 | Climax Fertilizer 5-3-5 | The Rogers & Hubbard Co., Middletown | 4.46 | 5.42 | 0.54 | 4.07 | 3.53 | .... | 5.60 | 888 |
| 848 | Oats and Top Dressing Fertilizer, 10-3-8 | The Rogers & Hubbard Co., Middletown | 8.34 | 10.14 | 2.33 | 8.78 | 6.45 | .... | 8.97 | 848 |
| 750 | Tobacco Grower Brand | The Rogers & Hubbard Co., Middletown | 5.18 | 6.30 | 0.29 | 3.97 | 3.68 | .... | 5.50 | 750 |
| 1680 | Shoemaker's Swift-Sure Fertilizer, Car 58355 | American Sumatra Tobacco Co., Bloomfield | 3.47 | 4.22 | 1.55 | 11.10 | 9.55 | 0.23 | 0.57 | 1680 |
| 1691 | No. 1 Mixture with Manure | Silberman & Kahn, Hartford | 6.55 | 7.96 | 0.40 | 4.43 | 4.03 | 0.32 | 6.71 | 1691 |
| 1692 | No. 2 Mixture with Stems | Silberman & Kahn, Hartford | 7.33 | 8.91 | 0.30 | 4.88 | 4.58 | 0.37 | 6.95 | 1692 |
| 1693 | No. 3 Mixture with Stems | Silberman & Kahn, Hartford | 7.07 | 8.60 | 0.40 | 5.08 | 4.68 | 0.20 | 1.21 | 1693 |
| 1859 | Old Land Fertilizer | Silberman & Kahn, Hartford | 6.95 | 8.45 | 0.18 | 5.00 | 4.82 | 0.35 | 4.19 | 1859 |
| 1860 | "New Land" Fertilizer | Silberman & Kahn, Hartford | 6.57 | 7.99 | 0.18 | 4.63 | 4.45 | 0.32 | 5.72 | 1860 |



TABLE XVII. ANALYSES OF SPECIAL AND HOME MIXTURES—*Concluded.*

| Station No. | Manufacturer or Brand. | Place of Sampling. | Total Nitrogen. | Ammonia equivalent to total nitrogen. | Phosphoric Acid. Citrate-insoluble. | Phosphoric Acid. Total. | Phosphoric Acid. So-called "Available." | Potash. As Muriate. | Potash. Total. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Sampled by Purchaser:* | | % | % | % | % | % | % | % | |
| 1848 | O & W Fertilizer | Silberman & Kahn, Hartford | 2.86 | 3.48 | 0.28 | 7.50 | 7.22 | 3.72 | 3.72 | 1848 |
| 2118 | Fertilizer | Silberman & Kahn, Hartford | 5.91 | 7.19 | 0.56 | 4.19 | 3.63 | 0.15 | 4.24 | 2118 |
| 1895 | Olds & Whipple Special Mixture No. 1 | M. Silverberg, Ellington | 8.18 | 9.95 | .... | 1.65 | .... | 0.57 | 18.61 | 1895 |
| 1896 | Olds & Whipple Special Mixture No. 2 | M. Silverberg, Ellington | 8.14 | 9.90 | .... | 1.70 | .... | 0.27 | 17.01 | 1896 |
| 1652 | Olds & Whipple 5-8-7 Fertilizer with KCL | H. E. Wells, Warehouse Point | 4.24 | 5.15 | 1.07 | 9.25 | 8.18 | 7.35 | 7.35 | 1652 |
| 1653 | Olds & Whipple Grass Fertilizer 6-6-4 | H. E. Wells, Warehouse Point | 4.90 | 5.96 | 0.95 | 7.58 | 6.63 | 5.02 | 5.02 | 1653 |
| 1654 | Olds & Whipple Special Fertilizer No. 3 | H. E. Wells, Warehouse Point | 8.13 | 9.88 | 0.10 | 7.94 | 7.84 | 0.68 | 13.49 | 1654 |
| 1655 | Olds & Whipple Special Fertilizer No. 4 | H. E. Wells, Warehouse Point | 7.93 | 9.64 | 0.10 | 8.94 | 8.84 | 0.60 | 14.72 | 1655 |
| 1874 | Olds & Whipple Special Fertilizer Mixture No. 12 | H. E. Wells, Warehouse Point | .... | .... | .... | .... | .... | 0.66 | 14.13 | 1874 |
| 2229 | Dahlium (for dahlias) Plantspur Products Co., Ridgefield, N. J. | C. Lewis Alling, West Haven | 4.19 | .... | 0.96 | 3.98 | 3.02 | 3.16 | 3.16 | 2229 |

## Table XVIII. Analyses of Sheep Manure, Etc.

| Station No. | Manufacturer or Brand. | Place of Sampling. | Total Nitrogen. | Ammonia equivalent to total nitrogen. Found. | Ammonia equivalent to total nitrogen. Guaranteed. | Phosphoric Acid. Available. Found. | Phosphoric Acid. Available. Guaranteed. | Phosphoric Acid. Total. Found. | Phosphoric Acid. Total. Guaranteed. | Potash. Found. | Potash. Guaranteed. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | % | % | % | % | % | % | % | % | % | |
| | *Sampled by Station.* | | | | | | | | | | | |
| 1494 | AAC Pulverized Sheep and Goat Manure. American Agricultural Chemical Co., New York City | Roodner Grain Co., So. Norwalk | 1.52 | 1.85 | 1.50 | .... | .... | 1.00 | 0.50 | 3.08 | 2.00 | 1494 |
| 1563 | Sheep and Goat Manure. Armour Fertilizer Works, New York City | F. A. Bartlett Tree Expert Co., Stamford | 1.30 | 1.58 | 1.50 | .... | .... | 1.25 | 1.00 | 3.11 | 2.00 | 1563 |
| 1392 | Berkshire Sheep Manure. Berkshire Chemical Co., Bridgeport, Conn. | C. Buckingham & Co., Southport | 2.14 | 2.60 | 2.18 | 1.60 | 1.00 | 1.80 | .... | 2.91 | 2.00 | 1392 |
| 1404 | Par Plus Brand Reinforced Sheep Manure. A. H. Case & Co., Buffalo, N. Y. | S. D. Woodruff & Son, Orange | 2.66 | 3.23 | 2.25 | 2.65 | 0.75 | 3.30 | 1.50 | 2.33 | 1.50 | 1404 |
| 1579 | Corenco Sheep Manure. Consolidated Rendering Co., Boston, Mass. | Knowles & Lombard Co., Guilford | 1.50 | 1.82 | 1.50 | .... | .... | 1.25 | 0.50 | 3.08 | 2.00 | 1579 |
| 1442 | Davey Shredded Cattle Manure. Davey Tree Expert Co., Kent, Ohio | R. E. Landis, Sound Beach | 1.96 | 2.38 | 1.20 | .... | .... | 1.39 | 1.00 | 2.15 | 1.00 | 1442 |
| 1416 | "Sheep's Head" Pulverized Sheep Manure. National Guano Co., Aurora, Ill. | Cadwell & Jones, Hartford | 2.20 | 2.67 | 2.73 | 1.68 | 1.00 | 1.83 | 1.25 | 3.33 | 2.00 | 1416 |
| 1464 | Favorite Sheep Manure. Olds & Whipple, Inc., Hartford | Sampled at factory | 1.38 | 1.68 | 1.65 | .... | .... | 1.14 | 0.75 | 3.07 | 2.50 | 1464 |
| 1477 | Groz-It Pulverized Sheep Manure. Pacific Manure & Fertz. Co., San Francisco, Cal. | F. T. Blish Hardware Co., So. Manchester | 1.61 | 1.96 | 1.80 | .... | .... | 0.95 | 0.75 | 3.35 | 3.00 | 1477 |
| 1533 | Premier Brand Poultry Manure. Premier Poultry Manure Co., Chicago, Ill. | Lightbourn & Pond, New Haven | 5.64 | 6.86 | 6.00 | 2.82 | 2.50 | 3.05 | 2.75 | 1.34 | 1.30 | 1533 |
| 1534 | Premier Brand Sheep Manure. Premier Poultry Manure Co., Chicago, Ill. | Lightbourn & Pond, New Haven | 1.84 | 2.24 | 2.00 | 0.88 | 0.80 | 1.08 | 1.00 | 1.85 | 2.00 | 1534 |
| 1417 | Wizard Brand Cattle Manure. Pulverized Manure Co., Chicago, Ill. | S. P. Strople, New Britain | 2.01 | 2.44 | 2.10 | 1.05 | 1.00 | 1.30 | .... | 1.55 | 1.00 | 1417 |
| 1418 | Wizard Brand Pulverized Sheep Manure. Pulverized Manure Co., Chicago, Ill. | S. P. Strople, New Britain | 1.90 | 2.31 | 2.43 | 1.73 | 1.25 | 1.88 | .... | 3.44 | 2.00 | 1418 |
| 2000 | Royster's Sheep and Goat Manure. F. S. Royster Guano Co., Baltimore, Md. | F. H. Woodruff & Sons, Milford | 1.37 | 1.67 | 1.50 | 1.40 | 1.00 | 1.55 | .... | 3.24 | 2.00 | 2000 |
| 2159 | Sheep and Goat Manure. I. P. Thomas & Sons, Philadelphia, Pa. | Ira W. Beers, Hamden | 1.42 | 1.73 | 1.50 | .... | .... | 1.23 | 1.00 | 3.59 | 2.00 | 2159 |

TABLE XIX. ANALYSES OF LIMESTONE, ETC.

| Station No. | Manufacturer or Brand. | Sampled by | Chemical Analysis. Lime (CaO). Found. | Chemical Analysis. Lime (CaO). Guaranteed. | Chemical Analysis. Magnesia (MgO). Found. | Chemical Analysis. Magnesia (MgO). Guaranteed. | Chemical Analysis. Total Oxides. | Chemical Analysis. Insoluble in acid. | Mechanical Analysis. 20 mesh. | Mechanical Analysis. 40 mesh. | Mechanical Analysis. 50 mesh. | Mechanical Analysis. 80 mesh. | Mechanical Analysis. 100 mesh. | Station No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | % | % | % | % | % | % | % | % | % | % | % | |
| | **Farnam Cheshire Lime Co., Farnams, Mass.** | | | | | | | | | | | | | |
| 1830 | Lime | John F. Luddy, Hazardville | 67.28 | .... | 0.68 | .... | 67.96 | .... | 92.5 | 62.5 | 36.5 | 17.5 | 12.5 | 1830 |
| | **Lee Lime Co., Lee, Mass.** | | | | | | | | | | | | | |
| 2055 | Hydrated Lime | Woodbury Co-operative Assoc., Inc., Woodbury | 47.39 | .... | 30.35 | .... | 77.74 | .... | 97.5 | 91.0 | 57.5 | 19.0 | 6.5 | 2055 |
| | **Miller Lime Co., West Stockbridge, Mass.** | | | | | | | | | | | | | |
| 2056 | Hydrated Lime | Woodbury Co-operative Assoc., Woodbury | 59.61 | .... | 2.63 | .... | 62.24 | .... | .... | .... | .... | .... | .... | 2056 |
| | **New England Lime Co., Canaan, Conn.** | | | | | | | | | | | | | |
| 1772 | Hydrated Lime | T. R. Swanback, Windsor | 45.61 | .... | 31.35 | .... | 76.96 | .... | 98.9 | 96.6 | 89.3 | 61.1 | 16.9 | 1772 |
| | **Manufacturer Unknown.** | | | | | | | | | | | | | |
| 410 | Burned Agricultural Lime | Ira W. Beers, Hamden | 40.90 | .... | 28.03 | .... | 68.93 | .... | 89.5 | 43.0 | 33.0 | 16.0 | 15.5 | 410 |
| 1363 | Limestone | Robt. Coe, Durham | 52.94 | .... | 0.54 | .... | 53.48 | .... | 92.5 | 76.0 | 64.0 | 53.5 | 49.0 | 1363 |
| 1501 | Lime | Chas. D. Lewis, Hartford | 33.22 | .... | 1.26 | .... | 34.48 | .... | .... | .... | .... | .... | .... | 1501 |

TABLE XX. MISCELLANEOUS MATERIALS.

| No. | Material | Nitrogen. | Phosphoric acid. | Potash. | Remarks. |
|---|---|---|---|---|---|
| | | % | % | % | |
| 2068 | Acid Phosphate ?.. | .... | 3.20 | 0.17 | Much $CO_2$. No water sol. carbonate. Not leached ashes. Probably limestone. |
| 1242 | Bone meal ....... | .... | .... | .... | No foreign material detected. |
| 1591 | Bone meal........ | .... | .... | .... | For identification. |
| 571 | Cattle manure .... | 2.75 | 0.89 | 0.99 | Moisture 13.93%. |
| 1207 | Chicken manure .. | 2.36 | 3.52 | 1.50 | Moisture 21.52%. |
| 1208 | Chicken manure .. | 0.90 | 1.18 | 0.48 | Moisture 73.70%. |
| 887 | Cotton hulls ...... | 0.58 | .... | .... | Ash 2.80; fibre 35.93. |
| 517 | Cotton waste ..... | 1.45 | 0.59 | 1.05 | .................................. |
| 1479 | Fertilizer 5-4-5 ... | .... | .... | .... | Appeared to contain castor pomace and cottonseed meal as source of organic nitrogen. Chlorine 1.03%. |
| 210 | Fertilizer ........ | .... | 3.95 | .... | Avail. $P_2O_5$ 3.82%; moisture 6.38%. Referee sample. |
| 211 | Fertilizer ........ | .... | 3.24 | 5.15 | Avail. $P_2O_5$ 2.91%; moisture 6.25%. Referee sample. |
| 9838 | Fertilizer ........ | .... | .... | .... | No salt (NaCL) found. |
| 1019 | Fertilizer ........ | .... | .... | 14.10 | Check sample. 13.94% by alternate A. O. A. C. method. |
| 913 | Fertilizer ........ | 4.14 | 7.97 | 6.25 | .................................. |
| 1557 | Fertilizer ........ | 5.06 | 2.05 | 10.96 | .................................. |
| 1556 | Fertilizer ........ | 5.19 | 2.05 | 10.99 | .................................. |
| 1960 | Fertilizer ........ | 5.90 | 3.47 | 7.85 | .................................. |
| 387 | Fertilizer ........ | 5.78 | 5.78 | 5.98 | .................................. |
| 1387 | Fish, dry, ground.. | 8.49 | .... | .... | Trace of ammon. sulphate crystal. $NH_3$ 0.18%. Probably accidental contamination. |
| 2150 | Material for identification ......... | .... | ..... | 56.07 | Muriate of potash. Chlorine much, sulphate trace, nitrate none. |
| 2078 | Material for identification ........ | 14.76 | .... | 11.36 | Nitrate of potash-soda. |
| 1296 | Muck ............ | .... | .... | .... | Moisture 4.94%: ash 87.00%; organic and volatile 8.06%. |
| 757 | Nitrate of Soda ?.. | 8.82 | 6.16 | 0.64 | Not nitrate of soda. Probably mixture of nitrate of soda and acid phosphate. |
| 1847 | Nitrophoska No. 3 | .... | .... | .... | CaO 0.54%; MgO 0.10%. |
| 487 | Poultry Manure ... | 5.04 | 1.93 | 1.24 | Dry, pulverized. |
| 1346 | Sewage Sludge ... | 0.81 | 0.28 | 0.07 | Water 56.34%; ash 16.43%; organic and volatile 27.23%. |
| 1347 | Sewage Sludge ... | 0.70 | 0.26 | 0.04 | Water 30.00%; ash 52.50%; organic and volatile 17.50%. |
| 1348 | Sewage Sludge ... | 0.75 | 0.42 | 0.05 | Water 24.50%; ash 61.96%; organic and volatile 13.54%. |
| 1488 | Sewage Sludge ... | 1.08 | 0.54 | 0.07 | Water 45.80%; ash 31.31%; organic and volatile 22.89%. |



TABLE XX. MISCELLANEOUS MATERIALS—*Concluded.*

| No. | Material | Nitrogen. | Phosphoric acid. | Potash. | Remarks. |
|---|---|---|---|---|---|
| | | % | % | % | |
| 1663 | Sewage Sludge ... | 1.92 | .... | .... | Water 4.83%; ash 40.50%; organic and volatile 54.67%. |
| 1300 | Sheep Manure .... | .... | .... | .... | Some acid phosphate present; also limestone and shell; trace of ground bone. |
| 9811 | Sheep Manure .... | .... | .... | .... | Appeared to be genuine. No ammonia sulphate detected. |
| 9813<br>9814 | Soils .......... | .... | .... | .... | Ether extract of soils yellow and fluorescent. Ether residue had appearance and consistency of vaselene. Soils impregnated with mineral oil or grease. |
| 2069 | Soil or Humus .... | 0.32 | 0.10 | 0.12 | Water 27.28%; ash 58.18%. |
| 656 | Tankage ........ | 3.15 | 5.94 | .... | .................................. |
| 907 | Tankage ........ | 8.33 | 11.08 | .... | Trace of mineral phosphate. |
| 9805 | Tankage ........ | 3.92 | 15.75 | .... | Appeared to be genuine. No ammonia salts detected. Much bone and meat present. |
| 1484 | Tobacco dust ..... | 0.78 | 0.35 | 0.93 | .................................. |
| 1386 | Tobacco stems..... | 1.18 | 0.70 | 3.59 | .................................. |

## CHLORINE IN FERTILIZER MATERIALS.

Tobacco growers desire to avoid chlorine so far as possible in their fertilizer mixtures and are therefore concerned with the chlorine content of their raw materials. Data obtained in the last two years as well as some obtained earlier are summarized in Table XXI.

Chlorine was extracted with hot water as directed in the method for water-soluble potash in mixed fertilizers, omitting ammonia and ammonium oxalate, and determined volumetrically.

TABLE XXI. CHLORINE IN SOME FERTILIZER MATERIALS.

| Material | No. of Samples Tested | Chlorine, Cl., per cent. Range | Average |
|---|---|---|---|
| Ammonium phosphate | 2 | trace | .... |
| Ammonium sulphate | 13 | none to 1.4 | .... |
| Blood, dried | 2 | 0.3 to 1.4 | 0.80 |
| Bone, ground | 12 | trace to 1.2 | 0.25 |
| Calcium nitrate | 1 | none | .... |
| Calurea | 2 | none | .... |
| Castor pomace | 4 | trace to 0.1 | 0.06 |
| Cottonseed meal | 4 | trace | .... |
| Cottonhull ashes | .. | 0.2[1] | .... |
| Cow manure (72% water) | .. | 0.1[1] | .... |
| Fish scrap | 48 | 0.1 to 0.7[2] | 0.25 |
| Horse manure (66% water) | .. | 0.1[1] | .... |
| Linseed meal | 4 | none | .... |
| Potassium carbonate | 22 | trace to 1.2 | 0.11 |
| Potassium nitrate | 6 | 0.6 to 1.5 | 0.98 |
| Potassium sulphate | 20 | trace to 4.6 | 2.22 |
| Potassium-magnesium sulphate | 2 | 1.5 to 2.7 | 1.90 |
| Sodium nitrate | 12 | 0.1 to 1.6 | 0.56 |
| Sodium-potassium nitrate | 6 | trace to 0.8 | 0.41 |
| Superphosphate (acid phosphate) | 4 | trace | .... |
| Tankage | 12 | trace to 1.1 | 0.40 |
| Tobacco stems (20% water) | .. | 0.5[1] | .... |
| Wood ashes | .. | 0.5[1] | .... |

[1] Taken from a compilation by Dr. Jenkins in 1922.
[2] Conn. Exp. Sta., Bull. 250, p. 43, 1923. This is excluding two samples which were found to contain 2.6 and 3.3% of chlorine and which are extraordinary.

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## ADDENDA, ETC.

Page 11, To the brands registered by Apothecaries Hall Co. add, Tobacco Starter.
Page 14, Frisbie's Top Dresser, 8-6-5, should read 8-6-6.
Page 17, The Rogers & Hubbard Co., 5-10-15 Fertilizer, should read 5-10-5.
Page 18, to the brands registered by F. S. Royster Guano Co. add, Royster's Trucker's Delight.
Page 18, to the brands registered by M. L. Shoemaker & Co. add, "Swift-Sure" Tobacco Starter, 4-10-0.

Bulletin 309 December, 1929

# FIFTY YEARS' INDEX

## 1877-1927

E. H. JENKINS

Connecticut
Agricultural Experiment Station
New Haven

The bulletins of this station are mailed free to citizens of Connecticut who apply for them and to other applicants as far as the editions permit.

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THE TUTTLE, MOREHOUSE & TAYLOR COMPANY, NEW HAVEN, CONN.

## FOREWORD

In preparing this general index to the annual reports of the Connecticut Agricultural Experiment Station for the fifty years, 1877-1927, only matters of permanent interest and value have been included. For example, the details of the reports on fertilizers and feeding stuffs and other items of passing interest, such as descriptions of well known chemical methods, are omitted.

Three special indexes have been printed as follows: Index to Reports on Foods and Drugs, 1896-1914, Bulletin 187; Index to Reports on Foods and Drugs, 1915-1925, Bulletin 284, and the General Index to Reports of the State Entomologist, 1901-1925, Bulletin 281. These are referred to by title and page, but the details are omitted. The botany department is preparing an index of hosts and fungi and these are not in the general index, but the more important botanical papers are included.

Bulletins of Immediate Information are listed, but their subject matter is not indexed. The acts of the general assembly concerning the station's duties and its buildings and grounds are included, but the general maintenance appropriations are not cited.

Following the general index are (a) an index to analyses of miscellaneous materials, (b) a list of the personnel, (c) list of all bulletins issued since the founding of the station, and (d) lists of all publications, including journal papers, arranged according to departments.

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Pokrob, W., '98, i; '04, ii.

Rice, C. J., '82, 2; '02, xii.
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Riley, J. E., '26, iii.
Rodman, C. W., '07-'08, xi; '09-'10, xi.
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Sturgis, W. C., '01, xiii; '02, xii.

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Washburn, J. H., '86, 9.
Webb, J. J., '77, 2; '83, iii.
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Wells, H. L., '78, 2; '80, 2.
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Williams, M. C., '01, xiii.
Winton, A. L., '84, 2; '07-'08, xi.

Zappe, M. P., '14, iii.

## Employees on the Grant of the Carnegie Institution of Washington, D. C.

| Name | Appointed | Resigned |
|---|---|---|
| C. A. Brautlecht | July 1, 1906 | March 31, 1908 |
| Helen C. Cannon | October 25, 1920 | December 31, 1925 |
| S. H. Clapp | March 15, 1905 | August 31, 1907 |
| A. C. Gilbert | June 7, 1905 | March 31, 1906 |
| Ralph D. Gilbert | October 1, 1904 | March 31, 1906 |
| Herbert H. Guest | June 13, 1910 | July 29, 1911 |
| Isaac F. Harris[1] | April 10, 1906 | December 15, 1906 |
| Frederick W. Heyl | June 1, 1907 | June 30, 1908 |
| Albert G. Hogan | July 1, 1913 | September 16, 1913 |
| Leigh I. Holdredge | October 19, 1909 | July 31, 1912 |
| D. Breese Jones | May 11, 1908 | October 30, 1909 |
| C. S. Leavenworth | January 5, 1908 | |
| Leonard M. Liddle | July 1, 1909 | August 31, 1910 |
| E. V. McCollum | May 1, 1906 | July 31, 1906 |
| Clyde R. Newell | June 23, 1911 | August 31, 1911 |
| Laurence S. Nolan | April 10, 1910 | |
| O. L. Nolan | May 13, 1907 | March 31, 1920 |
| H. B. Vickery | June 1, 1922 | |
| Alfred J. Wakeman | April 1, 1912 | |

[1] Mr. Harris was on the station payroll before being on the Carnegie staff.

## LIST OF STATION BULLETINS

Analysis of "Composition for Grass," No. 1.
Analysis of "Composition for Vegetables," No. 2.
Analysis of Soluble Pacific Guano, No. 3.
Fertilizer Analyses, Nos. 4 to 8.
Analyses of Leached Ashes and Egg Food, No. 9.
Fertilizer Analyses, Nos. 10 to 22.
Analyses of Hay, No. 23.
Fertilizer Analyses, Nos. 24 to 33.
Analyses of Hay, No. 34.
Analyses of Maize Kernel, No. 35.
Shell Marl, Marine Mud and Oyster Shell Lime, No. 36.
Fresh Water Sediments, No. 37.
Fertilizer Analyses, Nos. 38 to 43.
Pollard Fertilizers: Caution, No. 44.
Fertilizer Analyses, Nos. 45 to 47.
Forester's Fertilizers, No. 48.
Analyses of Swamp Muck, No. 49.
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Fertilizer Analyses, Nos. 62 to 67.
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Fungous Diseases of Plants (and Fertilizer Analyses), No. 97.
Home Mixed Fertilizers, No. 98.
Fertilizer Analyses, June, 1889, No. 99.
Fertilizer Analyses, September, 1889, No. 100.
Fertilizer Analyses, January, 1890, No 101.
Fungicides, No. 102.
Fertilizers, No. 103.
Fertilizers, No. 104.

NOTE. From 1877 to 1916, inclusive, the station's annual reports consisted of the results of investigations reported by the staff. Beginning with 1905, the reports are divided into parts, for example, "Part II, Fifteenth Report of the State Entomologist," Report for 1915. At this time, the bulletins were of a more popular nature or took the form of monographs. Commencing with the Forty-First Report, 1917, this distinction was dropped and all publication was in the bulletin series, those issued each year being brought together to constitute the annual report.

A few of the earlier reports and bulletins are now available for distribution to libraries and a list may be obtained from the station.

Potato Scab, Proteids of the Oat Kernel, Milk Testing, No. 105.
Babcock Method of Determining Fat in Milk and Cream: Analyses of Butter; Fertilizers, No. 106.
Connecticut Species of Gymnosporangium, No. 107.
Examination of the Seed of Orchard Grass: Ash Analysis of White Globe Onions: Determination of Fat in Cream by the Babcock Method, No. 108.
Fertilizers, No. 109.
Fertilizers, No. 110.
Common Fungous Diseases and Their Treatment, No. 111.
Gunning-Kjeldahl Method and a Modification Applicable in the Presence of Nitrates, No. 112.
Fertilizers, No. 113.
Fertilizers, No. 114.
Common Fungous Diseases and Their Treatment, No. 115.
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Analyses of Fertilizers. Trade Values of Fertilizer Ingredients for 1895. Poultry, No. 120.
Elm Leaf Beetle and San José Scale, No. 121.
Cost of Nitrogen, Phosphoric Acid and Potash in Connecticut, No. 122.
Examination of Food Products Sold in Connecticut, No. 123.
The Cost of Plant Food in Connecticut, No. 124.
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Insecticides: Their Preparation and Use, No. 126.
Cost of Plant Food in Connecticut, Spring Months of 1898, No. 127.
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Inspection and Care of Nursery Stock, No. 129.
Commercial Feeding Stuffs in the Connecticut Market, No. 130.
The Protection of Shade Trees in Towns and Cities, No. 131.
Condimental and Medicinal Cattle and Poultry Foods, No. 132.
Commercial Feeding Stuffs in the Connecticut Market, No. 133.
The New Law Concerning Insect Pests, 134.
The San José Scale-Insect: Its Appearance and Spread in Connecticut, No. 135.
Preliminary Experiments in Spraying to Kill the San José Scale-Insect. Season of 1901, No. 136.
The Growing of Tobacco Under Shade in Connecticut, No. 137.
Commercial Feeding Stuffs in the Connecticut Market, No. 138.
The Apple Tree Tent-Caterpillar, No. 139.
The White-Fly or Plant-House Aleyrodes, No. 140.
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The Selection of Tobacco Seed Plants, No. 150.
The Chief Injurious Scale-Insects of Connecticut, No. 151.
The Improvement of Corn in Connecticut, No. 152.
The Gipsy Moth and The Brown-Tail Moth, No. 153.
Chestnut in Connecticut and the Improvement of the Woodlot, No. 154.
The Elm Leaf Beetle, No. 155.
Cotton Seed Meal as a Fertilizer, No. 156.



Lead Arsenate and Paris Green, No. 157.
The Relation of Certain Biological Principles to Plant Breeding, No. 158.
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Feeds, Seeds and Weeds, No. 161.
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Second Report of the Tree Protection Examining Board, No. 263.
Report of the Director for the Year Ending October 31, 1924, No. 264.
Report of the State Entomologist, 1924, No. 265.
The Improvement of Naturally Cross-Pollinated Plants by Selection in Self-Fertilized Lines. 1. The Production of Inbred Strains of Corn, No. 266.
Report on Food and Drug Products, 1924, No. 267.
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Perithecia of Thielavia Basicola Zopf in Culture and the Stimulation of Their Production by Extracts from other Fungi, No. 269.
Report on Commercial Fertilizers, 1925, No. 270.
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A Chemical Investigation of Some Standard Spray Mixtures, No. 278.
The Genetics and Morphology of Some Endosperm Characters in Maize, No. 279.
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Quality of Vegetable Seeds Sold in Packets in Connecticut, 1926, No. 283.
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Report on Food and Drug Products, 1926, Part I, No. 286.
Report on Food and Drug Products, 1926, Part II, No. 287.
Biology of Birch Leaf Skeletonizer, No. 288.
Report on Commercial Feeding Stuffs, 1926, No. 289.
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Some Insect Pests of Nursery Stock in Connecticut, No. 292.
Quality of Vegetable Seed Bought by Market Gardeners in Connecticut, No. 293.
Report of the State Entomologist, 1927, No. 294.
Report on Food and Drug Products, 1927, No. 295.

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Blight and Rot of Potatoes, No. 2.
Fumigation and Treatment of Nursery Stock, No. 3.
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The Uses of the Agricultural Experiment Station, No. 6.
"Universal Military Service," for Farmers, No. 7.
Diseases of Bees: Their Detection and Treatment, No. 8.
The Connecticut Fertilizer Law, No. 9.
The Treatment of Apple Trees Girdled by Mice, No. 10.
Why We Must Have Vegetables, No. 11.
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European Corn Borer Quarantine, No. 25.

The Apple and Thorn Skeletonizer, No. 26.
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Winter Condition of Apple and Peach Buds, No. 28.
Dormant Sprays for Orchard Pests, No. 29.
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Prematuring of Vegetables, Rots of Lettuce and Similar Troubles, No. 46.
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Practical Lawn Suggestions, No. 48.
Regulations for Carrying Out the Provisions of the Law Concerning Concentrated Commercial Feeding Stuffs, No. 49.
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The Asiatic Beetle Quarantine (Revision), No. 55.
The Japanese Beetle Quarantine, No. 56.
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The Japanese Beetle Quarantine (Revision), No. 58.
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Regulations for Carrying Out the Provisions of the Law Concerning Concentrated Commercial Feeding Stuffs, No. 60.
Regulations Concerning the Transportation of Nursery Stock in the United States and Canada (Revision), No. 61.

## *TOBACCO SUBSTATION*[1]

Condensed Recommendations for the Control of Wildfire, No. 1.
Wildfire of Tobacco in 1922, No. 2.
Experiments in the Curing and Fermentation of Connecticut Shade Tobacco, No. 3.
Recommendations for the Control of Wildfire (Revision), No. 4.
Fertilizer Experiments with Tobacco, No. 5.
Report of Tobacco Station at Windsor for 1925, No. 6.
The Phosphorous Requirements of Old Tobacco Soils, No. 7.
Report of Tobacco Station at Windsor for 1926, No. 8.
Prolonging the Life of Tobacco Shade Tent Poles, No. 9.
Report of Tobacco Station at Windsor for 1927, No. 10.

[1] The separate series of the tobacco substation was discontinued in 1927, Bulletin 10 being the last. They now appear as bulletins of the regular station series.

# ANALYTICAL CHEMISTRY

## Reports of the Station

Station publications of the work of the analytical chemistry laboratory in the inspection of commercial fertilizers, foods, drugs and commercial feeding stuffs are to be found numbered consecutively in the annual reports. Each annual report from 1877 has published fertilizer analyses. Reports on foods begin with 1896. The first drugs report was in 1908. Yearly reports on inspection of commercial feeding stuffs begin with 1899, though analyses were published periodically from 1877 until that time. Inspection of insecticides may be found in the biennial report for 1907-1908 and in the annual reports for 1922, 1924 and 1925.

## Journal Papers

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E. H. Jenkins. U. S. D. A., Div. Chem., Bull. 24, 1890, 79-83.
Abstract of Chemical Literature Relating to the Analysis of Dairy Products.
E. H. Jenkins. U. S. D. A., Div. Chem., Bull. 28, 1890, 29-51.
The Use of Sodium Chloride in the Lindo-Glodding Method of Determining Potash.
A. L. Winton. U. S. D. A., Div. Chem., Bull. 31, 1891, 148-150.
Compilation of Analyses of American Feeding Stuffs.
E. H. Jenkins and A. L. Winton. Office of Experiment Stations, Exp. Sta. Bull. 11, 1892.
Report on Dairy Products.
A. L. Winton. U. S. D. A., Div. Chem., Bull. 38, 1893, 92-108.
Fat Content of Cream on Keeping With and Without Bichromate of Potash.
A. L. Winton. U. S. D. A., Div. Chem., Bull. 43, 1894, 192-193.
Some Conditions Affecting the Accuracy of the Determination of Potash as Potassium Platinichloride.
A. L. Winton. Jour. Am. Chem. Soc., 1895, XVII, 453-466.
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H. J. Wheeler and A. L. Winton. U. S. D. A., Div. Chem., Bull. 47, 1896, 14-23.
A Modified Ammonium Molybdate Solution.
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Report on Potash.
A. L. Winton. U. S. D. A., Div. Chem., Bull. 49, 1897, 27-41.
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A. L. Winton and C. H. Jones. U. S. D. A., Div. Chem., Bull. 51, 1898, 29-42.
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A. L. Winton and H. J. Wheeler. Jour. Am. Chem. Soc., XX, 1898, 597-609.
What the Experiment Stations Have Learned About Raising and Curing Tobacco.
E. H. Jenkins. Mass. State Board Agr. Report for 1898, 18-50.
A Convenient Micro-Polariscope for Food Examination.
A. L. Winton. Jour. App. Micro., 1899, II, 550-551.
Detection of Coal-Tar Dyes in Fruit Products.
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The Analysis of Vanilla Extract.
A. L. Winton and M. Silverman. Jour. Am. Chem. Soc., 1902, XXIV, 1128-1135.

Impurities in American Wheat.
A. L. Winton. Zeitschr. Untersuch. Nahr. u. Genussmtl., 1903, VI, 432-447.
Anatomical Structure of Cultural Varieties of Millet.
A. L. Winton. Zeitschr. Untersuch. Nahr. u. Genussmtl., 1903, VI, 337-345.
Anatomy of Hemp Seed.
A. L. Winton. Zeitschr. Untersuch. Nahr. u. Genussmtl., 1904, VII, 385-388.
Microscopic Examination of American Cottonseed Cake.
A. L. Winton. Analyst, 1904, XXIX, 44-47.
Anatomy of the Fruits of Darnel and Chess.
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A. L. Winton and E. M. Bailey. Jour. Am. Chem. Soc., 1905, XXVII, 2.
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A Method for the Determination of Lead Number in Maple Sirup and Maple Sugar.
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Formation of Volatile Sulphur Compounds in Meat and Their Influence on the Detection of Added Sulphites.
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J. P. Street. Proceedings Asso. Off. Agr. Chemists, Bur. Chem., Bull. 122, 1908.
The Detection of Inferior Ammoniates in Commercial Fertilizers.
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[1] This list includes only articles published before the office of the state entomologist was created in 1901. Yearly reports of the state entomologist, numbers one to sixteen, comprising all the entomological work of the station, were published from 1901 to 1916, inclusive, in the annual reports of the station.



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Bulletin 310 January, 1930

Connecticut Agricultural Experiment Station
New Haven

# Canada-Leaming Corn

Donald F. Jones
W. Ralph Singleton

The bulletins of this station are mailed free to citizens of Connecticut who apply for them and to other applicants as far as the editions permit.

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THE TUTTLE, MOREHOUSE & TAYLOR COMPANY, NEW HAVEN, CONN.

# CANADA-LEAMING CORN

As the result of many years of study of the effects of inbreeding and crossing upon corn the Connecticut Agricultural Experiment Station, at New Haven, produced a new type of corn called Double Crossed Burr-Leaming and first sent it out for trial in 1917. The history and development of this corn is given in the Connecticut Agricultural College Extension Bulletin No. 108. Burr-Leaming has been grown in an increasing amount since its first introduction and is well adapted to many parts of southern New England for grain and silage.

There are many parts of northern New England where Burr-Leaming and other varieties of a similar season will not mature properly for silage. To meet the need for a variety of corn which has a large stalk growth and heavy grain yield and which at the same time ripens sufficiently early to give a good quality of silage in short seasons, the Connecticut Agricultural Experiment Station has produced a new type of crossed corn called Canada-Leaming. This has been tested three years, 1927, 1928 and 1929. Farmers find it to be early maturing and high yielding.

## A NEW TYPE OF CORN

Canada-Leaming is an entirely new type of corn, being a first generation hybrid of selected inbred strains of Canada Yellow flint and Leaming dent. It has long been known that crossing in both animals and plants gives an immediate stimulus to increased growth and greater yield in the first generation following the cross. This tendency to augment production is commonly called hybrid vigor. It has long been utilized in the mule, the sterile hybrid of the horse and the ass. Shorthorn-Angus and Shorthorn-Galloway crosses in cattle, Poland China-Chester White and Berkshire-Yorkshire crossbreds in swine and Shropshire-Merino combinations in sheep have been valued for many years and are becoming increasingly important. In all of these animals no attempt is made to use the crossbreds for breeding purposes. Animal husbandry-men have learned by long experience that these hybrids do not reproduce their own good qualities in their offspring. While the first cross is uniform in type, large, free from disease and fast growing, the second and later generations are variable, smaller, and often feeble and sometimes abnormal.

It has been demonstrated that this same principle of hybrid vigor which has long been used in animals can be applied to plants and particularly to corn. Plants have the added advantage that they can be put through a previous process of severe inbreeding which rids them of many abnormalities and hereditary weaknesses that make their appearance from time to time in barren plants, nubbiny ears and stunted stalks.

## QUALITIES OF FLINT AND DENT CORN

The eight-rowed flint corn now grown in New England is about the only type of this plant, still extensively used, that has come down from the Indians practically unchanged. It is raised in preference to dent corn where the growing season is short, where

Fig. 1. Canada-Leaming has the earliness of the flints and yields as much grain as many of the dents.

the spring is cold and wet, and where many of the days in mid-summer are cool. Under these conditions flint corn germinates better in early spring, starts with a more vigorous growth that gets ahead of the weeds and ripens into good sound grain before killing frosts come in the fall.

Dent corn is preferred wherever it can be properly matured on account of its large straight stalk that is free from tillers and its heavier production of grain where the growing season is long enough and sufficiently warm to permit its full development.

A first generation hybrid of the best of the New England flints with a suitable type of large, early-maturing dent corn, combining



many of the desirable features of both types with the advantage of hybrid vigor, would have value for New England conditions and other places having a similar season.

## ORIGIN OF CANADA-LEAMING

An extensive corn variety test carried out by the Connecticut experiment stations at Storrs and at New Haven, reported in Bulletin 259 of the latter station, had shown many varieties of flint and dent corn to be well adapted to this part of the country. A Canada Yellow flint grown by E. E. Burwell of New Haven was selected as one of the best of the flints. Leaming grown for 20 years by Heman Beardsley at Roxbury, Connecticut was selected as a large, productive, dent corn that matured every year.

These two varieties were put through a process of inbreeding by self fertilization as described in Bulletins 266 and 273. Sixteen of the best of the inbred flint strains were selected for crossing. The strains were first crossed by pairs. Each of these first generation hybrids was then cross-pollinated by each of the others and the resulting seed mixed and planted in an isolated field. Selected ears from this mixture have been used to propagate the parental types from year to year. The original inbred strains were produced by hand pollination but this is now no longer necessary in multiplying seed.

A similar combination of the best inbred strains of Beardsley's Leaming was made in the same way. Both of these re-synthesized varieties are about the same in general appearance as the original varieties but yield somewhat more and are freer from hereditary defects and abnormalities.

## PRODUCING CROSSED SEED

The Canada Yellow flint stock, produced in this way, is used as the seed parent while the Leaming stock produces the pollen. In practice, two rows of the flint are planted with one row of the dent alternating throughout the field. Both kinds of seed are planted at the same time. The tassels on the flint plants are all pulled out before pollen is shed. This very important task is somewhat tedious, but it is the only way that crossed seed corn can be produced at present. When the silks appear on the detasseled plants, pollen has just begun to be shed by the dent pollen parent, planted solely for that purpose in every third row.

Care is necessary in planting to make sure that the pollinator plants are properly distributed throughout the field. It is also essential that they produce pollen at exactly the right time. Furthermore, the tassels of the flint seed parent must be removed before they produce any pollen; otherwise part of the seed will not be crossed.

All of the ears borne on the dent pollinator plants are self bred and can not be used as crossed seed. Stock seed of both parental types is maintained in separate fields. Although seed from the pollinator plants can be used for planting the pollen producing rows in the crossing field another year, it is not advisable to use this seed for that purpose. It is practically impossible to get all of the tassels on the seed parent pulled out at the right time. In spite of careful attention some pollen will be produced. This will contaminate the pollen parent and if this seed is used continuously such mixing may destroy the type.

For all these reasons it will be appreciated that crossed corn seed costs considerably more to produce than ordinary seed. Silage corn seed as now obtained in common practice is grown in the western states from seed that may or may not have been grown in the east the year previous. Unless the stock seed is grown under proper supervision in the east and the fields grown for seed guarded against cross-pollination with unadapted varieties no dependable supply of seed corn can be maintained.

The question now before us is: does this method of producing crossed seed give sufficiently greater yields of grain and silage over an average period of years to justify the increased cost of the seed?

## CHARACTERISTICS OF CANADA-LEAMING

Using the flint type to produce the seed kernel has a distinct advantage. The plants ripen early in southern Connecticut, the grains are plump, hard, bright and dry out thoroughly, practically every year before cold weather. This insures a good quality of seed corn—a matter of prime importance with any seed. The cross-bred flint kernels germinate better and the young seedlings grow more vigorously than those of the dent type, as shown in Figure 2. Planted at the same time, in the same soil and treated exactly alike the two lots of seedlings are quite different in size within a few days after they are up. This difference is easily apparent in the field where dent corn is grown by the side of Canada-Leaming and this quick start is an advantage in permitting early cultivation, thereby getting ahead of the weeds.

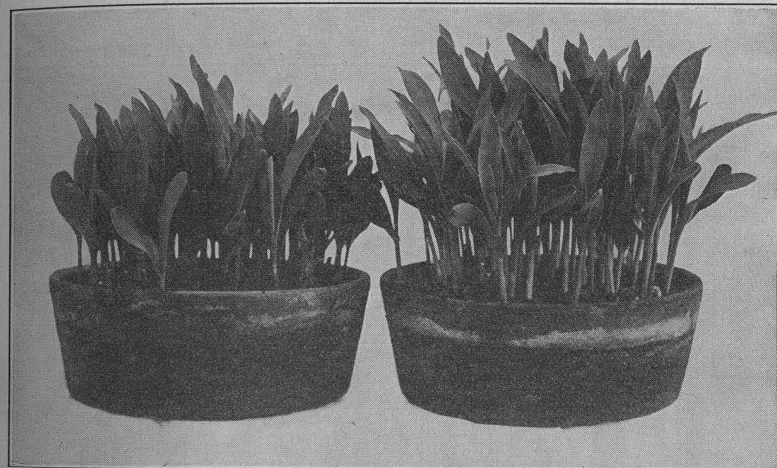
At New Haven, Canada-Leaming produces strong, sturdy stalks from 8 to 9 feet tall and usually one or more tillers. These side branches vary in size from a few inches to the height of the main stalk depending on the thickness of planting and the seasonal conditions. When planted 4 stalks to the hill with the hills 3′ by 3′ or the equivalent in drilled rows, few tillers are formed. Where the corn is grown for grain 3 stalks in the hill spaced 3.5′ by 3.5′ will give better developed ears.

Usually one large ear is produced on each stalk with many



having two or more. Very few barren stalks and nubbins are found in crossed corn where the soil and season are favorable and this is the big advantage of crossed seed based on inbred strains over ordinary seed corn.

The ears of this flint-dent combination are from 8 to 12 inches long with usually 12 rows of smooth, round kernels showing a slight indentation. They are intermediate in form between the flint and the dent kernel, but are somewhat more like the flint in hardness and texture. The kernels are not so large as the flint and are better adapted for feeding whole to poultry.



Leaming Canada-Leaming

FIG. 2. The flint type of kernel gives Canada-Leaming a quick start in the spring.

## EARLY MATURITY

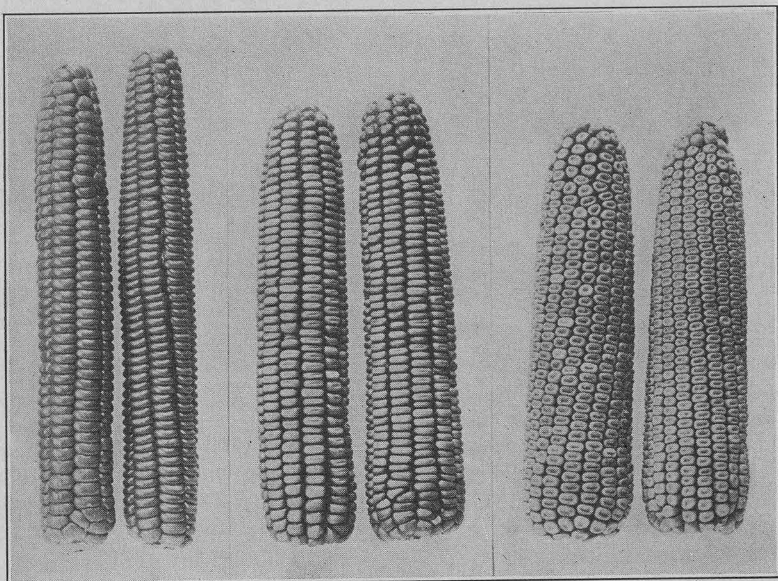
Canada-Leaming ordinarily matures for grain in about 100 to 110 days when planted the latter part of May in southern Connecticut. It often can be cut and shocked before this time and give corn that will cure properly in the crib. In maturity it is fully as early as the medium-sized flints of the Canada Yellow type although it is not as early as some of the small-eared strains of early-maturing flint corn.

## YIELD OF GRAIN

In two years trials at Mt. Carmel Canada-Leaming has yielded more dry shelled grain than any variety of flint or dent ripening within two weeks of the same time. These yields in bushels to the acre are as follows:

| | 1927 | 1928 |
|---|---|---|
| Canada-Leaming | 60.5 | 56.3 |
| Canada Yellow Flint | 44.8 | 39.6 |
| Sanford White Flint | 45.8 | 46.4 |
| Gold Nugget | ... | 47.7 |
| Century Dent | ... | 55.4 |

1928 Canada-Leaming was grown in the experiment station trials at Storrs, Connecticut, and yielded 3,430 pounds of ear corn in comparison with 2,853 pounds for Pride of the North, based on an average of six plots each.



Canada Flint Canada-Leaming Leaming Dent

FIG. 3. Canada-Leaming is the result of crossing, each year, Canada Yellow flint and Leaming dent.

In New York, Canada-Leaming was included in all of the regional tests in 1928. A report from R. D. Lewis states that, "as in 1927 it was outstanding in its performance in its maturity class. It is approximately the same maturity as, possibly a very little later than Hall's Gold Nugget, but decidedly superior to it. This is quite evident from an inspection of the summary table." The table follows:



Silage Corn Variety Test in Ten Counties in New York in 1928

| | Dry weight tons per acre | Shelled grain pounds per acre |
|---|---|---|
| Eureka | 4.30 | 251 |
| Canada-Leaming | 3.98 | 2721 |
| West Branch Sweepstakes | 3.90 | 2020 |
| Cornell No. 12 | 3.77 | 2106 |
| Cornell No. 11 (Morse) | 3.63 | 2752 |
| Golden Glow (Wis. No. 12) | 3.63 | 2565 |
| Luce's Favorite | 3.31 | 1527 |
| Leaming | 3.30 | 1352 |
| Golden Glow | 3.27 | 2273 |
| Alvord's White Cap | 3.16 | 2521 |
| Minnesota No. 13 | 2.77 | 2319 |

Reports have been received from 20 farms where Canada-Leaming was grown in 1928 and 1929 in Vermont, New Hampshire, Maine, Massachusetts and Connecticut, usually in comparison with other varieties. In all but two of these trials this crossed corn was considered to be superior in one or more respects to the corn grown in comparison with it. A few of the comments are as follows:

R. A. Burroughs, Vergennes, Vermont, 1928.—"Planted Eureka, Sweepstakes, Mammoth Yellow Flint, Burr-Leaming, Lancaster Sure Crop and Canada-Leaming this year on heavy clay with light coat of manure and 100 pounds of acid phosphate broadcast. We checked it up before harvesting about September 15 and decided that the Canada-Leaming was the best of all, well matured and eared and glazed, even though we were unable to plant it until late."

G. W. Wilder, Timber Top Farm, East Rindge, New Hampshire, 1929.—"Owing to rains, etc., we did not get the Canada-Leaming into the ground until around June 1. We got by far the best ensilage corn we have had in three years, though the season was not a good growing one. The stalks grew 10 to 12 feet high; the ears were, many of them, mature and all were in milk, though we began cutting around September 15. No one had ever seen better ensilage corn growing around here."

E. M. Brown, Waterville, Maine, 1929.—"I tried Canada-Leaming by the side of Mammoth flint. It had about 90 days to grow. Canada-Leaming had about the same fodder, more ears and was eight days earlier."

J. H. Putnam, Greenfield, Massachusetts, 1929.—"We tried out the Canada-Leaming for the second year in 1929 and found it very satisfactory. We are very much impressed with it, especially on our lower hill soils, due to the fact that it carries so large a percentage of grain."


**Fig. 4.** Canada-Leaming has strong, sturdy stalks from 8 to 9 feet tall.



Based upon its behavior in 1927, 1928 and 1929, it seems that Canada-Leaming has a useful place where an early maturing, high yielding corn of good grain quality is desired. In northern New England and northern New York, it can be grown advantageously wherever Gold Nugget, Mammoth Flint, Luce's Favorite and some of the early dents are now grown. In southern New England and in many places in New York State it can be ripened for grain and can be expected to give a larger yield and better maturity than Pride of the North, Century Dent, Canada Yellow Flint, Sanford White Flint or other varieties of a similar season.

While the production of crossed corn seed involves more care and attention to details and additional labor the process is relatively simple. It can be grown for seed only in those parts of the country where the flint type can be thoroughly matured and dried every year before cold weather. Any one interested in producing seed of Canada-Leaming corn should write to the Connecticut Agricultural Experiment Station at New Haven. Names of growers of seed will also be sent on request.

Bulletin 311 January, 1930

# TOBACCO SUBSTATION AT WINDSOR

# REPORT FOR 1929

P. J. ANDERSON, T. R. SWANBACK, O. E. STREET
AND OTHERS

ERRATUM

The figure showing the structure formula of nicotine on page 235 and similar figure for nicoteine on page 237 should be transposed.

Connecticut
Agricultural Experiment Station
New Haven

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## REPORT OF THE TOBACCO SUBSTATION FOR 1929[1]

The tobacco season of 1929 was marked, first, by exceptionally low rainfall during the growing period and, second, by the most destructive single hail storm in the history of the valley.

Rainfall for the critical months of June and July, and the less critical August, for 1929, as compared with the average of the last half century, was:

| | June | July | August |
|---|---|---|---|
| Rainfall in 1929 .......... | 1.67 | .98 | 4.87 |
| Average rainfall for 57 years | 3.09 | 4.36 | 4.39 |

More than half of the August rainfall was during the hailstorm of August 1. Thus, both the amount of rainfall and its distribution were unfavorable to production of a good crop of tobacco. The most noticeable effects of this dry season on the quality were more prominent veins and heavier leaves. The actual yield of the crop in pounds to the acre was therefore greater than would have been anticipated from a field inspection.

After the destructive hail, State Commissioner of Agriculture Buckingham made a farm to farm survey, from which we quote the following figures on the extent of the damage:

The total tobacco loss due to hail was more than $2,359,000 on the 715 farms which furnished complete information. Of this $391,000 was shade-grown tobacco, $1,750,000 was Broadleaf and $218,000 was Havana Seed (Table 1).

Table 1. Tobacco Hail Damage by Varieties

| Variety | Acres affected | Amount of damage |
|---|---|---|
| Broadleaf .......... | 6,613 | $1,749,840 |
| Shade-grown .......... | 2,438 | 391,282 |
| Havana Seed .......... | 1,045 | 218,354 |

In the case of shade-grown tobacco, the first picking and part of the second had been finished before the storm, so that the most valuable part of the crop was saved. It is estimated that, on farms within the hail area, 16 percent of the total value of the shade-grown crop was lost.

Broadleaf and Havana Seed tobacco suffered much more severely, with losses of 88 per cent and 70 per cent, respectively, of the total value of the crop. The proportion of the loss covered by insurance was so small as to be almost negligible.

[1] For bibliographical purposes all material should be credited to P. J. Anderson, T. R. Swanback and O. E. Street, unless otherwise indicated.

The storm ranged over ten towns, but the greatest devastation fell in South Windsor and East Hartford.

TABLE 2. TOBACCO HAIL DAMAGE BY TOWNS

| Town | Amount of damage |
|---|---|
| South Windsor | $907,000 |
| East Hartford | 658,000 |
| Windsor | 163,000 |
| Glastonbury | 153,000 |
| Manchester | 111,000 |
| Bloomfield | 89,000 |
| East Windsor | 86,000 |
| Simsbury | 79,000 |
| Vernon | 70,000 |
| Ellington | 43,000 |

FIGURE 5. This was a promising shade field before the hail storm.

A summary by towns of the figures made public by Commissioner Buckingham appears in Table 3.

Tobacco on all the experimental plots at Windsor was completely destroyed. All data for the year on these plots is confined to observations on growth before August 1. On the shade tobacco, however, the first three primings, 11 leaves, had been harvested and they furnished valuable information for the experiments on selection and breeding.



TABLE 3. HAIL LOSS BY TOWNS AND VARIETIES

| Town | No. farms affected | Shade-grown Per cent damage | Shade-grown Loss (dollars) | Broadleaf Per cent damage | Broadleaf Loss (dollars) | Havana seed Per cent damage | Havana seed Loss (dollars) |
|---|---|---|---|---|---|---|---|
| Bloomfield | 24 | 10 | 51,000 | 100 | 3,000 | 71 | 24,569 |
| East Hartford | 163 | 37 | 120,852 | 94 | 503,279 | 100 | 34,500 |
| East Windsor | 36 | 15 | 14,250 | 54 | 70,501 | 45 | 1,350 |
| Ellington | 15 | 10 | 17,500 | 47 | 17,343 | 60 | 8,100 |
| Glastonbury | 96 | 0 | 0 | 64 | 142,997 | 54 | 10,187 |
| Manchester | 63 | 0 | 0 | 90 | 93,524 | 96 | 16,128 |
| Simsbury | 35 | 8 | 51,460 | 70 | 2,100 | 51 | 25,298 |
| South Windsor | 235 | 75 | 52,500 | 97 | 854,975 | 0 | 0 |
| Vernon | 25 | 15 | 22,500 | 96 | 43,776 | 100 | 4,800 |
| Windsor | 90 | 13 | 51,220 | 56 | 18,345 | 68 | 93,432 |
| Total | 782 | 16 | 391,282 | 88 | 1,749,840 | 70 | 218,364 |

FIGURE 6. What the hail storm did to a good crop of Havana Seed tobacco.

One addition has been made to the scientific staff of the tobacco station. O. E. Street was appointed physiologist of the station July 1. He is engaged in biochemical investigations, in which his major study is the development of colors during the curing process.

Mention should be made here of the excellent tobacco research by members of the experiment station staff outside of the tobacco substation, and by the Connecticut Agricultural College staff:

Dr. E. M. Bailey and others of the analytical chemistry department made the numerous chemical analyses of tobacco which have been published in our reports. Their fertilizer analyses are also of inestimable value to the growers.

Dr. H. B. Vickery and Dr. G. W. Pucher have reported important progress in investigations of the nitrogenous constituents of the tobacco leaf and their transformation during the curing process.

M. F. Morgan and other members of the soils department have made notable contributions in their soil and nutrition studies on tobacco in the last five years.

Professor Davis and Professor Hendrickson of the college economics department are conducting an investigation of the economics of tobacco production and more recently Professor

FIGURE 7. Shade tobacco tent on the experiment station farm after the hail storm.

Boyd of the same department has begun a thorough study of the marketing problems of the tobacco industry.

The extension department has again contributed the part-time services of J. S. Owens in conducting curing demonstrations. There is, however, need for more extension work among the tobacco farmers.

The most important addition to the physical equipment of the tobacco substation during the year is an extensive system of lysimeters installed by the soils department. This affords means to study and measure plant food elements lost by leaching. The lysimeters have been in operation since June 1 and they are

FIGURE 8. Broadleaf after the hail storm.

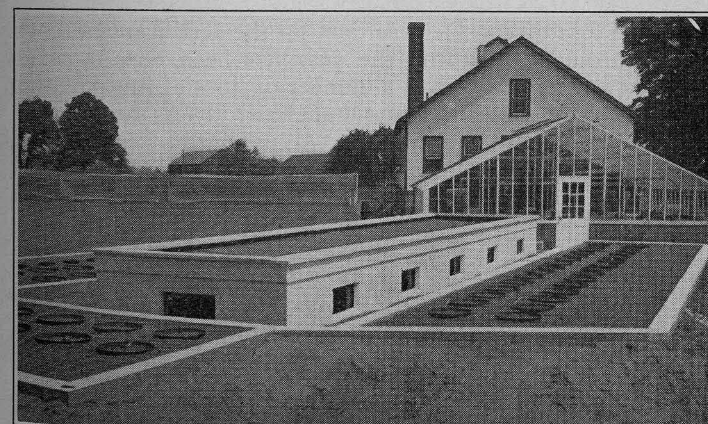


FIGURE 9. Exterior view of the lysimeters.

yielding interesting information which will be published in later reports. Illustrations are printed in Figures 9 and 10.

Other improvements are a garage and the addition of an adjacent acre for experiments.

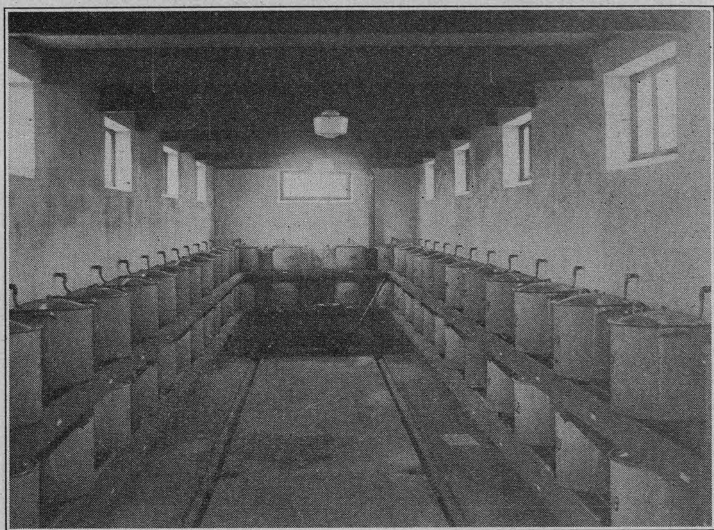


FIGURE 10. Interior of lysimeter pit.

Despite the loss of considerable data on the fertilizer and cover crop plots through the storm, the year has been one of steady improvement and of progress in a number of lines of investigation, the most important of which are summarized in this report.

## POTASH FERTILIZER EXPERIMENTS

Some observations and previously unrecorded data on the potash experiments in progress at the tobacco substation have accumulated since our last report.

### QUANTITATIVE SERIES

*Field growth.* A comparison during the 1929 growing season of the plots which had received 300 pounds, 200 pounds or 100 pounds of potash to the acre showed no marked differences in growth. However, on those plots to which no potash had been applied, except for 28 pounds to the acre in the organic fertilizer material, growth was noticeably smaller and leaves were less luxuriant. These plots never showed any acute symptoms of potash hunger, but on hot days they could be picked out readily from the others, because of their wilted and flagging leaves, a symptom which has been observed in previous seasons on the no-potash plots.

*Effect of quantity of potash on fire holding capacity of the leaves.* Samples of four grades of leaves from the plots of 1928 were force-sweated and aged until September, 1929, when strip burn tests were made in the usual manner, as described in previous reports. Results of these tests on the old series (third year of the experiment) are presented in Table 4 and a summary of the first three years is given in Table 5.

TABLE 4. OLD QUANTITATIVE POTASH SERIES ON FIELD V. STRIP BURN TESTS FOR CROP OF 1928

| Quantity of $K_2O$ applied | Plot No. | Duration of burn (seconds) Darks | Mediums | Lights | Seconds | Average for Plot | Average for Treatment |
|---|---|---|---|---|---|---|---|
| None ........... | K11 | 15 | .. | .. | 19 | 17 | 21 |
| | K11-1 | 24 | .. | .. | 26 | 25 | |
| 100 lbs. to acre .... | K12 | 48 | 39 | 44 | 49 | 45 | 41 |
| | K12-1 | 43 | 38 | 34 | 30 | 36 | |
| 200 lbs. to acre .... | K9 | 50 | 47 | 53 | 53 | 51 | 51 |
| | K9-1 | 44 | 54 | 55 | 47 | 50 | |

TABLE 5. SUMMARY OF THREE YEARS RESULTS ON THE ABOVE PLOTS

| Quantity of potash | Average burn for crop of 1926 | 1927 | 1928 | All |
|---|---|---|---|---|
| None .................. | 39 | 36 | 21 | 32 |
| 100 lbs. to acre ......... | 40 | 57 | 41 | 46 |
| 200 lbs. to acre ......... | 45 | 56 | 51 | 51 |

These data show that the fire holding capacity grows less every year on the no-potash plots. For the first year, the decline was hardly noticeable; it was very apparent for the second year and still more so the third. On the plots which had 100 pounds $K_2O$ to the acre, there was no ill effect on the fire holding capacity the first *two* years, but a decided drop in the third. The burn has been maintained throughout on the 200 pounds plots. In making these tests, it was observed that the ash on the no-potash plots was whiter than on the others. This was probably due to the increase of calcium and magnesium in the leaf when the potash content was reduced.

Similar burn tests were then made on tobacco from the more recent series of potash plots on Field I. Results of these tests (second year) are presented in Table 6. The fertilizer treatment

TABLE 6. NEW QUANTITATIVE POTASH SERIES ON FIELD I. STRIP BURN TEST FOR CROP OF 1928

| Quantity of $K_2O$ to acre | Plot No. | Duration of burn (seconds) for: Darks | Mediums | Lights | Seconds | Average for: Plot | Treatment |
|---|---|---|---|---|---|---|---|
| | K11-2 | 34 | 37 | 44 | 45 | 40 | |
| | K11-3 | 34 | 45 | 33 | 38 | 38 | |
| | K11-4 | 39 | 49 | 44 | 45 | 44 | |
| None .......... | K11-5 | 14 | 32 | 21 | 32 | 27 | 37 |
| | K12-2 | 50 | 40 | 47 | 43 | 45 | |
| 100 lbs. ......... | K12-3 | 54 | 59 | 53 | 58 | 56 | 52 |
| | K12-4 | 53 | 54 | 57 | 56 | 55 | |
| | K9-2 | 55 | 54 | 58 | 54 | 55 | |
| | K9-3 | 56 | 54 | 56 | 52 | 54 | |
| | K9-4 | 55 | 56 | 59 | 53 | 56 | |
| 200 lbs. ......... | K9-5 | 34 | 49 | 55 | 52 | 48 | 52 |
| | K9-6 | 43 | 58 | 59 | 56 | 54 | |
| | K9-7 | 53 | 53 | 48 | 49 | 51 | |
| | K9-8 | 26 | 44 | 48 | 55 | 43 | |
| | K13 | 35 | 48 | 50 | 49 | 46 | |
| | K13-1 | 41 | 40 | 56 | 46 | 46 | |
| 300 lbs. ......... | K13-2 | 44 | 52 | 57 | 51 | 51 | 51 |
| | K13-3 | 55 | 57 | 58 | 58 | 57 | |
| | K13-4 | 55 | 48 | 53 | 59 | 54 | |

of these plots is a replication of that on the older quantitative series previously mentioned, but with the addition of five plots on which 300 pounds potash to the acre were applied. As far as fire holding capacity is concerned, the results for the first two years duplicate those of the older series. That is, on the no-potash plots there is a slight decline in fire holding capacity the first year and a much more decided drop the second year. The other plots show no impairment in this respect during the first two years. Raising the rate of application to 300 pounds an acre has had no effect on the burn. Neither has this excessive quantity of potash pro-



duced any beneficial influence on the yield or quality of the crop, as was mentioned in our report for 1928.

*Influence of quantity of fertilizer potash on chemical composition of the leaves.* Sample hands of two grades (darks and seconds) from the first and second crops of the older quantitative series were analyzed by the department of chemistry to see to what extent an increased amount of fertilizer potash would influence the potash absorption of the leaf. These analyses are presented in Table 7. Since previous analyses at this station and elsewhere have shown that the quantity of other mineral bases in the leaf may also be affected by the amount of potash, calcium and magnesium were also determined.

TABLE 7. INFLUENCE OF QUANTITY OF FERTILIZER POTASH ON POTASH, LIME AND MAGNESIA IN THE LEAF

| Amount of $K_2O$ to acre in fertilizer | Plot No. | Grade | Percentage of: Potash ($K_2O$) 1926 | Ave. | Potash ($K_2O$) 1927 | Ave. | Lime (CaO) 1927 | Ave. | Magnesia (MgO) 1927 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|
| None (except 28 | K11 | D | 6.96 | 7.00 | 5.46 | | 5.33 | | 0.85 | |
| lbs. in organics) | K11 | S | 7.03 | | 4.71 | 5.46 | 7.02 | 5.74 | 1.09 | 0.94 |
| | K11-1 | D | | | 6.00 | | 4.28 | | 0.78 | |
| | K11-1 | S | | | 5.67 | | 6.33 | | 1.03 | |
| 100 lbs. total | K12 | D | 7.20 | 7.27 | 7.19 | | 4.25 | | 0.69 | |
| | K12 | S | 7.33 | | 7.18 | 7.00 | 6.00 | 5.18 | 0.93 | 0.82 |
| | K12-1 | D | | | 7.06 | | 4.42 | | 0.74 | |
| | K12-1 | S | | | 6.58 | | 6.04 | | 0.92 | |
| 200 lbs. total | K9 | D | 7.97 | 8.15 | 7.69 | | | | | |
| | K9 | S | 8.32 | | 7.97 | 7.64 | | | | |
| | K9-1 | D | | | 7.81 | | | | | |
| | K9-1 | S | | | 7.10 | | | | | |

From a study of this table we may conclude that:

1. *The percentage of potash in the leaf is materially affected by the quantity applied in the fertilizer—even though this soil contains an enormous natural reserve of potash.*
2. *The deficiency of potash in the leaf from the no-potash plots becomes more pronounced during the second year than the first.*
3. *One hundred pounds of potash to the acre in the fertilizer result in a deposit of less potash in the leaves than 200 pounds to the acre, but the deficiency during the second year is not more pronounced than during the first year.*
4. *Decrease in potash is accompanied by increase in both calcium and magnesium in the leaf. That is, the smaller the percentage of potash, the greater the percentage of calcium and magnesium (always one or both).*

In the 1927 "no-potash" samples the potash: calcium ratio was approximately 1:1. All previous analyses of tobacco from plots on the station farm have shown a ratio in which the potash figure was greater than 1.

5. *There is a general relation between fire holding capacity, as measured by the strip test, and the ratio of potash on the one side to calcium and magnesium on the other. The wider the ratio, in favor of potash, the longer the burn.*

There is, however, a danger of placing too much emphasis on this point. In the first place, it has been shown that in high-lime tobacco, the burn on the cigar is much better than the strip test would indicate, not only in duration but also in closeness of burn, aroma and taste. In the second place, too much potash may cause a dark charred ash, while an increase in calcium or magnesium will make the ash white and more porous. The optimum ratio of these mineral bases in cigar leaf tobacco has not yet been fully established.

## COMPARISON OF CARRIERS

In 1929, potash from five different carriers was compared. They were sulfate, nitrate, carbonate, tobacco stems, cottonhull ash, and various combinations of these. As far as could be judged in the field, no significant differences in the tobacco raised on these could be observed.

*Effect of different carriers on fire holding capacity.* Strip burn tests were made on the fermented samples of the 1928 crop in the same manner as mentioned above for the quantitative series. Results of the tests on the old qualitative series are presented in Table 8 and the average results for four years in Table 9. The differences in fire holding capacity are small. It may be significant, however, that during each of the four years the duration of burn for the carbonate plots has been somewhat the highest. Also, with one exception, the shortest burn has been on the sulfate plots.

TABLE 8. OLD QUALITATIVE SERIES ON FIELD V. STRIP BURN TEST FOR CROP OF 1928

| Carrier | Plot No. | Duration of burn (seconds) for: Darks | Mediums | Lights | Seconds | Average for: Plot | Treatment |
|---|---|---|---|---|---|---|---|
| Sulfate ......... | K1-2 | 51 | 50 | 49 | 47 | 49 | 46 |
| | K1-3 | 42 | 47 | 39 | 48 | 44 | |
| Carbonate ...... | K5 | 52 | 58 | 60 | 56 | 57 | 56 |
| | K5-1 | 56 | 53 | 58 | .. | 54 | |
| Nitrate ⅔ ...... | K7 | 59 | 54 | 53 | 56 | 56 | 54 |
| Carbonate ⅓ .... | K7-1 | 53 | 50 | 54 | 58 | 54 | |
| Sulfate ½ ...... | K8 | 57 | 44 | 59 | 54 | 54 | 53 |
| Carbonate ½ .... | K8-1 | 53 | 47 | 53 | 56 | 52 | |
| Sulfate ⅓ ...... Carbonate ⅓ ... Nitrate ⅓ ...... | K9 | 50 | 47 | 53 | 53 | 51 | 51 |
| | K9-1 | 44 | 54 | 55 | 47 | 50 | |



TABLE 9. OLD QUALITATIVE POTASH SERIES ON FIELD V. SUMMARY OF STRIP BURN TESTS FOR FOUR YEARS

| Carrier | Plots | Average duration of burn in: 1925 | 1926 | 1927 | 1928 | All four |
|---|---|---|---|---|---|---|
| Sulfate .......... | K1-2, K1-3 | 36 | 44 | 53 | 48 | 45 |
| Carbonate ....... | K5, K5-1 | 45 | 49 | 56 | 55 | 51 |
| Nitrate ⅔ ...... Carbonate ⅓ .... | K7, K7-1 | 43 | 41 | 53 | 54 | 48 |
| Sulfate ½ ...... Carbonate ½ .... | K8, K8-1 | 38 | 42 | 55 | 53 | 47 |
| Sulfate ⅓ ....... Carbonate ⅓ .... Nitrate ⅓ ....... | K9, K9-1 | 43 | 45 | 55 | 51 | 49 |

Results of the tests on the more recent series of potash plots on Field I, presented in Table 10, are similar to those of the older

TABLE 10. NEW QUALITATIVE POTASH SERIES ON FIELD I. STRIP BURN TESTS FOR CROP OF 1928

| Source of Potash | Plot No. | Duration of burn (seconds) for: Darks | Mediums | Lights | Seconds | Average for: Plot | Treatment |
|---|---|---|---|---|---|---|---|
| Sulfate ......... | K1-4 | 33 | 45 | 54 | 56 | 47 | 51 |
| | K1-5 | 38 | 44 | .. | 49 | 44 | |
| | K1-6 | 36 | 54 | 58 | 51 | 50 | |
| | K1-7 | 40 | .. | .. | 46 | 43 | |
| | K1-8 | 50 | 59 | 56 | 60 | 56 | |
| | K1-9 | 60 | 56 | 59 | 57 | 58 | |
| Carbonate ....... | K5-2 | 58 | .. | 60 | 54 | 57 | 54 |
| | K5-3 | 45 | 59 | 59 | 60 | 56 | |
| | K5-4 | 45 | 45 | 57 | 54 | 50 | |
| Nitrate ⅔ ..... Carbonate ⅓ .... | K7-2 | 53 | 52 | 49 | 49 | 51 | 52 |
| | K7-3 | 38 | 56 | 57 | 57 | 52 | |
| | K7-4 | 51 | 52 | .. | .. | 52 | |
| Sulfate ½ ..... Carbonate ½ .... | K8-2 | 27 | 48 | 55 | 52 | 46 | 49 |
| | K8-3 | 33 | 34 | 52 | 56 | 44 | |
| | K8-4 | 50 | 58 | 60 | 59 | 57 | |
| Sulfate ⅓ ...... Carbonate ⅓ .... Nitrate ⅓ ...... | K9-2 | 55 | 54 | 58 | 54 | 55 | 52 |
| | K9-3 | 56 | 54 | 56 | 52 | 54 | |
| | K9-4 | 55 | 56 | 59 | 53 | 56 | |
| | K9-5 | 34 | 49 | 55 | 52 | 48 | |
| | K9-6 | 43 | 58 | 59 | 56 | 54 | |
| | K9-7 | 53 | 53 | 48 | 49 | 51 | |
| | K9-8 | 26 | 44 | 48 | 55 | 43 | |
| Stems .......... | K14 | 54 | 51 | 54 | 52 | 53 | 53 |
| | K14-1 | 47 | 51 | .. | 55 | 51 | |
| | K14-2 | 54 | 57 | 51 | 56 | 54 | |

series. Again carbonate is at the top, but the differences in fire holding capacity between the treatments seem too small to be of much significance. Three plots which received all their potash in stems were included in this series. The fire holding capacity on these was as good as the others.

Summing up all the information we have obtained up to date on fire holding capacity as measured by the strip test, we may say that the differences produced by use of sulfate, carbonate, nitrate or tobacco stems or various combinations of the above are very small; possibly too small to be of consequence, if any one of the potash carriers is preferable from the standpoint of price, convenience in mixing, or the like.

*Effect of different potash carriers on chemical composition of tobacco.* Two questions occur as to the effect of different potash carriers on the composition of tobacco: First, does the leaf absorb more potash from one carrier than from another? Second, is the percentage of sulfur in the leaf increased when sulfate is used in the fertilizer? Samples of darks and seconds from the fermented crop of 1927 were analyzed by the chemistry department for sulfur and potash. As far as the amount of potash absorbed is concerned, these data, presented in Table 11, show that the differences are very small and not constant. There is no indication that tobacco will actually take up more potash from one carrier than from another.

TABLE 11. OLD QUALITATIVE POTASH SERIES. PERCENTAGE OF POTASH AND SULFUR IN CROPS OF 1926-1927

| Source of potash | Plot No. | Grade | Total sulfur (S) Crop of 1927 | Total sulfur (S) 1927 Ave. | Total sulfur (S) 1926 Ave. | Sulfate (S) 1927 | Sulfate (S) 1927 Ave. | Organic Sulfur 1927 | Potash ($K_2O$) 1927 | Potash ($K_2O$) 1927 Ave. | Potash ($K_2O$) 1926 Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sulfate | K1-2 | D | 0.50 | 0.49 | 0.57 | 0.36 | 0.36 | .14 | 7.27 | 7.83 | 8.49 |
| | K1-2 | S | 0.43 | | | 0.29 | | .14 | 7.53 | | |
| | K1-3 | D | 0.56 | | | 0.42 | | .14 | 8.13 | | |
| | K1-3 | S | 0.48 | | | 0.37 | | .11 | 8.40 | | |
| Carbonate | K5 | D | 0.43 | 0.42 | 0.46 | 0.28 | 0.28 | .15 | 7.16 | 7.60 | 8.13 |
| | K5 | S | 0.38 | | | 0.24 | | .14 | 7.65 | | |
| | K5-1 | D | 0.44 | | | 0.31 | | .13 | 7.82 | | |
| | K5-1 | S | 0.42 | | | 0.29 | | .13 | 7.76 | | |
| Nitr. ⅔, Carb. ⅓ | K7 | D | 0.45 | 0.43 | 0.43 | 0.31 | 0.29 | .14 | 7.36 | 7.80 | 8.50 |
| | K7 | S | 0.41 | | | 0.28 | | .13 | 7.85 | | |
| | K7-1 | D | 0.47 | | | 0.32 | | .15 | 7.98 | | |
| | K7-1 | S | 0.39 | | | 0.26 | | .13 | 8.02 | | |
| Sulf. ½, Carb. ½ | K8 | D | 0 47 | 0.46 | 0.52 | 0.32 | 0.33 | .15 | 7.69 | 7.82 | 8.13 |
| | K8 | S | 0.44 | | | 0.31 | | .13 | 7.67 | | |
| | K8-1 | D | 0.51 | | | 0.38 | | .13 | 7.85 | | |
| | K8-1 | S | 0.42 | | | 0.29 | | .13 | 8.08 | | |
| Sulf. ⅓, Carb. ⅓, Nitr. ⅓ | K9 | D | 0.44 | 0.45 | 0.54 | 0.31 | 0.32 | .13 | 7.69 | 7.64 | 8.15 |
| | K9 | S | 0.41 | | | 0.29 | | .12 | 7.97 | | |
| | K9-1 | D | 0.51 | | | 0.36 | | .15 | 7.81 | | |
| | K9-1 | S | 0.46 | | | 0.33 | | .13 | 7.10 | | |



The data on sulfur, however, are of more interest and importance. Sulfur occurs in two forms in the tobacco leaf. In the organic form it is a necessary constituent of the protoplasm. In the inorganic form it occurs as sulfate, probably combined mostly with potash as a base. In this latter form it is objectionable since it reduces the amount of potash which is free to combine with organic acids—it is only in the latter combination that potash promotes burn. It is therefore important to reduce as much as possible the inorganic or sulfate form. A study of the table shows first of all that the quantity of organic sulfur is remarkably constant (about .13 per cent of the dry weight of the leaf) and does not vary with the source of fertilizer potash. But the sulfate sulfur shows considerable variation, depending on the amount of this element which was applied in the fertilizer. Comparing for example the carbonate plots of 1927 with the sulfate plots of the same year, the sulfate sulfur was increased about one-third by application of sulfate of potash in the fertilizer. In other words, any sulfur which is added in the fertilizer will appear only as increased sulfate in the leaf. It is unnecessary in the development of the plant and calls for additional potash in order to keep up the burn. Although a certain small amount (.13 per cent) of sulfur is necessary to the growth of tobacco, there is no need to apply any extra sulfur in the fertilizer, since the plant will always be able to satisfy its needs from the soil sulfur or the sulfur which is unavoidably added in the organics of the fertilizer mixture.

The somewhat reduced fire holding capacity which has been found in the sulfate plots, as compared with the carbonate, is probably due to this small increase in sulfate sulfur. From the standpoint of good combustion it is probably fortunate that the ability of the tobacco plant to absorb increased quantities of sulfur is very limited. None of the analyses which have been made on Connecticut Valley tobacco show a sulfur content as high as one per cent while most of them come close to .5 per cent. In this respect, sulfur is in sharp contrast to chlorine, which the plant may absorb in large amounts, following rather regularly the quantity which has been applied to the soil.[1] Phosphorus, the third mineral acid element of the plant, acts more like sulfur. In fact, phosphorus is even more constant and it is difficult to change the percentage which occurs in the leaf, no matter how much is applied to the soil.

Jenkins, according to the report of the experiment station for 1896, page 328, found much greater differences in sulfur content between the tobacco grown with sulfate of potash and that grown

[1] In some recent Kentucky experiments (Kentucky Agricultural Experiment Station Report, **41**:17) the chlorine content of tobacco was raised from .048 per cent in unfertilized tobacco to 6.5 per cent in tobacco where 800 pounds KCl to the acre were used in the fertilizer.

with carbonate. The percentage of sulfur in the ash of the first was two to four times as much as that in the latter. This was accompanied by similar differences in fire holding capacity. Ames and Boltz (Ohio Agricultural Experiment Station Bulletin 285, page 187) also found both total sulfur and sulfate sulfur increased in the leaf when sulfate of potash was used. The same was true when other carriers of sulfur, such as superphosphate and sulfate of ammonia, were used.

Concerning increase in the sulfur content of Burley tobacco from increased application of sulfate of potash, we quote from the 1928 report of the Kentucky experiment station, page 17, "The percentage of sulfur in the tobacco increased with increasing applications of potassium sulfate, but at a much lower rate than in the case of chlorine, the range being from .4 per cent in the unfertilized tobacco to 1.187 per cent in tobacco fertilized with 800 pounds per acre of potassium sulfate."

From the consensus of data from all available sources, both in the Connecticut Valley and elsewhere, the following principles with regard to sulfur for tobacco may be regarded as thoroughly established.

1. *From a growth standpoint, the addition of sulfur in the fertilizer mixture is unnecessary.*
2. *Applications of sulfates to the soil increase the percentages of sulfates which will appear in the leaves.*
3. *Sulfates in the leaf are injurious to the burn.*

In view of these facts it is best to avoid in the fertilizer all materials containing considerable percentages of sulfur unless there should be some very distinct advantage from some other standpoint in using them.

*Effect of potash carriers on soil reaction.* This subject was discussed in some detail in the report for 1928. There remains to be added only the results on the fifth year of the series. This

TABLE 12. REACTION OF POTASH PLOTS IN 1929

| Source of potash | Plot No. | Reaction of soil | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1925 | 1929 | | | | |
| | | May 20 | May 20 | June 20 | July 2 | July 20 | August 20 |
| Sulfate ..... | K1-2 | 6.02 | 5.91 | 5.00 | 5.12 | 5.43 | 5.92 |
| | K1-3 | 5.09 | 5.06 | 4.25 | 4.32 | 4.96 | 4.76 |
| Carbonate .. | K5 | 5.53 | 5.56 | 4.83 | 4.80 | 4.98 | 5.23 |
| | K5-1 | 5.21 | 5.11 | 4.50 | 4.39 | 5.12 | 4.96 |
| Nitr. ⅔ .... | K7 | 5.31 | 5.13 | 4.43 | 4.55 | 4.92 | 5.17 |
| Carb. ⅓ ..... | K7-1 | 5.30 | 5.15 | 4.18 | 4.35 | 4.49 | 4.56 |
| Sulf. ½ .... | K8 | 5.26 | 5.32 | 4.50 | 4.60 | 4.92 | 4.93 |
| Carb. ½ .... | K8-1 | 5.10 | 5.30 | 4.25 | 4.42 | 4.76 | 4.73 |
| Sulf. ⅓ .... Carb. ⅓ .... Nitr. ⅓ .... | K9 | 5.05 | 5.21 | 4.73 | 4.71 | 5.21 | 5.07 |
| | K9-1 | 5.05 | 5.18 | 4.32 | 4.30 | 4.76 | 4.83 |



year it was thought best to determine reaction, not only immediately before and after removal of the crop, but also at several times in the growing season. The results for 1929 are presented in Table 12.

The samples of 1925 were taken before the experiment was started, immediately before application of fertilizer. The corresponding May samples for 1929 were also taken before application of fertilizers, four years after the first series of samples. Comparing these two columns it appears that the various treatments of the four intervening years have had little effect on the soil reaction.

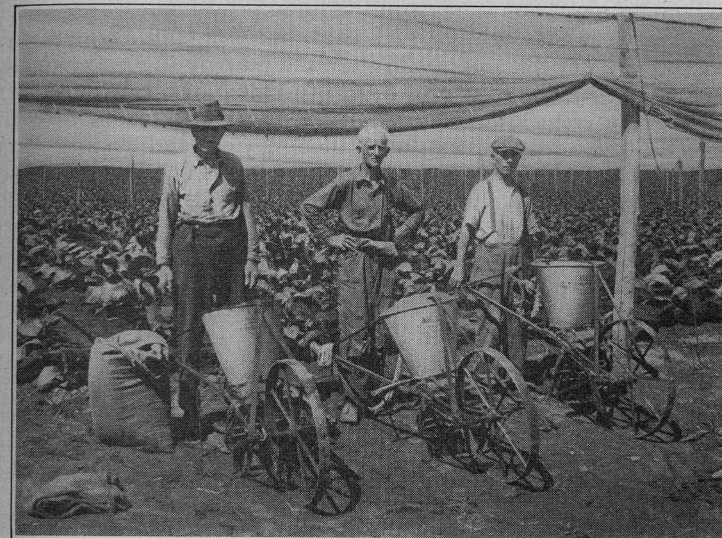


FIGURE 11. Side dressing the growing crop with wheelbarrow fertilizer sowers.

It will be noticed that during the remainder of the summer, all the plots were unusually acid, a condition which was not confined to these plots but was general throughout the state. The very dry summer following two years of heavy rainfall probably had some influence here. There was considerable variation in reaction up and down during the summer but no consistent tendency of any one treatment to make the soil more acid or less acid than the others.

We are justified in concluding, therefore, from all the results obtained through this five-year test that when sulfate, carbonate, nitrate or various combinations of them are used to supply 200 pounds of potash an acre, none of them will produce any significant change in reaction of a soil of this type.

## THE USE OF MANURE AS A SUPPLEMENT TO COMMERCIAL FERTILIZER

In previous reports of this station,[1] field tests on the value of manure when used *in addition to* the regular application of commercial fertilizer have been described. Yield and sorting records for the first three years of the experiment show that in general there has been an improvement, both in yield and percentage of better grades, from the use of either stable manure or artificial (adco) manure on our sandy soil. The improvement was greater during the wet years of 1927 and 1928, but was only slight in the comparatively dry year of 1926, the first year of the experiment.

The extremely dry season of 1929 presented an opportunity for observing the effect of annual applications of manure on growth during that type of a season, even though yield and sorting data were prevented by the hail storm. On all the manure plots, both stable and adco, the plants were badly stunted in growth and the leaves were dark green and curled under at the edges. In fact, these were the poorest plots on the farm and their strong contrast to the adjacent plots made them easy to pick out by the many observers who passed judgment. The tobacco would have been hardly worth harvesting, even if the hail had not destroyed it.

Various explanations might be advanced for this result, but at any rate it is certain that under the dry conditions of this test on a sandy soil, the accumulated organic matter did not serve to retain the water, a property frequently ascribed to it, for the use of the crop. On the plants, the symptoms were those of drought rather than of nitrogen starvation.

Different results were obtained in an experiment with shade tobacco on the S. F. Holcomb farm in West Granby. Here a heavy application of cow manure was made to alternating bents in the shade tent. On the manured bents the tobacco became taller and had a more luxuriant growth. Growth in the other bents was below the average and unsatisfactory. This was a new field, the second year in tobacco, which had been used many years for general crops. The available phosphorus was relatively low in the soil, 26 pounds phosphorus to the acre. These conditions may account for the results. In this case the commercial fertilizer was reduced to 850 pounds an acre, instead of 2300, where the manure was applied.

Despite the unfavorable results which were obtained on the station farm during the past year, other results and the experience of many growers lead us to believe that the moderate use of manure to supplement the commercial fertilizer is a good practice

[1] Tob. Sta. Bull. 10, 62. Conn. Agr. Exp. Sta. Bull. 299, 192.



wherever manure is available on the farms. Its purchase from outside sources at the high prices now commonly asked, however, is economically questionable. The shade tobacco grower may possibly be able to compensate himself for the added cost, but not the stalk grower. Manure contains a supply of all the elements which the growing plant needs, both the major three and the rarer elements. It may therefore supply a need which may be overlooked in preparing a concentrated chemical mixture. In this respect it is similar to tobacco stems. Some growers use stems and manure on alternate years and this practice seems to be sound.

When manure is used, the quantity of plant food supplied in the commercial mixture may be reduced, but not pound for pound, that is, a pound of plant food in manure does not seem to be as effective as a pound of the same element in a commercial mixture. Just how far this reduction may be carried is a matter for each grower to determine for his own type of soil. Certainly it is not economical to disregard entirely, as some do, the plant food which is added in manure.

It is generally conceded that manure alone will not produce the best results.[1] On the other hand, it is true that many fine crops of tobacco are being produced annually with no manure. Manure may be frequently beneficial, but it is not essential to the production of good tobacco.

### EFFECT OF MANURE ON SOIL ACIDITY

In order to determine what effect annual applications of manure may have on the reaction of the soil, samples from the manure plots and adjacent unmanured plots on the station farm were tested at three different times. The first of these was taken in

TABLE 13. EFFECT OF MANURE ON ACIDITY OF THE SOIL

| | pH reaction on— | | | | | |
|---|---|---|---|---|---|---|
| | May 8, 1929 | | July 3, 1929 | | October 15, 1929 | |
| Kind of manure | Manure | Check | Manure | Check | Manure | Check |
| Stable, 20 loads ....... | 5.60 | 5.27 | 5.00 | 4.75 | 5.57 | 5.27 |
| Stable, 40 loads ....... | 5.85 | 5.33 | 5.24 | 4.90 | 5.64 | 5.53 |
| Adco, 30 loads ....... | 5.59<br>5.50 | 5.25<br>5.30 | 5.15<br>5.30 | 4.63<br>4.60 | 5.77<br>5.90 | 5.24<br>5.03 |

the spring before plowing the land, one during the growing season when the crop was about half grown, and the third in the late fall of the fourth year of the test, before application of manure for the next year.

[1] This opinion has been confirmed recently by experiments in Pennsylvania. See Pa. Bull. 240, 1929. The same conclusion was expressed by Jenkins after his experiments in Poquonock more than 30 years ago. Report of Conn. Agr. Exp. Sta. for 1897, 250.

Results of the tests presented in Table 13 show that manure has invariably made the soil less acid. Since this is true for all the different times of the year, it is obvious that this is a permanent effect and not transitory. Since black rootrot is favored by an alkaline reaction of the soil, it is possible that this change in reaction may at least partly account for the greater prevalence of

FIGURE 12. The second hoeing.

this disease in fields which have been heavily manured. The greater abundance of organic matter in the soil is probably also a contributing factor.

### EFFECT OF MANURE ON THE BURN

Samples of the crop of 1928, taken from the center rows of each of the plots, were tested for fire holding capacity after sweating thoroughly and aging for a year. Results of these strip tests, presented in Table 14, indicate a slightly better burn for the manure plots. The differences, however, may be too small to be significant. Burn on all plots was so good that it is not easy to make any sharp distinction between tobacco grown with and without manure. At least we are safe in concluding that no impairment has resulted from the use of manure. These results agree rather closely with those of the Poquonock experiments of Jenkins, 1893-96. In three of the four years of that experiment, the fire holding capacity of the leaves from the manure plots was above the average of all the plots. In the fourth year it was somewhat below average (report for 1897, page 242).



In experiments in Ohio, Ames and Boltz (Ohio station Bulletin 285, 1915) also rated highly the burning qualities of tobacco from

TABLE 14. MANURE SERIES OF 1928. STRIP BURN TESTS ON SWEATED SAMPLES

| Carrier | Plot No. | Duration of burn (seconds) Darks | Mediums | Lights | Seconds | Average for Plot | Treatment |
|---|---|---|---|---|---|---|---|
| Stable, 40 loads .. | M1 | 58 | 53 | 47 | 53 | 53 | 56 |
| Stable, 20 loads .. | M1-1 | 59 | 59 | 59 | 57 | 58 | |
| Adco, 30 loads ... | M2 | 59 | 57 | 55 | 60 | 58 | 58 |
| | M2-1 | 58 | 54 | 59 | 59 | 58 | |
| No manure ...... | C3 | 58 | 54 | 54 | 57 | 56 | 53 |
| | C3-1 | 58 | 57 | 49 | 50 | 54 | |
| | C5 | 56 | .. | .. | 57 | 56 | |
| | C5-1 | 51 | 52 | 54 | 53 | 53 | |
| | C14 | 46 | 41 | 54 | 51 | 48 | |
| | C14-1 | 44 | 50 | 51 | 55 | 50 | |

the manure plots. It has been found both in Connecticut and Ohio that tobacco from those plots contains an increased percentage of chlorine, but this does not seem to have affected adversely the fire holding capacity.

# HYPER HUMUS

T. R. Swanback

Hyper Humus is a processed swamp peat residue, black and granular, consisting of decayed vegetation of past ages, which is marketed by the Hyper Humus Company of Newton, N. J. It is 80 per cent organic matter and has been used to advantage as a soil amendment for growing various crops which are benefited by increased organic matter in the soil. Since it seemed possible that tobacco also might be benefited by more organic matter in the sandy soils where it is commonly grown, some experiments with it have been made at this station. The results are here reported.

## GREENHOUSE EXPERIMENTS

Greenhouse tests were made first in an attempt to determine what quantity of Hyper Humus might be applied most profitably. For this test, four-gallon crocks were filled with common sand and Hyper Humus in the following proportions, each treatment being in duplicate:

1. No Hyper Humus added
2. 12.5% " " by volume
3. 25% " " " "
4. 25% " " " "
5. 50% " " " "

The material was well mixed with the sand, together with 0.25 gm. $CaCO_3$ for each crock.

A nutrient solution was added to the crocks, except for number 3. It had the following composition:

| | |
|---|---|
| Urea | 30 cc of 1% solution |
| Sodium acid phosphate | 24 cc " " " |
| Potassium carbonate | 40 cc " " " |
| Magnesium sulphate | 40 cc " " " |
| Traces of boron and iron. | |

Enough water was added to obtain suitable moisture. One plant was set in each and allowed to grow for about 75 days before harvesting. Weight of the plants when harvested is given in Table 15.

TABLE 15. RELATIVE GREEN WEIGHTS OF TOBACCO PLANTS IN GREENHOUSE TESTS

| Treatment and number | Green weight of 2 plants, ounces | Rel. weights of the total plant | Remarks |
|---|---|---|---|
| 1. No Hyper Humus | 3.88 | 1.00 | |
| 2. 12.5% " " | 5.26 | 1.37 | |
| 3. 25% " " | 4.88 | 1.26 | No nutrients added |
| 4. 25% " " | 6.00 | 1.52 | |
| 5. 50% " " | 8.38 | 2.16 | |



From this table it is evident that the 12.5 per cent treatment did nearly as well as the 25 per cent and was fully as good as treatment three, where no nutrients were added, but which also had 25 per cent Hyper Humus. The increased yield where Hyper Humus alone was added shows that the material either contains some available plant nutrients or may have increased the availability of those present. The benefit is more evident in the treatment with 50 per cent Hyper Humus, chemical treatment being the same as the check.

In a second test an attempt was made to determine the humus requirements for optimum growth, by using quantities of the material at closer intervals than in previous tests.

Pure silica sand, practically free from organic matter, was used in duplicate and percentages of Hyper Humus were 3, 6, 9, 12, 15, 18, 21, 24, 27 and 30 by volume. To each of the two-gallon crocks, two liters of the following nutrient solution was added.

| | |
|---|---|
| Ammonium nitrate | 0.200 gms. |
| Calcium nitrate | 1.000 " |
| Di-potassium hydrogen phosphate | 2.400 " |
| Magnesium sulfate | 1.000 " |
| Ferric citrate | 0.005 " |
| Traces of boron and manganese | |
| Water | 1,000 " |

One plant of Havana Seed tobacco was set in each crock. After a few weeks it was found that up to 21 per cent, each increase of Hyper Humus gave a corresponding increase in size of plants. They were harvested after two months. Dry weights at this time are given in Table 16.

From this experiment it appears that when pure silica sand is used, the quantity of Hyper Humus required for optimum growth lies around 21 per cent by volume, which would correspond to about 4.9 per cent of organic matter by weight.

Finally, a test was made to determine the ability of Hyper Humus to prevent or reduce leaching. Twelve two-gallon crocks were filled to a height of two inches with pure silica sand, on top of which was placed a two-inch layer of Hyper Humus. The crocks were then filled up with a mixture of common sand and station soil from a plot that had had no fertilizer treatment for a number of years, in the proportion of one to two.

Six crocks, for comparison, had a four-inch layer of silica sand at the bottom *without* a layer of Hyper Humus and were filled up with the sand-soil mixture. Nutrients were added in a dry form at the rate to the acre of:

| | | |
|---|---|---|
| 200 lbs. nitrogen | derived from | 455 lbs. potassium nitrate |
| 160 " phosphoric acid | | 300 " urea |
| 200 " potash | | 667 " sodium biphosphate |

The nutrients were thoroughly mixed into the soil and then the crocks were watered. One plant of Havana Seed tobacco was set in each crock. The plants developed about equally well in the two series. When they reached the budding stage, they were cut down in order to prevent the roots from penetrating the bottom layer

TABLE 16. DRY WEIGHTS OF TOBACCO PLANTS GROWN IN PURE SAND + VARYING QUANTITIES OF HYPER HUMUS

| Per cent Hyper Humus by volume | Approximate per cent of Hyper Humus by weights | Ounces: Whole plant, average of 2 plants | Ounces: Leaves: Leaves | Ounces: Leaves: Average of 2 plants |
|---|---|---|---|---|
| 0 | 0.0 | 1.35 | 0.45<br>0.40 | 0.43 |
| 3 | 0.7 | 2.50 | 0.50<br>0.60 | 0.55 |
| 6 | 1.4 | 3.30 | 0.70<br>0.55 | 0.63 |
| 9 | 2.1 | 3.25 | 0.55<br>0.75 | 0.65 |
| 12 | 2.8 | 3.25 | 0.70<br>0.75 | 0.73 |
| 15 | 3.5 | 3.45 | 0.70<br>0.80 | 0.75 |
| 18 | 4.2 | 3.00 | 0.70<br>0.75 | 0.73 |
| 21 | 4.9 | 4.20 | 0.80<br>0.85 | 0.83 |
| 24 | 5.6 | 4.20 | 0.75<br>0.80 | 0.80 |
| 27 | 6.3 | 3.85 | 0.85<br>0.75 | 0.80 |
| 30 | 7.0 | 3.80 | 0.80<br>0.85 | 0.83 |

of silica sand, which was not to be depleted in nutrients through absorption by the plants. Soil and Hyper Humus were removed from the crocks and the remaining silica sand was well mixed, so as to obtain composite samples from the twelve humus treated pots, as well as from the checks. On these samples, Mr. Jacobson of the soils department determined the content of nitrogen, phosphorus and potash.

The results are given below:

| | Per cent N | ppm $NO_3$ | ppm P | ppm K |
|---|---|---|---|---|
| Check (no Hyper Humus) ...... | .0139 | 21.7 | 15 | 44.22 |
| Hyper Humus treated .......... | .0187 | 20.8 | 15 | 41.41 |

It should be kept in mind that the volume of silica sand in the check pots was twice as large as that of the treatment. On this account the figures for the treatment would be cut approximately in half. The results of this test would thus indicate that Hyper Humus to an extent of 50 per cent decreases leaching of nutrients.

In another experiment, the quantity of silica sand at the bottom was equal for all treatments. Into two of them was placed a two-inch layer of Hyper Humus alone, two other crocks had a six-inch



layer of soil added and the third pair had a layer of humus and a layer of soil on top of the silica sand. An equal portion of a nitrate of soda solution was poured on the crocks containing soil. Thereafter equal amounts of water were poured on all the crocks, a procedure which was repeated a few times. Samples from the silica sand were taken, as in previous experiment, and content of nitrates was determined. The results are listed below:

| | Crock 1 | Crock 2 |
|---|---|---|
| Hyper Humus alone .......... | 37.2 ppm | 20.4 ppm |
| Soil alone .................... | 1136 " | 1107 " |
| Hyper Humus + soil .......... | 673 " | 569 " |

If the amount of nitrate present in the humus be subtracted from the nitrate content of the humus + soil treatment, it is apparent that the Hyper Humus was able to check about fifty per cent of the leaching, which is in agreement with the conclusion reached above.

## FIELD EXPERIMENTS

In 1927, plots of one-eightieth of an acre were laid out in two series, Series I on Field VII and Series II on Field VI, each including four different quantities of Hyper Humus applied to the soil, 10, 20, 30 and 40 tons to the acre. The material was spread on the plots in April and thoroughly harrowed into the soil, which also received commercial fertilizer, equally for all plots, at a rate of 250 pounds ammonia, 100 pounds phosphoric acid and 200 pounds potash to the acre. Plants on all were set early in June. During the growing season the growth in general was better on the treated plots than on plots not treated with Hyper Humus.

The tobacco was harvested early in August. Curing of the crops was very good for Series I, while some of the tobacco was damaged in the curing of the second series. Table 17 gives the sorting records for the Hyper Humus experiment of 1927.

TABLE 17. HYPER HUMUS PLOTS. SORTING RECORD FOR 1927 CROP

| | Tons Hyper Humus to acre | Yield of leaves, lbs. to acre | Percentage of grades: L | M | LS | SS | LD | DS | F | B | Grade index |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series I | None | 1062 | 7 | 5 | 14 | 10 | 31 | 6 | 16 | 11 | .346 |
| " " | 10 | 1197 | 16 | 8 | 19 | 7 | 30 | 1 | 10 | 9 | .454 |
| " " | 20 | 1121 | 10 | 6 | 21 | 6 | 31 | 4 | 12 | 10 | .403 |
| " " | 30 | 1145 | 19 | 9 | 15 | 6 | 31 | 1 | 13 | 6 | .466 |
| " " | 40 | 1227 | 16 | 7 | 21 | 7 | 30 | 2 | 11 | 6 | .460 |
| Series II | None | 1296 | 9 | 8 | 15 | 5 | 47 | 3 | 11 | 2 | .403 |
| " " | 10 | 1387 | 5 | 4 | 20 | 4 | 36 | 7 | 14 | 10 | .352 |
| " " | 20 | 1296 | 4 | 6 | 15 | 7 | 33 | 14 | 15 | 6 | .335 |
| " " | 20 | 1397 | 7 | 4 | 19 | 5 | 40 | 2 | 14 | 9 | .370 |
| " " | 30 | 1441 | 8 | 7 | 15 | 4 | 43 | 2 | 13 | 8 | .378 |
| " " | 40 | 1208 | | 4 | 14 | 7 | 32 | 10 | 16 | 17 | .284 |

The tobacco in Series I was all rated as of good quality. Yield figures and grade indexes indicate that there were no appreciable differences in results between the varying quantities of Hyper Humus, although in general the treatments all show better results than the check plots. From the results above the following summary is made:

| | | |
|---|---|---|
| Average yields without Hyper Humus .. | 1179 | lbs. to acre |
| " " with Hyper Humus .... | 1269 | " " " |
| " grade without Hyper Humus.. | .375 | |
| " " with Hyper Humus .... | .389 | |

The tests were continued in 1928. In the fall of 1927 the treated plots received the same amounts of Hyper Humus as were applied in the spring of the same year. Although the crop in the field looked rather promising, the sorting records of the cured tobacco have a very poor showing, as may be learned from Table 18.

TABLE 18. SORTING RECORDS OF HYPER HUMUS. CROP OF 1928

| | Total Hyper Humus to acre | Acre yield Plot | Acre yield Ave. | Percentage of grades L | M | LS | SS | LD | DS | F | Grade index Plot | Grade index Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Series I | None | 880 | | 1 | .. | 14 | 20 | 18 | 25 | 22 | .280 | |
| " " | 10 | 986 | | .. | .. | .. | 33 | 32 | 14 | 21 | .244 | |
| " " | 20 | 908 | | | | | 34 | 27 | 15 | 24 | .237 | |
| " " | 30[1] | | | | | | | | | | | |
| " " | 40 | 1080 | | 4 | | 13 | 27 | 24 | 17 | 15 | .320 | |
| Series II | None | 1305 | 1199 | 4 | 9 | 33 | 10 | 27 | 5 | 12 | .425 | .350 |
| " " | None | 1093 | | 7 | 4 | 20 | 13 | 33 | 8 | 15 | .275 | |
| " " | 10 | 926 | | | | 23 | 16 | 20 | 17 | 24 | .302 | |
| " " | 20 | 1051 | 1036 | 3 | | 15 | 22 | 28 | 11 | 21 | .313 | .347 |
| " " | 20 | 1020 | | 3 | 5 | 29 | 7 | 31 | 7 | 18 | .380 | |
| " " | 30 | 1312 | | | | 24 | 9 | 42 | 11 | 14 | .333 | |
| " " | 40 | 1175 | | 3 | 2 | 13 | 26 | 24 | 15 | 17 | .317 | |

Neither the yields nor the grade indexes, with two exceptions, were improved by the treatments. A summary of the results will plainly show the slight differences:

| | | |
|---|---|---|
| Average yield without Hyper Humus ........ | 1039 | lbs. to acre |
| " " with Hyper Humus ........... | 1049 | " " " |
| " grade index without Hyper Humus .. | .315 | |
| " " " with Hyper Humus .... | .312 | |

It may be mentioned that adjacent to the Hyper Humus plots in Series I was a manure plot which yielded 1069 pounds to the acre with a grade index of .319. Comparing this result with the best result in Series I, it is apparent that this treatment, now amounting to 80 tons of Hyper Humus to the acre, gave results similar to the same application of manure. This raises the question whether Hyper Humus will stand in competition with manure, economically or otherwise, in field culture of tobacco.

[1] Excluded because of error in stripping.



BURN TESTS

Burn tests were made on sweated samples of tobacco from the Hyper Humus series of the 1928 crop. The technique of these is described in previous bulletins of this station.

The results, recorded in Table 19, show that Hyper Humus in most cases had lowered the fire holding capacity, as judged by the strip test. A possible explanation to this may be the fact that Hyper Humus, contrary to ordinary peat, contains considerable lime, since it is produced from an old lake basin with calcareous sedimentation.

TABIE 19. HYPER HUMUS SERIES FOR 1928. STRIP BURN TEST ON SWEATED SAMPLES

| Tons Hyper Humus to acre | Duration of burn (seconds) Darks | Mediums | Lights | Seconds | Average |
|---|---|---|---|---|---|
| None | 58 | 54 | 54 | 57 | 56 |
| 20 | 43 | | | 53 | 48 |
| 40 | 53 | | | 59 | 56 |
| 60 | 57 | | | 54 | 56 |
| 80 | 55 | | 50 | 42 | 49 |
| None | 56 | 45 | 60 | 58 | 55 |
| None | 56 | 56 | 52 | 54 | 55 |
| 20 | 29 | | | 32 | 31 |
| 40 | | 33 | 34 | | 34 |
| 40 | 25 | | 18 | 30 | 24 |
| 60 | 58 | | | 52 | 55 |
| 80 | 48 | 22 | 23 | 22 | 29 |

SUMMARY OF SERIES I AND II

| | | |
|---|---|---|
| 20 tons of Hyper Humus .................. | 40 | sec. |
| 40 " " " " .................. | 43 | " |
| 60 " " " " .................. | 56 | " |
| 80 " " " " .................. | 39 | " |
| Average of checks (no Hyper Humus) ...... | 56 | " |
| " " Hyper Humus treatments ....... | 45 | " |

SEED BED EXPERIMENTS

Inquiry from several growers on the use of Hyper Humus for tobacco seed beds led us to undertake a test with this material on two of the station seed beds, each measuring about three and one-third square rods or 880 square feet.

In October, 1928, one ton of Hyper Humus was harrowed into each of the beds. For comparison, a third received about one ton of well decomposed horse manure. Each bed received one bag of castor pomace which was harrowed in together with the humus and the manure. The following spring it was observed that *the growth* of tobacco plants was equally good in the two treatments. Also the *soil temperature* remained the same in both.

In *pulling the plants,* it was noticed that fully as big a lump of soil stuck to the roots from humus treated beds as from the manured one. One year's result would probably not justify any recommendations but the test seems to permit the use of Hyper Humus as a substitute for manure in seed beds, especially where the latter is not readily available.

### DISCUSSION OF RESULTS

It is evident from the greenhouse experiments that addition of Hyper Humus up to a certain extent has benefited the growth of tobacco, while in the field tests the results are only slightly in favor of the material. An important difference in the experiments

FIGURE 13. Application of poison bait for killing cut worms.

is that in the greenhouse tests the humus was added to sand practically free from organic matter, while in the field the treatments were merely an addition to the organic matter already present. Ordinarily the tobacco soils in the Connecticut Valley contain from three to five per cent organic matter[1] and increasing the content in the fields where it is lower than this would probably be beneficial. Appleman,[2] investigating the effect of organic matter on soils, found that an early crop of potatoes came up sooner than did the potatoes in the control rows. This investigator also noted that the content of $CO_2$ increased in the treated rows up to 0.24 per cent, as compared with 0.058 per cent in the

[1] Conn. Tob. Substation Bull. 10, 66-71, 1927.
[2] C. O. Appleman: Percentage of Carbon Dioxide in Soil Air, Soil Science, 1927, XXIV, 241-245.



non-treated ones. The carbonic acid present in the soil would probably serve as a solvent for less available nutrients.

In order to observe to what extent organic matter had increased in the humus-treated plots, samples were taken six months after the second application from the various treatments, as well as from the checks. The content of organic matter was determined by Mr. Jacobson of the soils department. Results are given below:

| | |
|---|---|
| Average content of organic matter from check plots | 3.45% |
| " " " " " " application of 20 ton H-H | 3.67% |
| " " " " " " " " 40 " " | 4.10% |
| " " " " " " " " 60 " " | 4.63% |
| " " " " " " " " 80 " " | 4.63% |

Up to 60 tons to the acre there was a steady increase in organic matter, while further applications did not increase the content correspondingly.

In general, the addition of Hyper Humus has caused little improvement in yield. Carbonaceous material, that is, not fully decomposed plant residues, present in a soil requires for its decomposition a certain amount of nitrogen. Investigators[3] have found a distinct relation between the carbon and nitrogen contents of soils. That is, the carbon-nitrogen ratio will remain constant. Therefore, where Hyper Humus is used as a soil amendment, care should be taken to supply sufficient nitrogen to permit the biological changes in the soil, as well as the nutrition of the plants grown thereon.

Finally, it should be mentioned that the soil reaction had not changed through the addition of the various quantities of humus. Determinations were made in July, 1929, with the following results:

| | |
|---|---|
| Checks (No H-H) | 4.90 pH |
| 20 tons H-H | 4.90 " |
| 40 " " | 4.93 " |
| 60 " " | 4.85 " |
| 80 " " | 4.83 " |

[3] Sievers, F. J., and Holtz, H. F. The Significance of Nitrogen in Soil Organic Matter Relationships. Wash. Agr. Exp. Sta. Bull. 206, 1926.

# CHEMICAL COMPOSITION OF A POOR BURNING TOBACCO CROP COMPARED WITH A GOOD BURNING CROP

E. M. Bailey and P. J. Anderson

It is well known to leaf dealers and manufacturers that crops of certain years do not burn well, while those of other years are distinguished by their excellent burning qualities. This difference has also been observed in the burn tests which have been made on the crops of the different years at the experiment station. The crop of 1924 had an extremely low fire holding capacity, coaled badly on the cigar and had a bitter taste. The crop of 1927, in contrast, had an unusually long fire holding capacity and good burning qualities on the cigar. In our report for 1928, it was pointed out that the fire holding capacity of our crops has shown a general correlation with the rainfall of the season during which they were grown. Thus the poor burning crop of 1924 was grown in an extremely dry season and the good burning crop of 1927 during a season of high rainfall. This same correlation between rainfall and burn has been observed in Pennsylvania by Haley, Nassett and Olson.[1]

There are two ways in which a season might affect the leaf; it might change its chemical composition, or it might change the mechanical structure of the leaf. In order to see how the season affects the chemical composition, tobacco from the two contrasting crops of 1924 and 1927 was analyzed by the analytical chemistry department. Samples were taken from plots which had the same fertilizer treatment for the two years, as well as during the intervening years. This included six plots of the old potash series and six plots from the lime series. Two grades, darks, D, and seconds, S, were selected for analyses. Some of the samples from the 1924 crop were not available because they had been used up in previous tests.

Results of the analyses are presented in Table 20.

This table shows that there were considerable and consistent differences in content of potash, chlorine, nitrogen and calcium and smaller differences in magnesium and phosphorus.

*Potash.* During the wet year the potash content was consistently higher, in the old potash series, than during the dry year. In the lime series, however, the potash content had been greatly reduced by yearly applications of lime. Morgan, Anderson and Dorsey[2] have shown that this reduction in potash content consistently follows application of lime and also on these same plots the fire holding capacity was correspondingly reduced. Haley, Nassett and Olson found that the potash content of tobacco leaves is higher during seasons of heavy rainfall. In view of the well known influence of potash in promoting burn, it seems likely that this was a contributing factor in making the 1927 crop burn better than the 1924 crop.

[1] Plant Physiology, 1928, III, 185-197.
[2] Conn. Agr. Exp. Sta. Bull. 306, 1929.



*Chlorine.* In the dry year crop of 1924, the chlorine content of the leaves was from two to ten times as great as in the 1927 crop. Perhaps no one element is more deleterious to burn than chlorine. It is therefore probable that this was a second contributing factor to the poor burn of the 1924 crop. Since chlorine salts are very readily leached from the soil, it is to be expected that during the wet year, any chlorine which was in the fertilizer would be quickly carried away, while during the dry year the chlorine salts would be absorbed by the roots of the plants.

*Calcium.* This element was consistently higher in the 1924 crop. According to the explanation offered by Haley, Nassett and Olson, calcium in the soil complex is replaced by potassium when potash salts are applied in fertilizer. This results in the accumulation of calcium salts in the surface soil. Heavy rains leach them down, but in a dry season they remain and are absorbed by the tobacco roots, which results in a more abundant deposit of calcium salts in the leaves.

In previous articles we have presented abundant data to show the retarding influence of lime on the fire holding capacity of tobacco as measured by the strip test. This apparently has been due to magnesium rather than calcium. Calcium salts are not known to improve the fire holding capacity, but on the other hand, there is little conclusive evidence that they hinder it.

*Magnesium.* Only the plots K1, K1-1, K3, T1b and T2b give us a true comparison of the magnesia content in dry and wet years. These show that more magnesia was deposited in the leaves in a dry year. The explanation of this is probably the same as for calcium. Plots K2 and K2-1 received annual applications of sulfate of potash magnesia and the high magnesia content of the later year may be due to accumulation of that element through the intervening years. Plots T1a and T2a and T3a received yearly application of magnesia in limestone and as a result the 1927 crop showed the highest percentage of magnesia of any of the samples tested. Comparison of these figures with the K2, K2-1 figures for the same year shows that dolomitic limestone is more effective than double manure salts in introducing magnesia into the leaves wherever such a result is desired.

In previous reports we have shown that magnesia has a decided influence in reducing the fire holding capacity of tobacco. Garner also finds that all magnesium salts are injurious to burn. Like the calcium salts, however, they make the ash white.

The greater abundance of magnesium in the leaf during a dry year is probably another contributing factor to poor burn.

*Nitrogen.* The most striking contrast shown by the analyses is in the nitrogen content. In every comparison without exception nitrogen is higher in the tobacco of the dry year. This applies not only to total nitrogen but also to every form of nitrogen. All the forms of nitrogen, with the exception of nitrates, are considered injurious to burn of tobacco. Any beneficial influence of the small amount of nitrate was probably more than counterbalanced by the quantity of the other nitrogenous compounds. The higher nicotine content may account for the bitter taste of the 1924 crop and the greater abundance of albuminous compounds for its poor aroma. The high nitrogen content of the leaf in a dry year is probably due to accumulation of nitrates in the surface soil—without leaching—and to retarded growth which prevents proper dilution in the plant.

*Phosphorus.* Phosphoric acid content was consistently higher in the dry year. The explanation is not obvious. Phosphates are injurious to fire holding capacity.

*Sulfur.* Total sulfur was also somewhat higher in the dry year. The apparent exceptions shown in the tobacco from plots K2 and K2-1 are due to the larger quantity of sulfur supplied yearly to these plots in double manure salts. The same differences in sulfur content were shown in the crop of 1926[1] on these plots. The injurious effect of sulfur on burn is discussed in another section of this report.

*Manganese* was consistently higher in the dry year. The apparent exceptions in plot T1b are due to the heavy annual applications of sulfate of ammonia to this plot. This made the soil more acid. It has been shown in previous reports of this station that a more acid soil results in increased manganese in the leaf. This same fact probably explains the increase of manganese during the dry year of 1924 in the other plots, that is, the soil is naturally more acid during a dry year. No data are available on the effect of increased manganese on the burn.

*Silica, iron and alumina* were all consistently more abundant in the leaves in the wet year. All three are probably inert as far as burn is concerned.

## ALKALINITY OF THE WATER SOLUBLE ASH[2]

As long ago as 1870, Schloesing[3] showed that there is in general a direct relation between the alkalinity of the water soluble constituents of a tobacco ash and its fire holding capacity. Alkalinity

[1] Conn. Agr. Exp. Sta. Bull. 299, 157.
[2] Determined according to Methods of Analysis, Asso. Off. Agr. Chemists, Edition 1925, page 180, sections 9, 12 and 13. Two grams of material used.
[3] Schloesing, Th. Uber die Verbrennlichkeit des Tobaks. Journ. F. prak chemie, LXXXI, 143-150.



TABLE 20. COMPOSITION OF CROP OF 1924 (POOR BURN) COMPARED WITH CROP OF 1927 (GOOD BURN), MOISTURE FREE BASIS

| Plot | Grade | Treatment | | Total ash 1924 | Total ash 1927 | $SiO_2$ 1924 | $SiO_2$ 1927 | $Fe_2O_3$ + $Al_2O_3$ 1924 | $Fe_2O_3$ + $Al_2O_3$ 1927 | CaO 1924 | CaO 1927 | MgO 1924 | MgO 1927 | $Mn_3O_4$ 1924 | $Mn_3O_4$ 1927 | $K_2O$ 1924 | $K_2O$ 1927 | $P_2O_5$ 1924 | $P_2O_5$ 1927 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Potash Series* | | | | | | | | | | | | | | | | | |
| K1 | D | All K in H. G. sulfate | | 26.18 | 25.33 | 2.45 | 3.65 | 0.42 | 0.43 | 5.16 | 4.47 | 1.35 | 0.58 | 0.16 | 0.10 | 8.08 | 8.00 | 1.01 | 0.78 |
| K1 | S | | | | 31.40 | | 5.50 | | 0.76 | | 5.59 | | 0.75 | | 0.15 | | 9.26 | | 0.72 |
| K2 | D | All K in double manure salts | | 25.76 | 25.84 | 2.46 | 3.84 | 0.33 | 0.49 | 4.86 | 3.88 | 1.44 | 1.22 | 0.16 | 0.12 | 7.80 | 8.43 | 0.99 | 0.76 |
| K2 | S | | | 28.23 | 30.84 | 3.36 | 6.63 | 0.40 | 0.89 | 5.63 | 4.42 | 1.63 | 1.71 | 0.16 | 0.16 | 7.97 | 8.84 | 0.87 | 0.65 |
| K3 | D | Half and half | | 26.46 | 26.41 | 3.02 | 4.51 | 0.31 | 0.45 | 5.03 | 4.17 | 1.36 | 0.99 | 0.11 | 0.09 | 7.93 | 8.00 | 0.92 | 0.84 |
| K3 | S | | | | 31.58 | | 7.85 | | 0.88 | | 4.96 | | 1.20 | | 0.13 | | 8.39 | | 0.68 |
| K1-1 | D | All K in H. G. sulfate | | 26.41 | 24.97 | 2.86 | 3.53 | 0.38 | 0.35 | 5.17 | 4.08 | 1.36 | 1.04 | 0.16 | 0.06 | 7.88 | 8.31 | 1.05 | 0.79 |
| K1-1 | S | | | | 32.26 | | 8.07 | | 0.87 | | 4.91 | | 0.87 | | 0.13 | | 8.81 | | 0.64 |
| K2-1 | D | All K in double manure salts | | 25.68 | 26.73 | 2.76 | 4.28 | 0.37 | 0.47 | 4.98 | 3.99 | 1.31 | 1.81 | 0.13 | 0.12 | 7.48 | 8.24 | 0.92 | 0.74 |
| K2-1 | S | | | 28.87 | 32.33 | 3.90 | 8.37 | 0.39 | 0.98 | 5.91 | 4.55 | 1.60 | 1.62 | 0.14 | 0.11 | 7.83 | 8.33 | 0.76 | 0.60 |
| K3-1 | D | Half and half | | | 25.39 | | 3.77 | | 0.38 | | 4.23 | | 1.09 | | 0.05 | | 7.89 | | 0.76 |
| K3-1 | S | | | | 30.66 | | 7.40 | | 0.73 | | 5.23 | | 1.43 | | 0.08 | | 7.59 | | 0.54 |
| | | *Lime Series* | | | | | | | | | | | | | | | | | |
| T1a | D | Acid fertilizer | With lime | 25.78 | 23.81 | 2.27 | 5.48 | 0.24 | 0.48 | 6.17 | 4.30 | 1.12 | 2.93 | 0.08 | tr. | 6.81 | 4.66 | 0.97 | 0.60 |
| T1a | S | | | | 28.17 | | 9.12 | | 0.83 | | 4.65 | | 3.91 | | tr. | | 3.89 | | 0.58 |
| T1b | D | | Without lime | 26.01 | 25.08 | 3.72 | 3.84 | 0.38 | 0.39 | 4.53 | 4.96 | 1.15 | 0.76 | 0.15 | 0.24 | 7.66 | 7.04 | 1.02 | 0.77 |
| T1b | S | | | 28.15 | 29.67 | 3.89 | 7.16 | 0.40 | 0.81 | 6.15 | 5.73 | 1.21 | 0.78 | 0.13 | 0.34 | 7.08 | 7.01 | 0.96 | 0.71 |
| T2a | D | Alkaline fertilizer | With lime | 25.46 | 22.85 | 2.65 | 3.90 | 0.22 | 0.24 | 5.87 | 4.21 | 1.08 | 2.35 | 0.02 | 0.00 | 6.82 | 5.51 | 0.89 | 0.61 |
| T2a | S | | | | 28.05 | | 7.12 | | 0.41 | | 4.91 | | 2.73 | | 0.00 | | 5.62 | | 0.48 |
| T2b | D | | Without lime | 25.29 | 24.28 | 2.52 | 3.66 | 0.33 | 0.52 | 5.77 | 4.76 | 1.06 | 0.70 | 0.04 | 0.02 | 6.90 | 7.11 | 0.96 | 0.68 |
| T2b | S | | | | 30.60 | | 8.62 | | 0.96 | | 4.96 | | 0.66 | | 0.02 | | 7.32 | | 0.58 |
| T3a | D | Neutral fertilizer | With lime | | 22.01 | | 3.17 | | 0.18 | | 4.19 | | 3.21 | | tr. | | 5.03 | | 0.53 |
| T3a | S | | | 29.39 | 25.73 | 3.99 | 6.60 | 0.38 | 0.41 | 7.87 | 4.49 | 1.33 | 4.23 | 0.02 | 0.00 | 5.99 | 4.24 | 0.62 | 0.42 |
| T3b | D | | Without lime | | 23.57 | | 3.23 | | 0.31 | | 4.57 | | 0.94 | | 0.02 | | 6.88 | | 0.67 |
| T3b | S | | | | 30.26 | | 8.97 | | 1.02 | | 5.62 | | 1.22 | | 0.03 | | 5.96 | | 0.40 |

TABLE 20. COMPOSITION OF CROP OF 1924 (POOR BURN) COMPARED WITH CROP OF 1927 (GOOD BURN), MOISTURE FREE BASIS (Continued)

| Plot | Grade | Treatment | | Cl 1924 | Cl 1927 | S (total) 1924 | S (total) 1927 | N (total) 1924 | N (total) 1927 | N (as $NH_3$) 1924 | N (as $NH_3$) 1927 | N (as $NO_3$) 1924 | N (as $NO_3$) 1927 | N in (nicotine) 1924 | N in (nicotine) 1927 | Nicotine 1924 | Nicotine 1927 | Alkalinity of water soluble ash 1924 | Alkalinity of water soluble ash 1927 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Potash Series* | | | | | | | | | | | | | | | | | |
| K1 | D | All K in H. G. sulfate | | 0.61 | 0.43 | 0.86 | 0.73 | 4.79 | 4.00 | 0.47 | 0.24 | 0.62 | 0.37 | 0.37 | 0.29 | 2.17 | 1.69 | 94.8 | 108.0 |
| K1 | S | | | | 0.37 | | 0.76 | | 3.09 | | 0.06 | | 0.62 | | 0.15 | | 0.86 | | 129.8 |
| K2 | D | All K in double manure salts | | 0.54 | 0.27 | 0.93 | 0.86 | 4.64 | 3.82 | 0.45 | 0.19 | 0.36 | 0.13 | 0.39 | 0.29 | 2.23 | 1.69 | 91.0 | 109.0 |
| K2 | S | | | 0.50 | 0.18 | 0.79 | 0.83 | 5.10 | 3.05 | 0.34 | 0.13 | 0.62 | 0.52 | 0.38 | 0.17 | 2.19 | 0.97 | 100.0 | 124.5 |
| K3 | D | Half and half | | 0.59 | 0.21 | 0.82 | 0.79 | 4.65 | 3.67 | 0.43 | 0.15 | 0.39 | 0.17 | 0.41 | 0.20 | 2.40 | 1.17 | 90.5 | 111.0 |
| K3 | S | | | | 0.15 | | 0.73 | | 2.70 | | 0.08 | | 0.39 | | 0.12 | | 0.67 | | 125.4 |
| K1-1 | D | All K in H. G. sulfate | | 0.65 | 0.26 | 0.83 | 0.76 | 4.70 | 3.75 | 0.52 | 0.24 | 0.84 | 0.17 | 0.43 | 0.36 | 2.46 | 2.09 | 91.0 | 114.3 |
| K1-1 | S | | | | 0.15 | | 0.68 | | 2.45 | | 0.09 | | 0.21 | | 0.17 | | 0.98 | | 137.0 |
| K2-1 | D | All K in double manure salts | | 0.53 | 0.27 | 0.89 | 0.96 | 4.55 | 3.47 | 0.45 | 0.19 | 0.52 | 0.35 | 0.45 | 0.27 | 2.58 | 1.54 | 89.5 | 105.5 |
| K2-1 | S | | | 0.44 | 0.14 | 0.74 | 0.82 | 3.76 | 2.44 | 0.31 | 0.13 | 0.77 | 0.30 | 0.35 | 0.16 | 2.00 | 0.91 | 102.0 | 115.5 |
| K3-1 | D | Half and half | | | 0.25 | | 0.79 | | 3.73 | | 0.30 | | 0.26 | | 0.38 | | 2.20 | | 108.5 |
| K3-1 | S | | | | 0.15 | | 0.59 | | 2.37 | | 0.13 | | 0.22 | | 0.20 | | 1.18 | | 116.5 |
| | | *Lime Series* | | | | | | | | | | | | | | | | | |
| T1a | D | Acid fertilizer | With lime | 0.48 | 0.04 | 0.74 | 0.58 | 5.10 | 2.67 | 0.56 | 0.25 | 0.52 | 0.00 | 0.48 | 0.41 | 2.80 | 2.37 | | |
| T1a | S | | | | 0.04 | | 0.55 | | 2.18 | | 0.21 | | 0.00 | | 0.35 | | 2.02 | | |
| T1b | D | | Without lime | 0.51 | 0.09 | 1.03 | 0.78 | 5.37 | 3.74 | 0.63 | 0.27 | 0.83 | 0.26 | 0.40 | 0.36 | 2.34 | 2.06 | | |
| T1b | S | | | 0.41 | 0.04 | 0.79 | 0.69 | 4.47 | 2.80 | 0.45 | 0.15 | 0.75 | 0.13 | 0.39 | 0.23 | 2.24 | 1.34 | | |
| T2a | D | Alkaline fertilizer | With lime | 0.50 | 0.04 | 0.51 | 0.45 | 4.78 | 2.76 | 0.49 | 0.24 | 0.64 | 0.00 | 0.45 | 0.35 | 2.62 | 2.00 | | |
| T2a | S | | | | 0.09 | | 0.45 | | 2.08 | | 0.09 | | 0.00 | | 0.23 | | 1.34 | | |
| T2b | D | | Without lime | 0.47 | 0.28 | 0.54 | 0.47 | 4.89 | 3.38 | 0.52 | 0.26 | 0.62 | 0.09 | 0.49 | 0.39 | 2.82 | 2.27 | | |
| T2b | S | | | | 0.42 | | 0.42 | | 2.36 | | 0.13 | | 0.13 | | 0.25 | | 1.47 | | |
| T3a | D | Neutral fertilizer | With lime | | 0.04 | | 0.37 | | 2.83 | | 0.28 | | 0.04 | | 0.43 | | 2.46 | | |
| T3a | S | | | 0.47 | 0.22 | 0.42 | 0.34 | 3.81 | 1.97 | 0.30 | 0.22 | 0.86 | 0.00 | 0.47 | 0.35 | 2.71 | 2.03 | | |
| T3b | D | | Without lime | | 0.04 | | 0.53 | | 3.34 | | 0.26 | | 0.09 | | 0.39 | | 2.24 | | |
| T3b | S | | | | 0.04 | | 0.39 | | 2.09 | | 0.17 | | 0.00 | | 0.24 | | 1.41 | | |



of the ash solution is due almost entirely to the carbonate of potash which it contains; that is, the more carbonate, the more alkaline the solution. The leaf does not contain carbonate of potash, but when it is burned, potash salts of the organic acids, malate, citrate, and others in the leaf, are oxidized to carbonate. The inorganic potash salts, sulfate, chloride and phosphate, are not changed. Hence the alkalinity of the ash solution is a measure of the quantity of organic potash salts which the leaf contains, and, as has been frequently pointed out, the more organic potash salts, the better the burn.

In the good burning crop of 1927, the increased percentage of potash and reduced percentage of sulfate, chlorine and phosphate would indicate that more of the potash was combined with the organic acids than in the poor burning crop of 1924. In order to see whether this relationship is further indicated by the alkalinity of the water soluble ash, and to determine the parallelism between this factor and the fire holding capacity of the leaf, the analyses recorded in the last two columns of Table 20 were made.

These figures show that in every case the results are as would be anticipated; that is, the alkalinity of the good burning 1927 crop is uniformly much higher than that of the poor burning crop of 1924. Also it is of interest to note that the alkalinity of the seconds, usually the best burning leaves, is in every case higher than that of the darks from the same plot.

Alkalinity of the soluble ash thus appears in this comparison to be a good index to fire holding capacity.

# CHEMICAL INVESTIGATIONS OF TOBACCO[1]

By Hubert Bradford Vickery and George W. Pucher

In spite of the great economic importance of the tobacco plant, there is not available sufficient accurate information on the nature of the various chemical compounds that are present in the green leaf or the changes which they undergo during the curing and fermentation processes. The identification of these compounds and a study of the reactions by which they are formed and in which they play a part is of fundamental importance for the understanding of the metabolism of the plant and may lead to improved methods for the production and use of the tobacco plant.

Although a plant tissue contains a complex mixture of substances, it is possible to classify these substances into groups the members of which have certain common characteristics. For practical reasons we have selected as our first point of attack the large and complex group of compounds that contain nitrogen.

The nitrogenous compounds of the tobacco plant may be divided, as a matter of convenience, into those that are soluble in hot water and those that are insoluble. It is this first group of compounds upon which our experimental work is being concentrated at the present time. This fraction contains volatile and non-volatile bases, nitrates, amides and amino acids, purines, and probably many other substances of less well-known types. As a first step in the elaborate series of operations that must be carried out before any single substance can be isolated and identified, accurate methods of chemical analysis must be developed so that the various details of the manipulations may be followed quantitatively. The analysis of tobacco extracts presents such unusual difficulties that new or considerably modified methods, even for the determination of the most commonly occurring nitrogenous substances, must be devised.

The presence of nicotine, a base almost as volatile as ammonia, in tobacco extracts has made it necessary to develop a special technique for the determination of ammonia nitrogen and of amide nitrogen. The methods hitherto used are elaborate and tedious, involving uncertain corrections for the nicotine present. Our method takes advantage of a curious property of permutit, a synthetic silicate, which, at the proper reaction, undergoes selective

[1] The chemical investigations of tobacco herein described were carried out as part of a general project under the title "Cell Chemistry," by the Department of Biochemistry of the Connecticut Agricultural Experiment Station, New Haven, Conn. The Department has enjoyed the benefit of close coöperation from the Tobacco Substation. The expenses were shared by the Connecticut Agricultural Experiment Station and the Carnegie Institution of Washington, D. C.



quantitative base exchange with ammonia in the presence of other volatile bases such as nicotine and trimethylamine, thereby removing the ammonia from the solution. The ammonia so taken up may be quantitatively released by adjusting the reaction and then estimated colorimetrically by Nessler's solution. The figures thus obtained represent the actual ammonia content of the extracts analyzed and corrections for nicotine or other amines are not required. The presence of nicotine and ammonia has also made it advisable to develop a modification of the Jones method for the determination of nitrates that are usually present in the extract. This modification enables us to determine the nitrate content of tobacco with considerable accuracy.

The presence of nitrates in tobacco plant extracts makes it necessary to employ special methods for the determination of total nitrogen in them. We have confirmed the observations of Ranker (1)[1] that the well-known and widely used salicylic acid-zinc method, when applied to aqueous extracts, gives inaccurate results and this observation has compelled us to develop a method that can be applied to aqueous solutions. The results of this investigation are being prepared for publication at the present time.

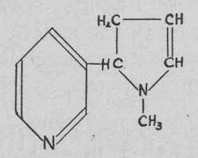
It may also be mentioned here that evidence has been accumulated which indicates that the determination of peptide nitrogen by the methods generally used may be erroneous when tobacco samples containing large quantities of nitrates are analyzed.

Each method of analysis must be studied in detail in order to ascertain whether the data obtained have significant value when the method is applied to tobacco extracts.

## THE BASES OF TOBACCO EXTRACTS.

### a. NICOTINE.

Nicotine is the chief volatile alkaloid of the tobacco plant.




Structure formula of nicotine.

This substance has received a great deal of attention from tobacco investigators. Nevertheless, in spite of a vast accumulation of data, there is still no real explanation of the source of nicotine in the plant nor more than speculation concerning its function.

[1] Numbers in parentheses refer to bibliography on page 245.

The amount of nicotine present in the tobacco leaf varies over a wide range depending upon the age, species and method of cultivation. The relationship between the age of the plant and its content of nicotine is extremely interesting. Thus it has been shown by Smirnov (2) that nicotine constantly increases during the life period of the plant. This investigator believes that nicotine represents a passive substance in the metabolism and that the quantity present may serve as an index of the age of the plant.

Pictet (3, 4) has suggested that nicotine may be formed during the growth of the plant from decomposition of the complex nitrogenous constituents, such as protein, nucleic acids, chlorophyll, etc., in the tissues. Mothes (5), however, has taken exception to this view and advanced experimental evidence to show that nicotine is not derived from the breakdown of protein. This investigator concluded that: 1. Nicotine is not a reserve material for nitrogen metabolism. 2. Nicotine synthesis takes place where there is active growth and is influenced neither by light nor by the introduction of outside sources of nitrogen. 3. The quantity of nicotine synthesized is not proportional to the size of the leaves. 4. There is no relationship between the amount of protein and the amount of nicotine synthesized.

Garner (6) has suggested that nicotine is present in the tobacco leaf in two forms, the one combined with organic acids of the leaf and the other free, or very loosely combined. The "free" nicotine has been correlated with the flavor of tobacco, a high proportion being, in part at least, responsible for the harsh and disagreeable taste sometimes observed. In view of this the determination of the proportion of "free" nicotine may be of importance in judging the quality of tobacco.

Nicotine is an organic base and can combine with one or with two equivalents of acid. The extent to which combination takes place varies with the hydrogen ion concentration of the solution. The hydrogen ion concentration of an extract of tobacco depends upon the relative proportions of the soluble basic and acidic substances derived from the leaf: the extent of hydrolysis of the salts of nicotine contained in such an extract will determine the fraction of the total nicotine which is present as "free" nicotine. The well-known equation

$$pH = pK + \log \frac{[\text{free base}]}{[\text{salt of base}]}$$

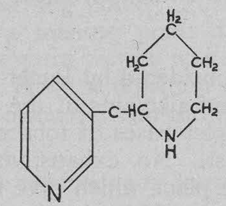
shows that the degree of hydrolysis, represented by the last term, depends only on the reaction of the solution and the dissociation constant of the base. Once the magnitude of the dissociation constant of nicotine has been determined, a curve can be constructed from which the proportion of the nicotine present in the "free" form in a sample of tobacco can be read directly at the point corresponding to the hydrogen ion concentration of an aqueous



extract of the sample. The dissociation constants of nicotine have therefore been determined (7) and a curve showing the relation between the degree of hydrolysis and the hydrogen ion concentration has been constructed. This curve permits an accurate and simple evaluation of the "free" nicotine of tobacco samples, since a determination of the hydrogen ion concentration only is required. This is most conveniently accomplished by the quinhydrone electrode.

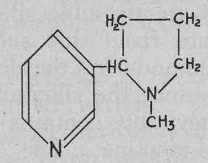
### b. ALKALOIDS OTHER THAN NICOTINE IN TOBACCO EXTRACTS.

Pictet and Rotschy (8) first demonstrated that there are a number of bases that possess properties allied to those of nicotine present in tobacco extracts. Of these, nicotimine, a liquid isomeric with nicotine, is volatile with steam. The formula proposed by Pictet and Rotschy represents this substance as 2-piperidyl-3 pyridine. The correctness of this formula was not, however, conclusively proved.




Nicotimine.

Two other bases isolated by Pictet and Rotschy were not volatile with steam. Nicoteine, a liquid, was assigned a formula

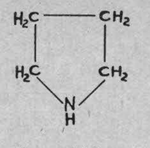



Nicoteine.

which represents a reduced form of nicotine. Nicotelline was isolated as a crystalline solid. No structure has been assigned to it.

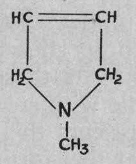
Noga (9) some years ago described two substances isolated from tobacco as new alkaloids to which he gave the names isonicoteine and nicotoine. The experimental evidence for the existence of these substances is not entirely convincing.

In addition to the alkaloids that have been mentioned, Pictet and Court (4) isolated from cured tobacco small amounts of the simple nitrogenous bases, pyrrolidine,



Pyrrolidine.

and N-methyl pyrroline.



N-methyl Pyrroline

These substances were considered by Pictet as probable precursors of nicotine and the related alkaloids of the tobacco plant.

The alkaloids and simpler bases of tobacco are of great interest to the plant physiologist. No exhaustive investigation of the metabolic changes in the plant which give rise to their formation has ever been published, although the problem is of much importance.

It is clear from this discussion of the work of Pictet that a steam distillate obtained from an alkaline extract of tobacco may contain other substances in addition to nicotine. One, at least, of these substances is an alkaloid that behaves in a manner similar to nicotine, that is, it forms an insoluble silicotungstate and picrate and is difficult to separate from this substance. It is evident, therefore, that existing methods for the determination of nicotine in tobacco are not exact, since the silicotungstate precipitate prepared in the usual way inevitably contains any other volatile alkaloid similar in structure to nicotine. The "nicotine" determination on the steam distillate of a tobacco sample therefore gives values that represent the sum of the nicotine and the other volatile base or bases that are precipitated by silicotungstic acid. Inasmuch as the other volatile bases make up only a small part of the whole, the complexity of the precipitate is not of great significance in practical work, but this fact must be recognized in any detailed study of the chemistry of the tobacco plant.

A rough idea of the amount of the substances other than nicotine that are precipitated by silicotungstic acid from the steam volatile fraction of extracts of cured tobacco leaves was secured from the following data. A steam distillate that contained 63.0 gm. of



nicotine as determined by silicotungstic acid precipitation was subjected to a careful examination by fractional crystallization of the picrates of the alkaloids. The equivalent of 58.0 gm. of nicotine was obtained as picrate and 4.1 gm. of other alkaloids, likewise as picrates, were found. Thus at least 6.5 per cent of the "nicotine" indicated by the silicotungstic acid method actually represents volatile bases other than nicotine. These are minimum values since losses occurred in the manipulations.

From the bases other than nicotine, 0.6 gm. of a base was isolated that reacted with nitrous acid and with benzoyl chloride in the manner described by Pictet and Rotschy for nicotimine. This material gave a beautifully crystalline dipicrate much more soluble than nicotine dipicrate and quite different from it in appearance. The decomposition point was 179.5-180.5° C. (uncorr.), whereas nicotine dipicrate decomposes at 218-220° C. (uncorr.). Pictet described his preparation as an oily picrate that melted at 163°C. Our preparation, perhaps due to its greater degree of purity, had a higher melting point. In the crude form it yielded an oily picrate with a melting point around 170-175°C. The nitrogen content of the pure picrate was 18.29 per cent, while the nitrogen calculated for nicotine dipicrate was 18.06 per cent. The substance is therefore isomeric with nicotine.

#### C. THE ABSENCE OF NICOTINE IN MATURED TOBACCO SEEDS

In order to gain some insight into the formation of nicotine in the plant, a quantitative comparison of the nicotine content of ungerminated and germinated tobacco seed was carried out. This study was undertaken to establish definitely the presence or absence of volatile bases of a complexity comparable to that of nicotine in matured tobacco seed and also to discover whether seeds germinated entirely without outside sources of food were capable of producing nicotine.

In regard to the occurrence of nicotine in tobacco seed, the literature is at considerable variance. Thus Scurti and Perciabasco (10), Paris (11), Bernardini (12), Chaze (13), and Ilyin (14) maintain that there is no nicotine in tobacco seed. On the other hand, Albo (15), Ciamician and Ravenna (16), and Klein and Herndlhofer (17) claim to have demonstrated the presence of this alkaloid in the seed. None of the investigators who have claimed that nicotine is present in tobacco seed have attempted to isolate this substance and thus conclusively establish their contention.

Little information regarding the amounts of nicotine present in very young tobacco plants has been published and, as far as we have found, no one has reported the isolation of this alkaloid from such material. Chuard and Mellet (18) reported no nicotine in 20 day old plants, while in plants at 50 days the leaves contained

0.33 per cent and the roots 0.15 per cent. Chaze (13) demonstrated the presence of nicotine in 1 mm. plants by a histochemical technique with Bouchart's reagent. Paris also states that germinating seed contains a small quantity of nicotine.

a. *Experiment 1.* 20 gm. finely ground seed of Cuban shade tobacco were suspended in water, an excess of sodium hydroxide was added and the material was distilled with steam into N/10 hydrochloric acid until 2 liters of distillate had been collected. The distillate was concentrated at a reaction of pH 4.0 *in vacuo* to a volume of 50 cc. On the addition of silicotungstic acid no precipitate was formed.

b. *Experiment 2.* 100 gm. of seed of Connecticut Havana tobacco were extracted three times with boiling water. The extract was concentrated *in vacuo* to a volume of 200 cc. and 100 cc. of this extract (50 gm. seed) were distilled at alkaline reaction with steam into acid and the distillate was concentrated to 50 cc. On the addition of silicotungstic acid no precipitate was obtained. Several other experiments on different batches of seed were carried out with similar negative results.

According to Rasmussen (19) silicotungstic acid will give a detectable precipitate with nicotine in a dilution of 1 : 300,000. Since, in Experiment 2, a distillate from 50 gm. of seed gave no precipitate with silicotungstic acid, it may be concluded that matured tobacco seed contains only undetectable traces of nicotine, confirming the recent experimental work of Ilyin. This investigator found that immature seeds contain some nicotine (substances precipitable with silicotungstic acid) which progressively diminishes until complete disappearance at full maturity. This observation probably explains the conflicting views in the literature on the occurrence of nicotine in tobacco seeds, since some of the investigators may have been dealing with mixtures of immature and mature seeds.

#### d. THE ISOLATION OF NICOTINE FROM 9-11 DAY GERMINATED TOBACCO SEED

*Preparation of Material.* Seed of Cuban shade tobacco which showed 90 per cent germination and contained no nicotine was germinated in the dark on blotters for from 9-11 days until a growth of about 2-3 cm. was obtained. The seedlings were then removed from the blotters and, after weighing, were transferred immediately to a closed vessel containing chloroform. The material was held in an atmosphere of chloroform for 2-3 hours and then spread out on shallow pans and dried overnight at 60-70° C. The dry material could be separated by means of sieves into two parts. The separation was not perfect, but two fractions were obtained, one of which contained the greater part of the cotyledon and hypocotyl, and the other chiefly the seed coats and ungerminated seeds.



*Preparation of Extracts.* Samples of these two fractions and also of the original seed each weighing 100 gm. were extracted three times by boiling with ten times their weight of distilled water. The aqueous extracts were concentrated *in vacuo* and made to a definite volume for subsequent analyses. They are referred to in what follows as the hypocotyl-cotyledon extract, the seed coat extract, and the seed extract.

*Isolation of Nicotine from the Hypocotyl-Cotyledon Extract.* 100 cc. of the water extract of the cotyledons and hypocotyls, equivalent to 19 gm. dry substance, were concentrated *in vacuo* to a thick sirup after the addition of 5 cc. 2N hydrochloric acid. The sirup, after the addition of an excess of sodium hydroxide, was distilled with steam, with the constant addition of a little butyl alcohol to prevent foaming, into an excess of hydrochloric acid until about 1000 cc. of aqueous distillate had been collected. The distillate was concentrated *in vacuo* to 25 cc., was made alkaline with sodium hydroxide and extracted with ether. After *cautious* evaporation of the ether 30 mg. of a light yellow oil with the characteristic odor of crude nicotine remained. The oil was dissolved in 5-10 cc. of water and poured into 25 cc. of a saturated aqueous solution of picric acid. A voluminous yellow precipitate immediately formed and 50-60 cc. of boiling water were required to effect its complete solution. When the solution was cooled characteristic needles of nicotine dipicrate separated. These were filtered off, washed with water and alcohol and dried. The crystals sintered at 218° and decomposed at 220-221° C. After recrystallization from water the decomposition point was raised to 224-225° C., and a mixture of this material with a sample of pure nicotine dipicrate showed no depression of the decomposition point.

It is therefore clear that nicotine is present in the sprouts and cotyledons of tobacco seed after only 9-11 days of germination. It is also evident that nicotine can be synthesized by the plant from the reserve of food material in the seed at a very early stage of growth and, unless one is prepared to admit that atmospheric nitrogen enters into the reaction, that outside sources of nitrogen are not called upon at this stage for the synthesis. These experiments strikingly confirm the work of Mothes (5), who found that nicotine synthesis takes place during the early growth of the plant.

### NITROGEN DISTRIBUTION IN GERMINATED AND UNGERMINATED SEED

In view of the demonstration that nicotine is synthesized by the germinating plant from its own reserve of food material it was interesting to investigate the distribution of the nicotine nitrogen as well as the other forms of nitrogen in the extracts of the germinated and ungerminated seed. These data are presented here in detail since only a limited number of analyses of tobacco seed before and during the early stages of germination are recorded in the literature. Paris (10) records an incomplete analysis of mature tobacco seeds. Ilyin (14), whose paper was received during the preparation of this bulletin, presents analyses of some of the nitrogenous constituents of three types of oriental tobacco seed. Ilyin also studied the distribution of nitrogen in these seeds at germination intervals of 5-15 days. However, no similar data have been recorded, as far as we are aware, on the type of tobacco seed used in these investigations. For comparative purposes the averages of the figures obtained by Ilyin are appended to the data presented in Tables 21 and 22. Our analyses were performed on the three extracts whose preparation has already been described. Duplicate determinations were made in all cases by the following methods:

TABLE 21. ANALYSIS OF UNGERMINATED AND GERMINATED SEED IN PER CENT OF DRY WEIGHT

| | Ungerminated seed | Ungerminated oriental tobacco seed[1] Ilyin (14) | Germinated seed: Seed coat | Germinated seed: Cotyledons Hypocotyls | Germinated oriental tobacco seed[1] Ilyin (14) |
|---|---|---|---|---|---|
| | % | % | % | % | % |
| *Total Insoluble Solids* | **80.40** | .... | **88.51** | **77.80** | .... |
| Insoluble inorganic | 1.32 | .... | 2.64 | 2.21 | .... |
| Insoluble organic | 79.08 | .... | 85.87 | 75.59 | .... |
| *Total Soluble Solids* | **19.60** | .... | **11.49** | **22.20** | .... |
| Soluble inorganic | 2.59 | .... | 1.32 | 3.35 | .... |
| Soluble organic | 17.01 | .... | 10.17 | 18.85 | .... |
| Reducing substances (as glucose) | 0.00 | .... | 2.60 | 8.09 | .... |
| *Total Nitrogen* | **4.06** | **4.02** | **3.96** | **5.56** | **4.78** |
| Insoluble nitrogen (chiefly protein) | 3.46 | 3.87 | 3.39 | 4.15 | 3.94 |
| *Soluble Nitrogen* | **0.60** | 0.15 | **0.57** | **1.41** | 0.84 |
| Ammonia nitrogen | 0.02 | .... | 0.06 | 0.13 | 0.13 |
| Nitrate nitrogen | 0.03 | .... | 0.00 | 0.00 | .... |
| Amide nitrogen | 0.06 | .... | 0.04 | 0.10 | 0.27 |
| Nicotine nitrogen | 0.00 | 0.001 | 0.01 | 0.05 | 0.05 |
| Unknown volatile base nitrogen | 0.01 | .... | 0.03 | 0.04 | .... |
| α amino nitrogen | 0.09 | .... | 0.15 | 0.43 | 0.43 |
| Peptide nitrogen | 0.13 | .... | 0.04 | 0.02 | .... |
| *Other nitrogen* (unknown forms) | 0.26 | .... | 0.24 | 0.64 | .... |
| Basic nitrogen | 0.11 | .... | 0.06 | 0.20 | .... |
| Non-basic nitrogen | 0.29 | .... | 0.29 | 0.64 | .... |
| *Reaction of Extract* (pH) | **6.72** | .... | **5.82** | **5.23** | .... |

Total nitrogen—Kjeldahl.
Ammonia nitrogen—Colorimetric with permutit, see Vickery and Pucher (20).



Nitrate nitrogen—Modification of Jones method, see Vickery and Pucher (21).
Amide nitrogen—Method, see Vickery and Pucher (20).
Nicotine—Silicotungstic acid method (22).
Unknown volatile bases—Total volatile base nitrogen by titration minus nicotine nitrogen minus ammonia nitrogen.
α amino nitrogen—Van Slyke method (23).
Peptide nitrogen—Hydrolysis of extract with 8N sulphuric acid and determination of increase of α amino nitrogen by Van Slyke method.
Basic nitrogen—Nitrogen in phosphotungstic acid precipitate of hydrolyzed extract according to Osborne and Harris (24).
pH—Quinhydrone electrode.

Table 21 presents the data obtained upon germinated and ungerminated seeds calculated to per cent of the dry material.

TABLE 22. DISTRIBUTION OF THE NITROGEN IN UNGERMINATED AND GERMINATED SEED

| | Total soluble nitrogen: Ungerminated seed | Total soluble nitrogen: Germinated seed, Seed coat | Total soluble nitrogen: Germinated seed, Cotyledons Hypocotyls | Total soluble and insoluble nitrogen: Ungerminated seed | Total soluble and insoluble nitrogen: Germinated seed, Seed coat | Total soluble and insoluble nitrogen: Germinated seed, Cotyledons Hypocotyls |
|---|---|---|---|---|---|---|
| | % | % | % | % | % | % |
| Ammonia nitrogen | 3.33 | 10.53 | 9.22 | 0.49 | 1.52 | 2.34 |
| Nitrate nitrogen | 5.00 | 0.00 | 0.00 | 0.74 | 0.00 | 0.00 |
| Amide nitrogen | 10.00 | 7.02 | 7.08 | 1.48 | 1.01 | 1.80 |
| Nicotine nitrogen | 0.00 | 1.76 | 3.54 | 0.00 | 0.25 | 0.90 |
| Unknown volatile base nitrogen | 1.67 | 5.27 | 2.84 | 0.25 | 0.76 | 0.72 |
| α amino nitrogen | 15.00 | 26.30 | 30.5 | 2.22 | 3.78 | 7.73 |
| Peptide nitrogen | 21.7 | 7.02 | 1.42 | 3.20 | 1.01 | 0.36 |
| Other nitrogen (unknown forms) | 43.3 | 42.1 | 45.4 | 6.41 | 6.06 | 11.51 |
| Total soluble nitrogen | | | | 14.79 | 14.39 | 25.36 |
| Insoluble nitrogen (chiefly protein) | | | | 85.21 | 85.61 | 74.64 |
| Basic nitrogen | 18.3 | 10.5 | 14.2 | 2.71 | 1.52 | 3.60 |
| Non-basic nitrogen | 48.4 | 50.8 | 45.4 | 7.15 | 7.33 | 11.51 |

It will be observed that the aqueous extract of ungerminated seed is less acid than that from the germinated material.

In Table 22, the proportions of the different forms of nitrogen have been recalculated as percentages of the total soluble nitrogen and of the total nitrogen respectively. These figures show that about 3.5 per cent of the soluble nitrogen, equivalent to 0.90 per cent of the total nitrogen of the cotyledons and hypocotyls, and about 1.8 per cent of the soluble nitrogen, equivalent to 0.25 per cent of the total nitrogen of the seed coat, is nicotine. These

[1] Average of 10-11 day germination in the dark.

figures agree in order of magnitude with those of Ilyin, who obtained about 1 per cent of the total nitrogen as nicotine at the same period of germination. During the germination, as would be expected, there is a marked increase in total soluble nitrogen, but the data indicate that the ungerminated seed is relatively higher in amide nitrogen than the germinated material. The nitrate present in seed disappears during germination.

The cotyledons and hypocotyls contained 8 per cent of reducing sugar, as estimated by the Benedict method. Glucosazone equivalent to 3.3 per cent of sugar expressed as glucose was obtained by direct isolation. Thus only about 41 per cent of the total reducing substances are represented by glucose (or fructose). The remaining reducing substances may consist of other carbohydrates or of substances of unknown nature.

### THE OCCURRENCE OF NITRATE NITROGEN IN TOBACCO

It is stated in the literature that tobacco contains nitrate. The quantities generally reported are, however, small. In the course of our work certain samples of tobacco were encountered which contained unusually high proportions of nitrate. In view of this a brief study was made of some of the factors that contribute to the high nitrate content of tobacco. Experiments were also conducted with the object of demonstrating conclusively that the substance which is estimated as nitrate by indirect methods actually is this substance.

TABLE 23. VARIATIONS IN NITRATE CONTENT OF GREEN TOBACCO GROWN UNDER DIFFERENT CONDITIONS

| | | Nitrate N / Total N | Nitrate N / Total soluble N | Nitrate N / Dry weight |
|---|---|---|---|---|
| | | % | % | % |
| No. 1 | Nitrogen starved | 0.0[1] | 0.0 | 0.00 |
| No. 2 | $KNO_3$ fertilizer | 14.7 | 45.0 | 0.72 |
| No. 3 | Organic fertilizer | 23.2 | 53.0 | 1.19 |

The data reported in Table 23 show the extremes of the variation in the nitrate content of the tobacco samples we investigated. These samples were grown in the hothouse and differed only in the type and quantity of nitrogenous fertilizer received. The plants in Experiment 1 received no fertilizer; they were dwarfed and the leaves were yellow in color. In Experiment 2 the plants received daily as much potassium nitrate solution as they would endure. Growth was abundant and the plants were normal in appearance. The plants in Experiment 3 received their nitrogen in the organic form from castor pomace and cotton seed meal. Here also normal growth was obtained. Aqueous extracts of the leaves of all of these plants were prepared and analyzed.

[1] Negative diphenylamine reaction.



These data indicate that the nitrate nitrogen may vary from zero to 23 per cent of the total nitrogen or from zero to 50 per cent of the total soluble nitrogen of the plant. From samples 2 and 3 nitron nitrate equivalent in amount to more than 90 per cent of the indicated nitrate content was isolated in the crystalline form.

Wide variations in the proportions of nitrate nitrogen may also occur in tobacco plants grown under field conditions. The data in Table 24 represent analyses of dried cured samples of 1927 field crops grown on plots with different sources of nitrogenous fertilizers.

TABLE 24. VARIATIONS IN NITRATE CONTENT OF CURED TOBACCO GROWN UNDER DIFFERENT CONDITIONS

| | Nitrate N / Total N | Nitrate N / Dry weight |
|---|---|---|
| | % | % |
| No fertilizer | 3.54 | 0.113 |
| Sodium nitrate | 3.54 | 0.093 |
| Castor pomace | 4.92 | 0.121 |
| Calcium nitrate | 7.64 | 0.213 |
| Cotton seed meal | 9.27 | 0.296 |
| Urea | 16.21 | 0.598 |
| Ammonium sulphate | 19.48 | 0.779 |

The nature of the fertilizer employed exerts considerable influence upon the proportion of nitrate in the cured tobacco. The low values obtained with sodium nitrate fertilization are unquestionably due to the fact that 1927 was a very rainy season and soluble salts, such as sodium nitrate, were leached from the soil before maximum storage in the plant could take place. The highest values were obtained with ammonium sulphate. This material is not readily leached out of the soil and consequently the plants had a continuous available source of nitrogen. It is evident from both Table 23 and 24 that the nitrate nitrogen found in tobacco may vary over a wide range, depending upon the rainfall during the growing season as well as upon the type of nitrogenous fertilization employed.

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## FIELD EXPERIMENTS ON BROWN ROOTROT[1]

**H. F. Murwin,[2] G. P. Clinton and P. J. Anderson**

During the seasons of 1925, 26, 27 and 28, field experiments on brown rootrot were conducted on a badly infected acre of tobacco land on the farm of T. F. Connor of Poquonock. No previous report of these experiments has been made. Although, in general, the results only confirm those which have been obtained in other sections, notably Massachusetts and Wisconsin, nevertheless it seems worth while to publish them as confirmatory evidence and also for the information of Connecticut growers who may not have access to publications from other states on this subject.

### OCCURRENCE AND SYMPTOMS

Brown rootrot occurs wherever tobacco is grown in New England, as well as in at least the majority of the tobacco growing sections of America. The disease is not new. Within the last fifteen years experiment station workers have studied and applied this new name to a stunted and uneven condition of tobacco crops which were planted on sod land or after certain other crops which appear to have an adverse effect on a following tobacco crop. That such an after effect existed has been known for generations.

The most readily observed symptom of the trouble above ground in the field is stunted growth. In the majority of instances the field is not affected throughout, but only in patches of irregular sizes and shape. This gives the field a non-uniform appearance. In places the tobacco appears normal in size, while in others it hangs back and appears to stop growing altogether. During hot days, plants in affected spots wilt more quickly. Affected plants do not die, but look unhealthy and stunted. From the symptoms above ground, a case of brown rootrot cannot be distinguished from black rootrot or various troubles caused by unfavorable soil conditions.

The only certain diagnostic character of the disease is the presence of dead roots of a brown color, the number of which depends on how severely the crop is affected. Roots of all sizes may be attacked. With the continuous dying of its roots the plant is stimulated to the production of an abnormally larger number

[1] Coöperative investigations between the Bureau of Plant Industry, U. S. D. A., and the Conn. Agr. Exp. Sta.

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of smaller roots which also continue to die, resulting in the production of a brush-like tuft of brown roots at the bottom of the stalk. Roots above the brush are likely to be larger and not so much affected. When the roots are washed and examined closely, it will be found that in the early stages of infection, a root will show brown dead areas or lesions, while the remaining portions of the root may be still white and healthy.

These root symptoms are the only ones by which the disease can be identified and when it is recalled that the natural color of any dead tobacco root almost irrespective of the agent which killed it, is brown, it is easy to understand why there has been so much uncertainty in its diagnosis and so much confusion and diversity of opinion as to its cause.

### CAUSE

Various causes of brown rootrot have been suggested and most of them supported by a certain amount of evidence. A review of the evidence for and against each would add nothing to the present discussion and will therefore not be attempted. This much is, however, certain:

1. It has not been shown that any organism, parasitic or saprophytic, is the cause.
2. There is abundant evidence that a preceding crop may cause it. But there is no considerable uniformity of opinion as to how the preceding crop operates to produce such a result.
3. Certain fertilizers, soil amendments or toxins have been shown to produce brown dead roots on tobacco plants under certain conditions, but it is not at all sure that this is the same trouble which is commonly observed in the field. In fact it is not at all certain that there is one single cause of brown rootrot. There may be a number of agents, any one of which may produce brown rootrot under the right conditions.
4. All soils do not react alike to the same causal agents, that is, on some soils it seems to be possible to produce a perfectly normal crop on sod land, while in adjacent fields the results may be failure. The same difference may be seen in spots of the same field, even where previous treatment of the whole field was the same.

### PLAN AND PURPOSE OF THE EXPERIMENT

The field experiments at Poquonock were undertaken with the object of determining further the effect of preceding crops and of other cultural practices on the development and on the prevention of brown rootrot. Specifically the questions for which an answer was sought were:



1. *Do certain preceding crops cause rootrot? Will the omission of these crops cure the trouble?*
2. *What effect has manure on rootrot?*
3. *What is the effect of lime?*
4. *Will fallowing be a benefit to affected land?*
5. *Will an acid fertilizer have any effect on rootrot?*
6. *Is the disease affected by the time of plowing the land?*
7. *Can it be cured by sterilization of the soil?*

The field was divided into one twentieth acre plots. All treatments were in duplicate and the figures presented in the tables

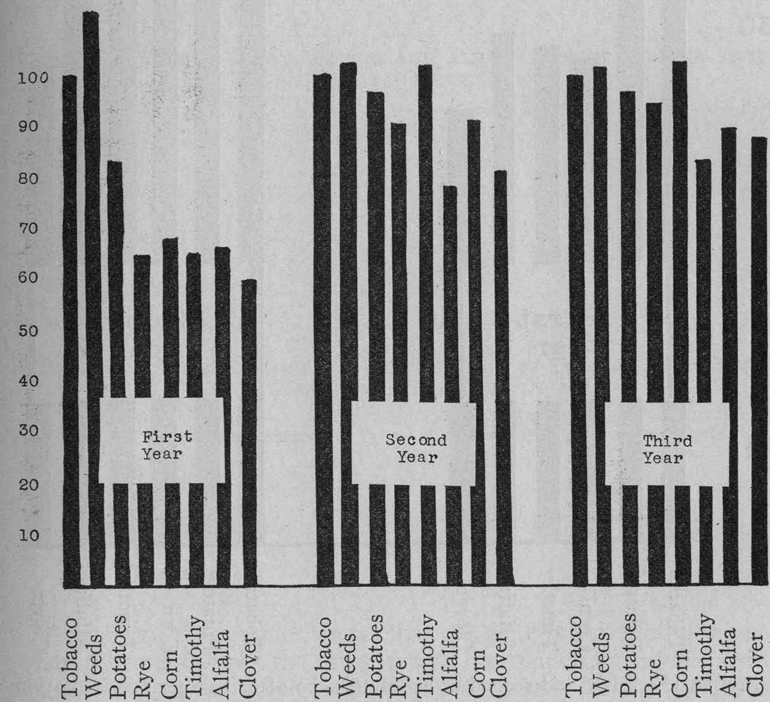


FIGURE 14. First, second and third crops of tobacco after one year of rotation crop (tobacco after tobacco = 100).

below represent the average yield of the two, calculated to an acre basis. Although the tobacco was sorted and percentages of grades recorded, they are not presented here, because in this investigation we are dealing more with yield than with quality. Results were judged first on the basis of yield and secondly from examination of roots for the symptoms of disease.

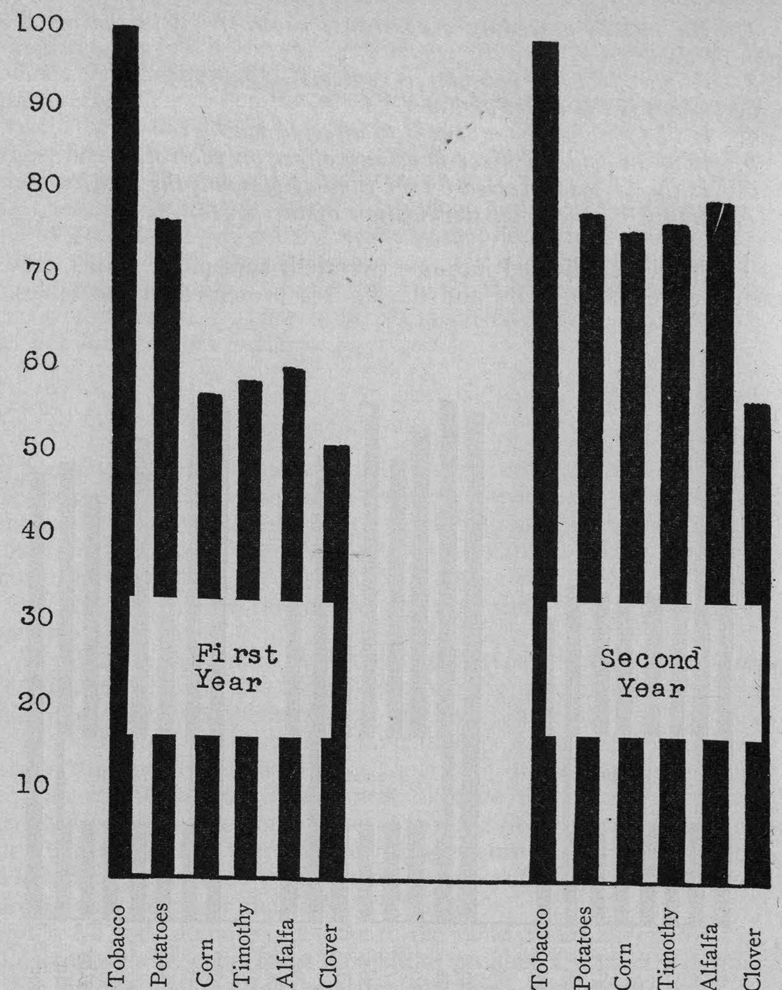


FIGURE 15. First and second crops of tobacco after two years of rotation crop.

## EFFECT OF PRECEDING CROPS

In 1925 the following crops were grown on duplicate plots:

1. Potatoes.
2. Corn.
3. Timothy.
4. Alfalfa (with nurse crop of oats).
5. Clover (with nurse crop of oats).



6. Rye. This crop had been grown in 1924 but was not harvested. Old straw rotted on ground in 1925 and self seeded.
7. Weeds. Plowed, then left to grow up in natural weed vegetation during 1925.

In 1926 one-half of each plot was set to tobacco, and the alternating crop repeated on the other half.

In 1927 and 1928 tobacco was raised on all plots.

This arrangement afforded an opportunity to measure the result of either one year or two years of each crop and also to get the after effects during the next two years. Yields under these different conditions are shown in Tables 25 and 26 and graphically in Figures 14 and 15.

TABLE 25. YIELD OF FIRST, SECOND AND THIRD CROPS OF TOBACCO AFTER ONE YEAR OF OTHER CROPS

| Preceding crop | Pounds to acre: First crop 1926 | Second crop 1927 | Third crop 1928 |
|---|---|---|---|
| Tobacco | 1181 | 1110 | 1167 |
| Timothy | 765 | 860 | 974 |
| Corn | 798 | 1146 | 1198 |
| Alfalfa and oat | 787 | 1017 | 1050 |
| Clover and oat | 709 | 915 | 1031 |
| Potatoes | 979 | 1071 | 1133 |
| Rye | 765 | 1013 | 1111 |
| Weeds | 1327 | 1138 | 1179 |

TABLE 26. YIELD OF FIRST AND SECOND CROPS OF TOBACCO AFTER TWO YEARS OF OTHER CROPS

| Preceding crop | Pounds to acre: First year 1927 | Second year 1928 |
|---|---|---|
| Tobacco | 1110 | 1167 |
| Timothy | 665 | 891 |
| Corn | 628 | 885 |
| Alfalfa and oats | 669 | 932 |
| Clover and oats | 561 | 767 |
| Potatoes | 852 | 893 |

A study of these tables shows that the yield is materially reduced when tobacco follows the other crops, the reduction in yield being somewhat greater when following two years of the preceding crop. The forage crops, timothy, alfalfa, clover and corn are particularly injurious. Potatoes cause less reduction than the forage crops. Plowing under a crop of rye straw from the second preceding year has had the same injurious effect as the forage crops. The best results were obtained by abandoning the field to natural weed growth for a year.

Decided recovery was observed in the second tobacco crop after the forage crop, complete recovery in the case of corn. This recovery was more pronounced during the third year but was not yet complete for all of them.

Roots from each plot were washed and examined for disease immediately after harvest each year. When the root condition of the different plots was tabulated and compared with the yields, there was found to be a fairly constant relation, which was, the more severe the root lesions, the smaller the yield. From this, it is safe to conclude that the low yields are due to brown rootrot and that the weight of cured tobacco is a measure of the percentage of infection on the roots.

### CONTINUOUS TOBACCO

The first year of this experiment, 1925, was a good growing season and yields on adjacent fields were high, yet, on the check plots of this field the average yield to the acre was only 860 pounds and the roots were found to be badly diseased. The increased yields of the following years (Table 25) and the root examinations show that there was a decided recovery when tobacco was grown continuously on the same plots. There may be an objection that the yields of 1926, '27 and '28 on all the plots were too low for profitable tobacco growing. This was largely due, however, to unfavorable weather conditions. On account of excessive rainfall, the crops of 1927 and 1928 were unusually light throughout this section. A severe hail storm in 1927 further reduced the yield of that year. This field was set to tobacco again in 1929 and although no yield records were taken, observations indicated that the crop on the whole was about normal.

These results agree with those obtained in other states, showing that the continuous growing of tobacco on the same land reduces brown rootrot damage.

### FALL PLOWING

Two plots were plowed in the fall and only disked in the spring. Two others were plowed in both fall and spring. Yields on these plots were as follows:

| | 1926 | 1927 |
|---|---|---|
| Plowed only in fall | 1181 | 1103 |
| Plowed fall and spring | 1181 | 1117 |

These figures do not indicate that plowing in both fall and spring produces any better results than fall plowing only.

### MANURE

Two plots had an application of manure at the rate of 20 tons to the acre in the spring of 1925, 1926 and 1927. This was in addition to the regular application of commercial fertilizer. Yields on these plots as compared with no manure plots were:

| | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|
| Manure | 1219 | 1361 | 1247 | 1191 |
| No manure | 860 | 1181 | 1110 | 1167 |



Observations in the field during the first years of the experiment showed marked improvement in growth where manure was added. The yields for the four years were higher than on the unmanured plots. The fact that one of the manure plots was on a corner of the field which was not so badly affected with rootrot may have accounted for some of this difference. Nevertheless it was evident throughout the series that manure was beneficial on this land.

### ACID FERTILIZER

On two of the plots a special fertilizer mixture, designed to give the soil a more acid reaction, was used instead of the regular mixture which was applied to the other plots. This mixture differed from the regular formula in having more than half of its nitrogen from sulfate of ammonia and was composed as follows:

1100 lbs. cottonseed meal
440 lbs. sulfate of ammonia
315 lbs. double superphosphate
367 lbs. sulfate of potash

Yield on these plots as compared with those where the general fertilizer was used were:

| | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|
| Acid fertilizer | 931 | 1248 | 824 | 918 |
| Neutral fertilizer | 860 | 1181 | 1110 | 1167 |

Apparently there was a slight improvement during the first two years, but it was followed in the succeeding two by a serious decline. Last year these plots showed the symptoms of manganese poisoning. This is characteristic of a soil which is too acid for tobacco. Since root examinations during the last years showed that these plants were practically free from root lesions, it is safe to conclude that the reduced yield was due to the very acid soil rather than to rootrot. When the series was started in 1925, this soil tested 4.91 pH. In the fall of 1927 the acid plots tested 3.81, much more acid than any other plot on the field.

We may conclude then that although an acid fertilizer may have a strong effect in eliminating brown rootrot, yet the injury from the increased acidity may be more disastrous than that from rootrot.

### LIME

Two of the plots were limed at the rate of one ton to the acre of air slaked lime in 1925, 1926 and 1927. Yields on these plots as compared with the unlimed plots were:

| | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|
| Limed | 958 | 1316 | 1262 | 1246 |
| Not limed | 860 | 1181 | 1110 | 1167 |

Starting with a reaction around 5.0 pH at the beginning of the experiment, the limed plots had reached a reaction of 6.7 pH, in the fall of 1927, much more alkaline than any of the other plots. Such a reaction is usually favorable to *black* rootrot, but this disease never became prevalent on this field. The yield data indicate that there has been considerable benefit from the use of lime on this particular field.

### FALLOW

When the first crop of this experiment was set in 1925, two plots were left without any plants. No fertilizer was applied, but they were plowed, harrowed and cultivated throughout the season, just as the plots which had tobacco on them.

In the next three years, they were fertilized and set to tobacco. Yields for these years were:

| | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|
| Fallowed | .... | 1170 | 1169 | 1197 |
| Not fallowed | 860 | 1181 | 1110 | 1167 |

These data show that fallowing has caused recovery to about the same degree as the continuous growing of tobacco, that is, the yield of the first crop after one year of tobacco was approximately the same as after one year of fallow. Examination of the roots showed reduction in severity of infection at about the same rate as the increase in yield.

### STERILIZING THE SOIL

In 1925, two plots were sterilized with steam—the ordinary steam pan method used on tobacco beds, and two others were sterilized with formaldehyde diluted one part in 25 of water and applied at the rate of one quart a square foot of soil. Yields on these plots for four years were:

| | 1925 | 1926 | 1927 | 1928 |
|---|---|---|---|---|
| Not sterilized | 860 | 1181 | 1110 | 1167 |
| Sterilized with formaldehyde | 1125 | 1283 | 1161 | 1211 |
| Steam sterilized | 1575 | 1530 | 1181 | 1214 |

Steaming the soil almost doubled the yield the first year. Root examination at the close of the season showed that the disease had been completely eliminated by this treatment. Steaming was not repeated the following years, but the benefit the second year was nearly as large as the first year and improvement was apparent in the field even in the third and fourth.

Formaldehyde greatly increased the yield the first year, but it was not as effective as steam. After the second year, the effects of the two were about the same.

A third method of sterilizing the soil was tried in a small way. Soil from the worst affected plots was spread in a thin layer on a board floor to dry and aerate for two weeks. A like amount of soil from the same plots was kept in moist condition. Both soils were then put into separate pots and one tobacco plant was grown in each of eight pots. The plants in the aerated soil grew much more rapidly than the others, which were stunted. At the end of six weeks, the former weighed approximately ten times as much as the latter. Root examination showed that aeration had eliminated the disease from the soil.



Because of the expense, these methods of sterilizing the soil will probably never be practical in the field in a large way, but they may be useful on small spots. They are of considerable interest for the information they may furnish as to the nature of the disease.

### SUMMARY

The type of brown rootrot which was present in this field is closely associated with the previous cropping system.

It becomes most severe when tobacco follows the forage crops, timothy, corn, rye, alfalfa or clover.

Potatoes are less injurious in this respect than the forage crops.

With continuous tobacco culture, injury is reduced to a very low amount.

Fallowing without fertilization has the same effect as continuous tobacco.

Abandoning the land to the natural weed growth for a year was more beneficial than either continuous tobacco cropping or fallowing.

Addition of stable manure increased the yield on this field.

Annual applications of lime were beneficial.

Use of an acid fertilizer reduced the disease on the roots, but did not increase yield, because the soil became too acid for good growth.

The disease can be completely eliminated by steaming the soil or thoroughly aerating it. Sterilizing by formaldehyde is less beneficial than the other methods.

Time of plowing the land as practiced in this experiment had no effect on the severity of the disease.

### RECOMMENDATIONS

On the basis of these experiments, supplemented by results of experiments in other sections, we recommend the following to the tobacco grower who has trouble with brown rootrot:

1. *Do not attempt to rotate tobacco with other crops. Avoid particularly the forage crops. Do not use timothy cover crops on land which shows a tendency toward brown rootrot.*
2. *Continuous tobacco culture is better than trying to "rest" the land by growing other crops. If there is opportunity to rest the land, let it grow up to the natural weed vegetation for a year or longer.*

# BLACK ROOTROT RESISTANT SHADE TOBACCO

John G. Wolf

Black rootrot of tobacco, caused by the fungus *Thielavia basicola* Zopf, has inflicted heavy loss on growers of shade tobacco. The disease prevents the normal growth of plants and thus reduces the yield, even on soil which has all the necessary plant nutrients.

Much of the so-called "running out of tobacco soils" is due to rootrot. When such crops as tobacco are grown year after year on the same land, the soil may eventually become infested with disease organisms and so be unsuitable for further growing of that crop.

The problem, then, is to produce a tobacco plant that will mature normally, season after season, on the same field. With this object in view the writer has carried out his investigations at the tobacco substation the last three seasons.

In the last quarter of a century, a great many disease-resistant crop plants have been developed. Among them are wilt-resistant cowpeas, wilt-resistant sea island cotton, alfalfa resistant to leaf spot, cabbage resistant to yellows, rust-resistant wheat, spinach resistant to yellows, rust-resistant asparagus, watermelon resistant to anthracnose, and smut resistant corn.

In tobacco, black rootrot-resistant strains have been found in the White Burley type, Wisconsin Havana Seed and Pennsylvania Broadleaf. No degree of resistance has ever been found in any strain of Connecticut shade tobacco.

In almost every instance, the first plant selections for resistance were made in fields where the crop was practically a failure, except for a few plants, possibly naturally immune, which stood above the others and seemed perfectly normal. Using these apparently resistant plants as a starting basis, eliminating all possible crossing by selfing, and using rigorous row selections for several generations, strains have been developed with the desired inheritance and a high probability of breeding true. Especially is this true with tobacco, which is normally self-fertilized.

Hugo De Vries, a Dutch botanist, described the appearance of new characters which were departures from normal. These he called "mutations." This change may be in only one visible feature, such as form of leaf, color of flower, or height of plant. They occurred in such a way that they could not be due to Mendelian segregation and many were proved to be actual germinal changes.

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Author's Acknowledgment. The writer acknowledges his appreciation and indebtedness for helpful suggestions and criticisms of Dr. Paul J. Anderson, pathologist-in-charge of the tobacco substation, and to Dr. Donald F. Jones, geneticist of the experiment station.



In self-fertilized species, these occurrences are extremely rare, but when found they may be assumed to be mutations and to have the potential ability to breed true. In cross-fertilized plants there is a greater chance to select desirable combinations of disease resistant factors.

It is well to note that a normally resistant plant in a certain locality may be a failure in some other geographical center, which is probably due to higher specialization of fungi to the host. Also, it is often difficult to obtain a uniformly "infected" soil for experimentation. In our investigation, at the J. Ford Ransom lot in Windsor, only about one-half of the area in use was found to be badly infected with rootrot.

Figure 16. Field of Cuban shade tobacco showing the desirable uniformity of stand when no rootrot is present.

## SYMPTOMS OF BLACK ROOTROT

This disease is prevalent in all the tobacco growing sections of the northern states and in Europe. Its presence in the tobacco field first becomes known to the farmer when he notices that the plants in certain parts of his lot lag behind the rest of the field. Some may stop growing completely. On hot days the affected plants wilt and the leaves flag. When the plants are pulled, many of the lateral roots are seen to be rotted off. The diseased portions of the roots are dark brown to black, instead of white, as a healthy root should be. On smaller roots the lesions go completely through and the root drops off, but on larger laterals the lesions appear as black, rough enlargements, while the center of the root may still be healthy. Loss of the roots has a direct connection with the flagging leaves, since the reduced root system is unable to supply enough water to equal the volume which is transpired by the leaves on a hot day.

Soils particularly conducive to rootrot are those which are heavy and cold, apt to be water-logged, those which are nearly neutral in reaction, usually due to liming, and those which have been manured heavily.

### IMPORTANCE OF BLACK ROOTROT TO THE SHADE INDUSTRY

Shade tobacco is more susceptible to black rootrot than either of the other two types of tobacco grown in Connecticut. Although it is well known to all shade growers that thousands of acres of shade land have "run out" since this type has been grown on it, it is not so well appreciated that most of this "running out" is due to increase in prevalence of the black rootrot fungus in the soil. When the reduced yield makes it no longer profitable, this land must be abandoned for a time and the poles and wire transferred to other land. This transfer, the added expense of leasing or purchasing new land, the necessity of operating at a distance from home and frequently from convenient sheds, all must be computed in the bill which the grower pays to rootrot. If it were possible to calculate in dollars the loss the growers have sustained from these operations and from the reduced yields, the figure would be in millions. Suffice it to say that it is the most serious disease problem with which the shade grower must contend.

### ORIGIN OF THE 4R RESISTANT STRAIN

Since resistant mutations have been found in other types of tobacco, it was not unreasonable to believe that one would be found sometime in the Cuban Shade type. Although many fields had been carefully searched for years, no indication of resistance was found until 1927. In July of that year it was discovered on the badly diseased part of a shade field, owned by Mr. Ransom, that a few strong luxuriant plants grew twice the height of the sickly little ones about them. They had sturdy stalks in contrast with the "pipe stem" stalks of the other plants. These large plants were not grouped in one place, but were scattered singly over more than half an acre. This part of the field had suffered from rootrot several years before 1927. When some of the *little* plants were now dug up they showed a badly rotted root system, characteristic of black rootrot.

Close examination and testing of the soil at the base of the few large normal plants failed to show any difference between this and the soil in the rest of the field. In leaf shape and other growth characteristics, these plants were like the normal plants from the unaffected part of the field. There was therefore no reason to suspect that these plants were a different type of tobacco, accidentally introduced, or that they were affected by any soil differences. They could only be a mutation or a hybrid from some previous crossing.



Inquiry revealed that the seed was the same as the owner had been using for several years. It was originally from the same strain as that grown by the other shade growers, the Hazelwood type, brought from Cuba by William Hazelwood in 1903, and selected for uniformity for a number of years by J. B. Stewart and co-workers. Mr. Stewart states that the seed which he finally distributed and is now universally grown in the valley is the progeny of a single plant which they selected. Therefore it does not seem likely that these plants could have come from segregation in a hybrid population.

Although the diseased plants "spindled up" taller in the latter part of the season, they *never* produced leaves of any commercial value and were always much inferior to the mutants in size. The seed heads of 18 of the larger plants were bagged to prevent any accidental crossing. The progeny of this seed was subsequently designated as the "4R strain" (abbreviation for Ransom Rootrot Resistant) to distinguish it from the ordinary shade tobacco.

After the seed had been harvested, the root systems of the bagged plants and of neighboring *small* plants were washed and examined. The root system of the susceptible plants was badly diseased, most of the lower roots being mere stubs. The best roots were at the top and had developed after the bottom ones had been rotted away. The root system of each of the 18 healthy was several times as large as the others and was characterized by strong long laterals *at the bottom*. There were lesions of black rootrot, however, even on these roots, but not nearly so numerous as on the susceptible plants and the injury was small. Apparently we had here, not immunity, but a high degree of resistance, or, possibly, it might be called increased root vigor.

### FURTHER TESTING OF THE 4R STRAIN IN 1928

This rootrot infested field, where the first selections were made, was kindly made available by Mr. Ransom to continue the selections under an environment favorable to development of the disease.

The selfed seed, obtained from the selected plants of 1927, were sown in 1928, the progeny of each plant being kept separate. In the bed no variation could be discerned between the resistant and the ordinary Cuban seedlings, both being vigorous and normal.

Late in May, these plants were set in the Ransom lot and also in an uninfested shade field on the station farm in order to observe the quality of the product under normal conditions. The regular Cuban was used as a check in both fields.

Early in the growing season, it was noticeable that many rows showed considerable vigor and some resistance when compared with the checks. Unfortunately for the experiment, this was a poor rootrot year, for the plants brought to the laboratory in July showed but little infestation, while the check rows had slightly more. Later observations taken on field growth showed the resistant rows to be far superior to the checks, in vigor and general growth.

About the middle of July, the best plants from the best rows

FIGURE 17. Row of common Cuban between rows of 4R Cuban. All set the same day.

were selected with the assistance of two experienced shade growers, Mr. Ransom and Mr. Stewart. The object of this selection was to choose plants having ideal Cuban characteristics, leaves of good texture, proper size and shape, with a goodly number of marketable leaves and generally showing good commercial possibilities. These were properly tagged and selfed by bagging.

The plants set in the station tent afforded an opportunity for comparing the quality and the tobacco was followed through to the grading tables. These leaves showed no significant difference in quality as compared with the regular Cuban. Apparently, then, the selections must be made mostly on the basis of apparent resistance. Soil samples taken on the field showed about the same reaction as the preceding year. The root systems when dug up



and carefully examined showed those of the resistant plants to be larger, yet having a few lesions of black rootrot. Since two rows had shown most promise during the season, twenty of the best plants from these two were selected for seed with which to continue the tests for 1929.

## CONTINUATION IN 1929

Seed of each of these 1928 selected plants was sown separately and one row each was set in the Ransom field early in June, 1929.

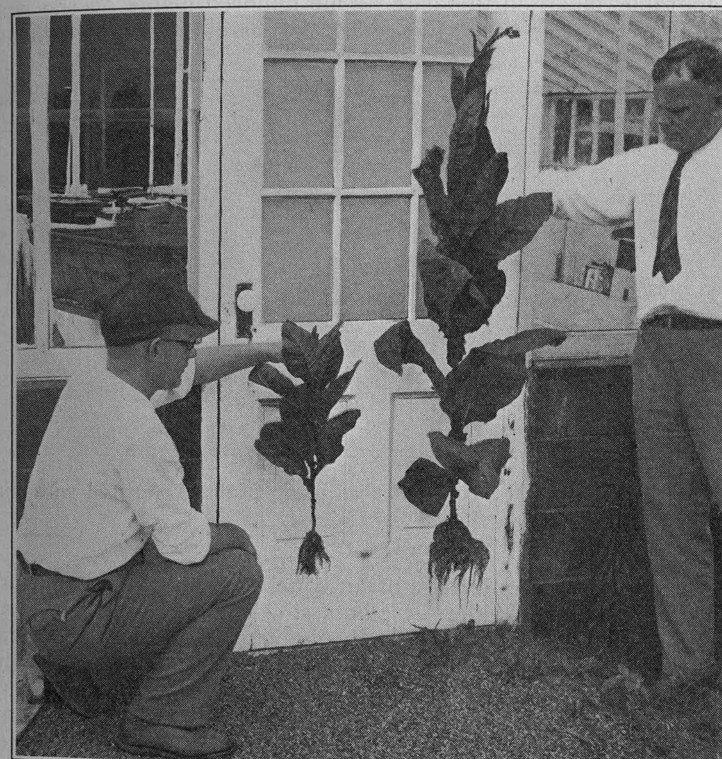

FIGURE 18. Resistant Cuban plant (4R) on right compared with common Cuban on left.

As before, ordinary Cuban was used for a check. As early as July 10, it was noticed that the check rows seemed stunted or were rather slow in starting and many rootrot lesions had developed, while the 4R strain was exceedingly vigorous and examination showed little, if any, rootrot infection.

One of the interesting facts of 1928 and 1929 was the uniformity of the plants in each of the resistant rows, which shows a definite mutational characteristic. As before, some rows seemed superior to others and showed considerable promise. This was evident on the left side of the field, where the rootrot infection had always been severe. On the right this variation was not so pronounced.

On July 16 the resistant rows far outstripped the check rows of the regular Cuban. This difference between the resistant and susceptible Cuban plants is shown in Figures 17 and 18 from photographs taken on this date. One hundred plants on the susceptible row at this time averaged 41 inches in height, in contrast

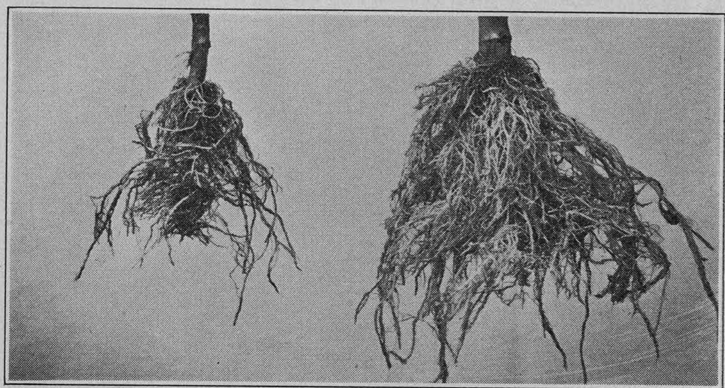

FIGURE 19. Root system of 4R Cuban plant (right) compared with that of common Cuban.

with 67 inches as the average of an equal number on the adjacent 4R row. On July 22 the 4R plants stood 24 inches higher than those on the check rows on the left side, where the rootrot infestation had been the worst. At this time, the resistant plants at the right, less infested part, also were taller and superior in every way to the normal check rows. The first priming of a resistant and an adjacent susceptible row was taken for measurements after curing and sweating. From these the following measurements were taken at time of sorting:

| | Susceptible Cuban | Resistant 4R4 |
|---|---|---|
| Average length of leaf ......... | 10 inches | 14 inches |
| Average width of leaf ......... | 5 " | 8 " |
| Weight of first picking (to acre) | 175 lbs. | 340 lbs. |

The 4R leaves were of good size, shape and quality. The leaves of the susceptible Cuban were short, narrow, pointed and practically none was considered to be of commercial value. Also none



of the leaves above the first picking became large enough to be of any value.

In early fall, the roots were dug and examined. The root systems of the resistant plants were large, white in color, had many strong laterals and were comparatively free of rootrot lesions. On the check, they were smaller, with stubs due to rotting off and with an abundance of lesions.

Late in July the best rows were selected and the best plants selfed by bagging. On the first of August the severe hail storm hit the section, but sufficient seed to continue this strain was saved.

## SUMMARY

1. *A strain of Cuban shade tobacco highly resistant to rootrot, but not differing in other respects from ordinary shade tobacco, has been isolated and tested for two years in this field.*

2. *The strain at this time is fairly uniform, which shows it to be a mutation and not a hybrid.*

3. *Resistance to disease is often not absolute and the extent of infection is greatly influenced by environmental conditions. It is therefore desirable that the 4R strain be tested on other fields, The station will be glad to furnish a limited amount of this seed for trial to growers who have infested fields.*

# SEASONAL FLUCTUATIONS IN SOIL REACTION

T. R. Swanback and M. F. Morgan

Soil acidity, as measured in terms of pH values, has become of such great interest to tobacco growers that soil tests are being made at frequent intervals on a great many tobacco fields. A considerable amount of confusion has arisen because carefully selected soil samples of the same field frequently show pronounced variation in reaction when collected at different dates. Is this phenomenon to be ascribed to errors in sampling or in method of measurement of pH values, or does the pH of the soil actually change from time to time?

Other investigators have noted seasonal changes in the acidity of certain plots where soil conditions and methods of testing were carefully controlled. Kelley[1] found variations in pH in the same plot which amounted to 1.0 pH during the year. During the summer, with a prolonged drouth, there was a continual increase in acidity, while fall rains produced a decrease. With the coming of winter, pH values showed a slight increase in acidity when the soil became frozen, while in the spring the soil returned to a normal reaction. Baver,[2] studying changes in acidity from day to day during the summer, observed that two unlimed plots became progressively acid through the season from May to September and concluded that there is a constant increase in acidity from spring to fall, with a return to approximately the original acidity the following spring. He ascribed this seasonal trend either to the dehydration of colloids by drying of the soil, or to the accumulation of soluble salts during the summer.

During the past three seasons data on periodic variations in the acidity of certain plots at Windsor show that tobacco soils of the Connecticut valley may also show a similar seasonal change in pH.

### SINGLE NITROGEN SOURCE PLOTS AT WINDSOR

A set of plots at Windsor, where the effect of different carriers of nitrogen is studied, has also been used to observe the soil reaction during the various seasons. Four plots were laid out in the spring of 1926: cottonseed meal, nitrate of soda, urea and sulfate of ammonia. Three were added to this series in the spring of 1929: castor pomace, linseed meal and dry ground fish.

Reactions were determined before fertilizers were applied in 1926 and 1927, and from December of that year up to date nearly every month.

The graphs in Figure 20 show that the reaction varies consider-

[1] Soil Science, 16, 46-47.
[2] Soil Science, 23, 403-407.



ably during the year. The heavy line, representing reactions on the cottonseed meal plot, probably expresses approximately the seasonal fluctuations in pH values which may occur in an ordinary tobacco soil. The differences between the summer months and other seasons may range from one-half to more than a unit pH.

Figure 20 also shows clearly the extremely acid condition which is produced by sulfate of ammonia, as compared to the tendency of nitrate of soda, while urea and the organic fertilizers are intermediate in their effects.

### SEASONAL TRENDS IN CONCRETE-WALLED SOIL PLOTS AT NEW HAVEN

Since the spring of 1927, the soil reaction of forty-eight small concrete-walled soil plots has been determined at frequent intervals. Various combinations of lime, nitrogen, phosphorus and potassium have been applied from time to time in experiments with vegetable crops. Urea has been the sole source of nitrogen.

On all treatments there was an increase in acidity during the summer of 1927. Marked fluctuations occurred, since the rainfall was irregularly distributed. There was a decrease in acidity in the fall, with a slight increase in the winter period. In 1928 there was no significant increase in acidity during a summer of heavy and well distributed rainfall. Fall and winter brought slightly more acid conditions. The spring of 1929 brought a return to conditions similar to previous years, while the very dry summer showed high acidity, which decreased after heavy August rains, and increased considerably during the dry period of early autumn. The acidity was still higher than normal in December, 1929, although it showed a gradual rise in pH values (decreasing acidity).

Treatments including nitrogen showed increasing acidity during the months following their application, to a much more marked degree. The following figures, compiled from thirty-four successive dates during the period May, 1927 to December, 1929, show that the nitrogen treatment is a very important factor in accentuating these periodic fluctuations:

| Treatment | Mean pH | Average departure from mean pH | Maximum pH | Minimum pH |
|---|---|---|---|---|
| None | 4.95 | .15 | 5.39 | 4.51 |
| PK | 5.07 | .13 | 5.40 | 4.61 |
| NPK | 4.81 | .29 | 5.48 | 4.15 |

### NITRATE CONTENT OF THE SOIL AS A FACTOR IN SEASONAL FLUCTUATIONS

The lysimeter experiments with different sources of nitrogen on various soils have provided some data as to seasonal change in pH on soils which were also studied weekly as to nitrate nitrogen content of soil in the period from June 1 to November 22, 1929.

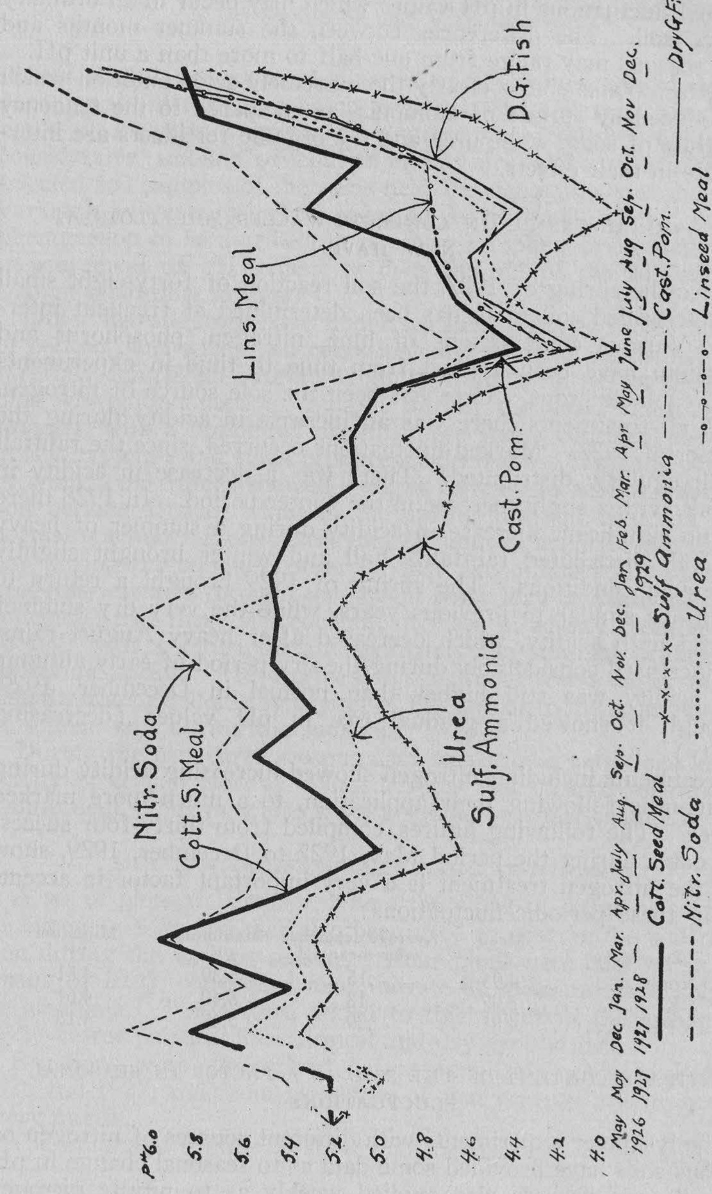


FIGURE 20. Curves of seasonal fluctuations in soil reaction on field plots at Windsor.



Four different soils were used. A fertilizer containing only the mineral elements was compared with added rates of application of nitrate of soda, sulfate of ammonia, urea and cottonseed meal,

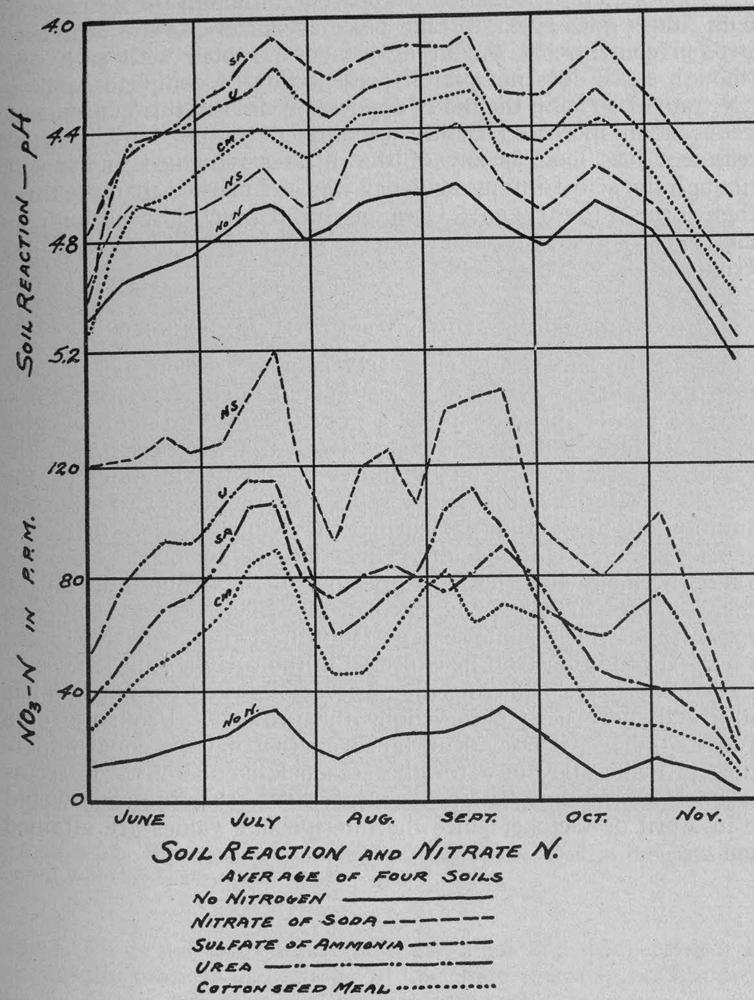


FIGURE 21.

at rates of application equivalent to 200 pounds of nitrogen to the acre, on each of the soils. The soil, in small cylinders, was kept fallow during the season.

Figure 21 shows the fluctuations in nitrate nitrogen and pH from week to week for the average values of the four soils. (It is to be noted that the pH is plotted upside down so that if an increased nitrate content is accompanied by increased acidity, the corresponding decreased pH will show as a rise in the curve.)

A good general correlation is apparent, although the decrease in acidity does not appear to take place as quickly as the decreased nitrogen content. A similar agreement is noted with each soil, although space does not permit presentation of complete data.

Nitrate of soda, in the heavy application used in this experiment, produced an increased acidity (compared to the "no nitrogen" treatment), as long as any of the nitrates remained in the soil, although the acid-forming tendency was less marked than the three other forms of nitrogen. Urea produced practically as high an acidity as sulfate of ammonia, although its effect was less permanent.

### CONCLUSIONS FROM PH FLUCTUATION STUDIES

During the late spring and early summer season, particularly after the application of high applications of nitrogenous fertilizers, there is a marked increase in soil acidity (decrease in pH). A dry season produces a more acid condition than a wet season. Withdrawal of nitrate nitrogen by the crop and the leaching of the fertilizer from the soil by heavy rains restores the pH to a normal condition in the autumn. During the winter season there are decreases or increases in acidity, which may be due on the one hand to mild periods when the frost goes out of the ground, or, on the other hand, to the accumulation of acids which are added by rain or snow and which cannot escape from the frozen soil. A return to normal conditions can be expected in the early spring.

The importance of having the tobacco soil tested for reaction has more and more been observed by the growers. From the data presented above, it is evident, however, that it is of equal importance to make allowance for the seasonal fluctuations. It seems reasonable to assume that proper times of testing the soils would be in April or October since the intermediate values are attained then.

## DAMPING OFF OF YOUNG SEEDLINGS

In unsterilized plant beds in the station greenhouse, young seedlings almost as soon as they could be seen, began to die off and disappear. This continued until the few plants left were more than an inch high. They died off in bunches, particularly where the stand was thickest. This same trouble appears always to be present in the greenhouse and has been observed in seed beds else-

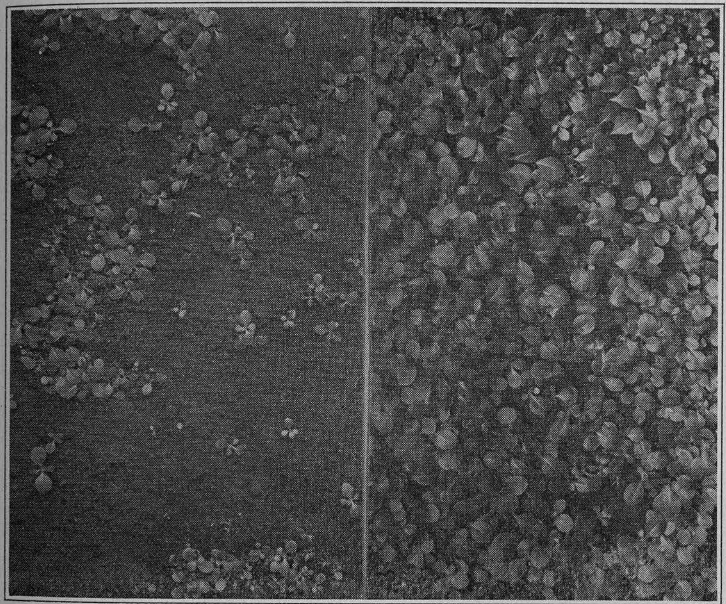

FIGURE 22. Sterilized and unsterilized plant beds. Bed to the right was soaked with 1% acetic acid.

where. It is not known just how prevalent and destructive it is among the tobacco plantations of the state, because no comprehensive survey has been made, but troubles which appear to be the same are common every year.

A close examination of the young plants shows that the stalk is attacked at the base between the soil and the first leaves. This part of the stalk shrivels to a string, then the plant topples over and dies on the ground. The affected part of the stem may remain green for a long time or may turn brown. Under damp conditions the top of the plant remains alive for some time after the stem is rotted through, but finally all parts of the plant become slimy and rotten.

When the dead plants are examined under the microscope, they are found to be completely permeated with the mycelium of a fungus, Pythium. This fungus lives in the soil, but is able to attack and live on the seedlings only in their very young stages.

In order to see whether this condition could be prevented by sterilization, two new beds were started with the same soil. The soil of one was saturated with a one per cent solution of acetic acid and was seeded about three weeks later. The other was seeded at the same time without sterilization. The plants all came

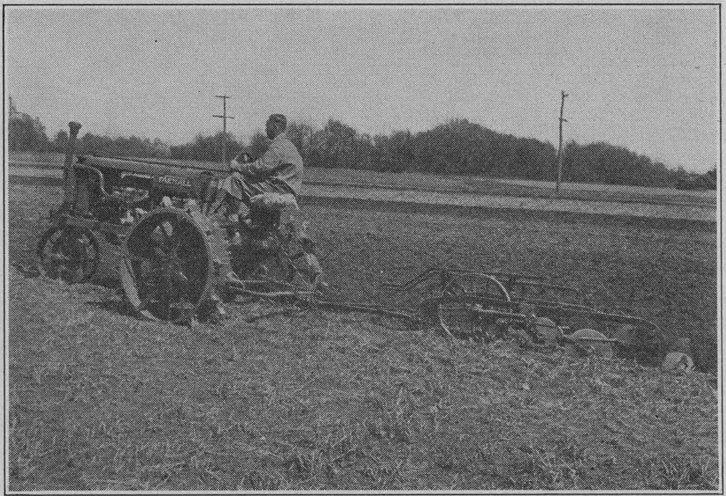

FIGURE 23. Tractor plowing in the open field.

up about alike but within a few days plants in the unsterilized soil began to disappear and the disease ran its normal course. The appearance of the sterilized and unsterilized beds when the plants were three weeks old is shown in Figure 22.

Acetic acid completely prevented the disease in the sterilized bed. Undoubtedly the same results could be obtained by sterilizing with formaldehyde or steam. Acetic acid has the advantage of being cheaper.

## RAISING TOBACCO BY TRACTOR

Just as in industry, machine labor is replacing hand labor, so in agriculture, the tractor is rapidly replacing both horse and man labor. In other types of farming, this change has progressed further than in tobacco growing, but even in this intensive farming, the change is inevitable. The many obvious advantages of the tractor make it only a question of a few years and some improvements in tractor machinery before we shall raise tobacco without horses and with much less hand labor. The greatest obstacle to more extensive use of the tractor is the conviction of many growers that it can be used only for a part of the operations

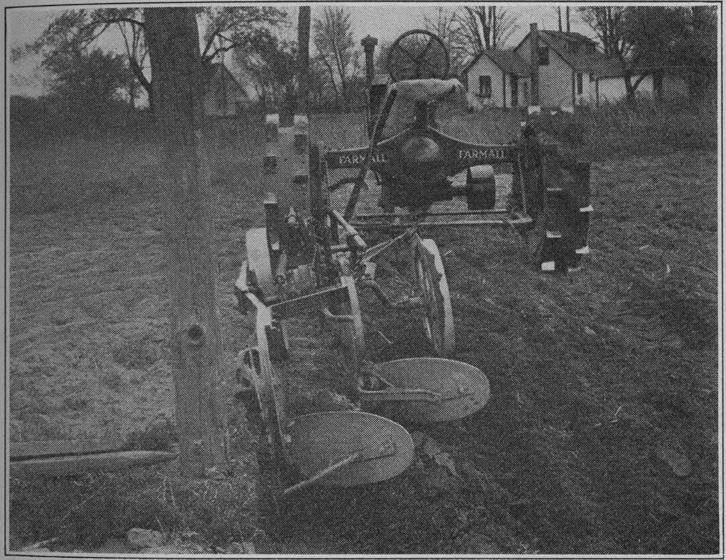

FIGURE 24. The off-set plow which will cut the furrow within two inches of the shade poles.

of growing the tobacco crop and that it will still be necessary to keep horses for the other operations. This means the maintenance of two power systems. If it could be demonstrated that the tractor can do *all* the operations just as well as horses, the substitution would be made rapidly.

To see how effectively all the operations of tobacco growing could be performed by tractor and to make improvements in tractor machinery so that it will be suitable for all necessary operations, an experiment in co-operation with the International Harvester Company was begun on the station farm. During the season of 1929 no horse was used for any operation on the farm. The tractor grown crop was just as good as other crops. It was necessary to experiment with different types of implements, but in the end a suitable one was found for every operation.

Plowing and harrowing the open fields presented no problem because these are already common practices with many growers. The shade fields presented a different problem, the necessity of finding a plow which would turn the furrow up close to the poles and between them. The two bottom plow illustrated in Figures 23 and 24 was finally adopted as suitable for this purpose. It has a very wide adjustable offset. For the furrow directly in the pole

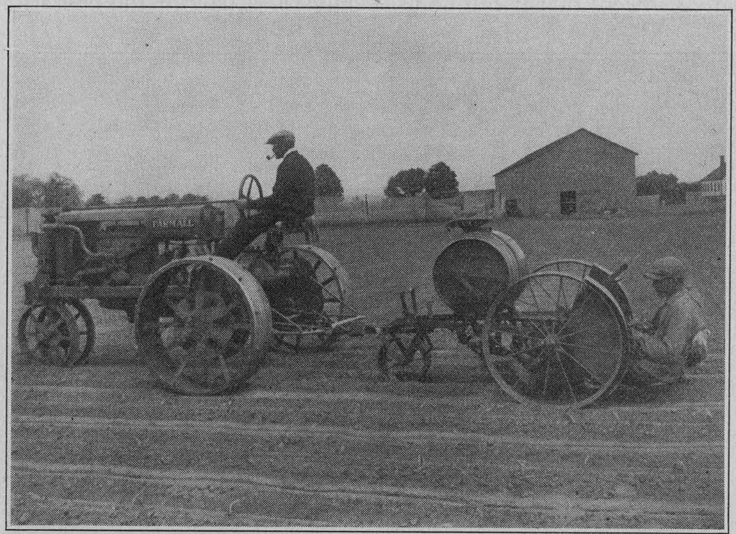


FIGURE 25. Setting by tractor. A two-row transplanter will be substituted next year for this one-row machine.

row a shift lever, not shown in the figure, was attached in such a way that the plow could be shifted around the poles. Although this did not operate as smoothly as desired, it is believed that this difficulty can be overcome so that it will not be necessary to use horses at all. The enormous saving in time and labor in fitting the land by tractor instead of horses needs little demonstration.

Shortening the pole of the fertilizer drill was all that was necessary for the operation of spreading the fertilizer. The same was true for the transplanter. The one-row setter shown in Figure 25 was an ordinary Bemis setter with a short pole. A two-row setter for this purpose has more recently been manufactured and it is preferable to the one-row setter, not only because of the saving in time, but more particularly because it keeps the distance between the pair of rows always the same. This is rather essential



for the best operation of the two-row cultivator to be used later. The uniformity of speed of the tractor and its suitability for making perfectly straight rows are distinct advantages over horses.

Cultivating was done with a two-row cultivator. The gangs of this machine are attached to the side of the tractor, where they can be watched by the driver. This also makes it possible to turn the outfit in a very small space at the end of the rows. Any combination of shovels may be used. With this outfit it is possible to cultivate until the tobacco is 30 inches high.

A stock objection to the tractor is that its weight and the broad wheels pack the soil too much. It was found in this experiment that packing could be entirely eliminated by the use of open-face wheels. For drawing the tobacco racks during harvesting it was necessary only to shorten the poles.

Further improvements are being made and the experiment will be continued, but there do not appear at present to be any great mechanical difficulties in the way of substituting tractors for horses entirely in growing tobacco.

## CEL-O-GLASS SEED BED SASH

"Cel-o-glass' is a glass substitute made of fine mesh wire screen imbedded in a translucent material, light and somewhat flexible. The manufacturers, the Acetol Products Company of New York, claim that it transmits 80 percent of the sun's rays, including 35 to 40 percent of the ultra violet rays which are excluded by ordinary glass.

It has been suggested that "cel-o-glass" could be substituted for ordinary glass in tobacco seed bed sash with the following advantages:

1. It is flexible and does not break. Hence the labor and expense of replacing glass are eliminated.
2. It is lighter and does not require as heavy a frame. (Frames which we used weighed less than half as much as glass frames.)
3. The labor of handling is greatly reduced.
4. The temperature is more uniform, that is, lower during the day and higher during the night than when ordinary glass is used.

The first three are obvious, since this material is not easily broken and the sash are much lighter than those ordinarily used. To test the fourth claim we made a trial, for which the manufacturers furnished the materials. One section of the 1929 beds was covered with six cel-o-glass sash, while on the next sections the ordinary sash were used. These sections were separated from each other and from the rest of the bed by board partitions.

Observations were made throughout the season, but no continuous temperature records were made. Plants under cel-o-glass did not grow as rapidly as under ordinary glass. It required about ten more days to grow them under the substitute to a size suitable for setting. Otherwise, no differences were observed.

Bulletin 312 February, 1930

# THOMAS B. OSBORNE
# A MEMORIAL

**Connecticut Agricultural Experiment Station**

**New Haven**

The bulletins of this station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.

*Thomas B. Osborne*

## FOREWORD

The outstanding contributions of Thomas Burr Osborne to the chemistry and physiology of proteins have brought honor to his name and have reflected lasting credit upon the institution he served so long and so devotedly. It seems fitting therefore that the Station should recognize his distinguished public service by some permanent testimonial of his worth. This bulletin aims to serve as a memorial of him by the colleagues with whom he labored daily, showing also something of his varied interests and activities aside from the problems of his life work, and something of those qualities which compelled the admiration of his associates and won their affection.

The committee gratefully acknowledges the courtesy of those editors who have permitted the reprinting of published articles, and desires to express its indebtedness to Miss Luva Francis who compiled the bibliography.

W. L. S.
E. H. J.
E. M. B.
H. B. V.

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## DR. OSBORNE AS AN ASSOCIATE

The facts about Dr. Osborne's inheritance, his education, his long-continued work, its great results and its final public recognition are set forth in the papers which follow. I wish to speak very briefly of some of the personal qualities of the man with whom I was associated in the Agricultural Station for more than forty years.

But it is not easy to speak soberly and without feeling of a companion and loved friend whose devotion to his work and whose dogged perseverance in meeting its difficulties I had watched almost daily for many years and in which I had shared his disappointments and his successes.

The first impression of a stranger meeting him for the discussion of things in which both were engaged would probably be that Osborne was a severe and just critic of his own work and that of others. He made it very clear that he could not accept any scientific statement unless its proof was absolutely clear to him. He hated half truths and "hedging," "for men in earnest have no time to waste in patching fig leaves for the naked truth," but kindly always. He was quick with suggestion and help to his associates, as free and judicious with praise as with criticism. His steady devotion to his work, the originality of his thought and the inspiration of his example raised the tone of the work of all who were his associates in the Station. Each of his assistants was a fellow worker, helped and encouraged by him and shown how his work was an important part of the whole research. Anxious as he was to keep his staff intact, when he saw that one was fitter for other and better paid work, he would tell him and, if he wished, help him in getting a more satisfactory place elsewhere. In times of their disability or illness he was quick to help, using his own means—sometimes largely—if that was needed.

Dr. Osborne had no taste for poetry, the drama or noble prose. He was a realist. He did not find in these things much stimulus for his imagination or charm for his leisure time. But he found both in thinking of the great problem which possessed him, a study of those things which are the basis of all physical life. It was a work which needed not only an expert chemist but a man of great originality, with clear thought on all the possibilities and withal a trained imagination; not "mere delectation meet for a minute's dream" but for the grasp of a vision and then strict testing of its value. He rejoiced in the discovery of a vitamin, but to see the knowledge of it saving the health and life of thousands of children in Russia was worth a lifetime. On the walls of his study hung the pictures of Liebig and Johnson, on his desk was his wife's picture and near by on the other wall was a large diagram of a protein complex as he conceived of it, changed from time to time as his work went forward.

These were his visions. He spent forty years of his life in study and laboratory, devoted to a particular problem, putting aside tempting offers to engage in better paid work elsewhere and the other temptation to exploit his work in popular articles.

Such was his life work, but not his life, which had wider interests.

During his boyhood and youth he was greatly interested in the study of plants, insects and particularly of birds. He was a keen and accurate observer, not only recognizing their names but their nesting, feeding and migrating habits. He collected nearly one thousand specimens, some mounted, but chiefly prepared skins. In C. H. Merriam's Catalogue of the birds of Connecticut acknowledgment is made and there is frequent reference to the valuable contributions of T. B. Osborne. About 1880 his collecting was discontinued, as he was occupied with his chemical studies, and the specimens were given away. But his intimate knowledge of bird life remained a lifelong interest and pleasure to him. While walking with friends and discussing things of mutual interest the flutter of a small bird or a bird song would halt everything until he had seen and identified his friend and interrupter. When plagued with insomnia, as he often was, he would catch in the fall and spring the notes of migrating birds flying high at night and sometimes recognize the species. A love of nature was music and poetry to him.

His interest in the political questions of the day was keen and his knowledge of financial matters made him an active director of the Second National Bank, where he served for years.

But this is not all that specially endeared him to very many who were his intimates or were within his influence. A wholesome clean-minded man, quick, impulsive, generous and broadminded and in all ways companionable; these qualities are a large part of what made the world better for his life and our lives the poorer by his going.

EDWARD H. JENKINS.

## THE WORK OF THOMAS BURR OSBORNE (1859-1929)[1]

It is given to few men to begin a scientific career with an investigation in an obscure and unattractive field, to continue their labors in it throughout a long and active life and ultimately to see this field become one of the most fertile and widely cultivated in their particular domain of science. The work of Thomas Burr Osborne on the vegetable proteins, continued from 1889 until his retirement in 1928, furnishes a striking example of a life devoted almost exclusively to scientific research upon a single group of substances and their derivatives. Owing to the diversified relationships of these substances this work has had a profound influence upon many phases of biochemistry.

Dr. Osborne was born in New Haven, Connecticut, on August 5, 1859. He was graduated from Yale University with the degree of B.A. in 1881, and received his doctorate from Yale in 1885. His dissertation was on "The Quantitative Determination of Niobium." From 1883 to 1886 he was an assistant in analytical chemistry at Yale and during this period published several papers dealing with analytical problems.

In May, 1886, at the invitation of Professor Samuel W. Johnson, professor of agricultural chemistry at Yale and director of the Connecticut Agricultural Experiment Station, Dr. Osborne became a member of the station scientific staff, forming a connection he retained until his death on January 29, 1929. Professor Johnson had become interested in Ritthausen's extensive studies of vegetable proteins. He was fully alive to their significance and suggested that further investigation was desirable. Accordingly, Dr. Osborne began in 1888 the labors that continued without interruption until his retirement.

Dr. Osborne's work on the vegetable proteins falls chronologically into three phases. From 1890 to 1901 the chief interest was in the preparation of pure specimens of the proteins of plant seeds. The initial investigation of the oat kernel, published in 1891, was followed by a series of papers in which the proteins from no less than thirty-two different seeds were described. Each of these was prepared, where possible, by a number of different methods; the criterion for purity and individuality was ultimate analysis for carbon, hydrogen, nitrogen and sulphur.

The properties of these substances were such as clearly to show the advantages, for scientific investigation, of the reserve proteins of seeds over the proteins of animal origin. Efforts to isolate proteins of definite properties from the complex mixtures in

[1] Reprinted from *Science*, **69**, 385 (1929) by permission of the editor.

animal tissues had been for the most part unsuccessful, and even as late as 1911 ovalbumin was the only animal protein that had been clearly characterized as a chemical individual. On the other hand, many seed proteins were early shown by Dr. Osborne to be chemical individuals and preparations possessing identical properties were reproducible at any time.

A careful investigation was made of the proteins which had been previously grouped under the terms legumin, conglutin and vitellin, and it was shown that many of the proteins which thus had been brought together were, in fact, distinct substances. Specific designations were, therefore, in many cases coined and the use of the older names was restricted to those proteins to which they had first been applied. This clarification of the nomenclature has been of immense assistance in bringing a semblance of order into an almost hopelessly confused subject.

A few proteins had been previously prepared in crystallized form by other investigators. Dr. Osborne crystallized many of the seed globulins, and the readiness with which this could be done emphasized the fact that these proteins were definite substances entitled to the serious consideration of chemists.

The second phase of Dr. Osborne's work was initiated in 1899 with a paper[2] in which it was shown that the crystalline protein edestin from hemp seed forms two compounds with hydrochloric acid, a mono- and a di-hydrochloride, that the solubility of edestin in acid increases in direct ratio with the amount of acid present and that a number of crystallized vegetable globulins behave as bases neutralizing definite proportions of acid. In other words, the behavior of these proteins was that to be expected of basic substances of fixed composition. This was the end towards which his careful descriptive studies had been directed, a demonstration that proteins were definite chemical individuals. The position here taken was strengthened by later papers in which it was shown that proteins in general behave towards acid like bases, that they form salts both with acids and with alkalies and show many evidences of a capacity to undergo electrolytic dissociation and enter into ionic reactions.

These results emphasized the desirability of more complete chemical characterizations of the different proteins. The development of the methods of analysis of proteins at the hands of Hausmann, of Kossel and of Fischer furnished powerful means for supplying this and full advantage was taken of them. Furthermore, determinations of physical properties such as specific rotation, the heat of combustion and solubility in saline solutions contributed materially to the solution of the problem.

By 1908, when the paper on "The Different Forms of Nitrogen

[2] T. B. Osborne, *J. Am. Chem. Soc.* 21, 486 (1899).



in Proteins,"[3] perhaps Dr. Osborne's most widely quoted contribution, appeared, data had been accumulated which indicated clearly that few proteins had been obtained that could not be completely characterized by the methods of amino acid analysis, coupled with a study of the physical properties.

Beginning in 1906 and continuing for about six years, Dr. Osborne, with the aid of a number of collaborators, carried out a series of analyses of the amino acid composition of proteins by the Fischer ester distillation method. These studies set a standard for such work which has been surpassed only since the introduction in recent years of greatly improved methods for dealing with certain of the amino acids. Characteristically, he returned again and again to the analysis of a few of the proteins, such as casein, gliadin and zein, which possess special economic importance, each time increasing the summation of the components by the use of more refined technique. These analyses laid the foundation for the extensive studies of the nutritive properties of proteins that were begun in collaboration with Professor Lafayette B. Mendel, of Yale University, in 1909 and continued until 1928. This aspect of protein chemistry had attracted Dr. Osborne's interest from the earlier part of his career; but he had realized that until pure and uniform material could be obtained in abundance and its composition established by chemical analysis, an investigation of the comparative nutritive properties of proteins was useless. The striking differences which now became evident in the composition of many of the proteins suggested that their biological values might be correspondingly unlike.

It may be worth while to point out that in 1911 the notion that proteins might differ widely in nutritive value was relatively new. The chemical methods showed that wide differences in amino acid make-up occurred and, where these failed, the anaphylactogenic relationships which had been studied in collaboration with Professor H. Gideon Wells, of Chicago, emphasized the difference in all save a few remarkable cases. But where wide chemical differences occurred, as between edestin and casein, both of which were found to be adequate for growth, it became necessary to suppose that the animal organism is capable of effecting far more elaborate and extensive chemical transformations than had generally been thought.

The investigation of the nutritive properties of the proteins involved the development of a technique for feeding individual small animals which would permit accurate measurements of the food intake. This was successfully accomplished, but the first experiments in which the pure isolated proteins were fed, together with sugar, starch, lard and an inorganic salt mixture, showed

[3] T. B. Osborne, C. S. Leavenworth and C. A. Brautlecht, *Am. J. Physiol.*, 23, 180 (1908).

that normal growth of young animals did not take place, although mature animals, as well as young, could be maintained for considerable periods. Growth of young animals could readily be secured when dried whole milk powder was furnished together with starch and lard. This appeared to indicate that milk contained something other than protein essential for growth. The preliminary assumption was made that the missing factor might be supplied by the inorganic constituents of the milk, and it was found that excellent growth could be secured when evaporated milk serum, from which casein and lactalbumin had been removed, the so-called "protein-free milk," was added in sufficient amounts to a diet of isolated protein, starch and lard. With the assistance of this material an extensive investigation revealed wide differences in the alimentation of animals on different proteins. Animals rapidly failed on zein and gelatin, were maintained on hordein, rye and wheat gliadin but grew well on edestin, wheat glutenin, lactalbumin or casein. Further work showed that the failure of animals on a zein diet was due to the lack of tryptophane and lysine in this protein. When these amino acids were supplied growth occurred. Similarly, gliadin could be made adequate for growth by an addition of lysine in which this protein was conspicuously deficient.

The use of protein-free milk in diets was attended by certain difficulties. It is not entirely free from nitrogen and it could not be successfully replaced by an artificial mixture of salts made to imitate the composition of milk ash as closely as possible. Furthermore, animals nourished on this diet over long periods ultimately ceased to grow and declined rapidly in weight. In every case such animals could be brought to a normal rate of growth by changing to a diet containing whole milk powder, and the ultimate failure on protein-free milk could be postponed or averted by feeding whole milk powder for occasional short intervals. An examination of the composition of the two types of food revealed that the most conspicuous difference lay in the presence of milk fat in the dried milk food. Experiment soon showed that the addition of butter to a casein, starch and protein-free milk diet sufficed to permit normal growth to maturity. When butter was added to a diet of dried skim milk upon which it had been found that animals ultimately failed, complete realimentation occurred.

These results were published in 1913. The paper describing them was submitted to the *Journal of Biological Chemistry* about three weeks after a paper by McCollum and Davis in which similar results secured by the use of an ether extract of egg yolk and of butter, were described. The observations indicated that a substance occurs in butter which is essential for animal growth. This substance was later designated as vitamin A.



In the following year the important observation was made that the same stimulation of growth could be secured by the addition of cod-liver oil to a diet of purified food substances and protein-free milk, a discovery which served to focus attention upon the value of this oil, in particular as a curative agent for the peculiar eye condition known as xerophthalmia that was regularly encountered by Osborne and Mendel in animals on the deficient diets. At the close of the war the sight of many children in Europe was preserved by its use, a remarkable example of the application of scientific results to practical problems.

The later extensive contributions of Dr. Osborne and his associates to the science of nutrition can only be indicated. Much labor was devoted to the study of the nutritive value of the proteins of the commercially important foods and this work gave a rational explanation of many practices which empirical experience had shown to be advantageous. The distribution of vitamins A and B in natural food products was studied and considerable success was attained in an effort to prepare a vitamin rich concentrate from yeast. The phenomena of growth, its suppression and acceleration under various regimens, the effect of the individual inorganic constituents of the diet, these and many other topics received attention at different times.

The remarkable influence of minute traces of certain organic substances, the presence or absence of which in the diet determine success or failure of nutrition, drew attention to the importance of an investigation of the constituents of living cells. This led to a detailed study of extracts of the alfalfa plant and of yeast, both of which are valuable sources of vitamins. Much of the information secured did not reach the stage of publication, but a striking demonstration was obtained of the complexity of the chemical environment in which the life process takes place.

It would be incorrect to assume that Dr. Osborne's interest in the fundamental chemistry of proteins waned as he penetrated more deeply into the mysteries of animal nutrition. Innumerable chemical problems arose as a result of the feeding work and demanded solution. Such, for example, was the discovery in 1913 of lysine among the products of hydrolysis of gliadin: its presence had escaped the notice of previous observers, including himself. A study of the constituents of milk in 1917 revealed a new protein soluble in diluted alcohol, the first animal protein possessing this property to be found. Its anaphylactogenic relationships were worked out in collaboration with Professor Wells in 1921, and it was demonstrated to be distinct from the other three proteins of milk.

Dr. Osborne made a fundamental contribution to the chemistry of nucleic acids in 1900, when he announced the discovery of tritico-nucleic acid in the wheat embryo and observed that this substance yielded the purines, guanine and adenine, in molecular proportions. Subsequently he made it clear that the various nucleoproteins which could be prepared from the wheat embryo were in reality salt-like compounds of one and the same protein with variable proportions of nucleic acid. Generalizing from these observations he pointed out that the numerous nucleoproteins from animal sources that had been described were, very probably, also salt-like compounds of protein with nucleic acid.

Although all the preparation work and much of the chemical investigation of the proteins was done before the modern conceptions of acidity had been advanced, Dr. Osborne was aware of the influence of different degrees of acidity on his preparations. One of his early papers on the effect of small amounts of acid on edestin[4] contains the phrase "the concentration of the hydrogen ions in the solution," and it was his custom invariably to state the indicator which he used. It was not sufficient to neutralize a solution; the solution was neutralized to phenolphthalein, or litmus, or tropeolin, as the case might be, and the differences in behavior so indicated were fully appreciated. It is this meticulous attention to detail which gives Dr. Osborne's early work a value to the present-day physical chemist and renders it possible to furnish an interpretation in terms of modern theory, as has recently been done by Cohn.

Dr. Osborne was one of the most distinguished pupils of Professor S. W. Johnson, and through him traced his intellectual ancestry back to Liebig, the founder of agricultural chemistry. A painstaking, careful investigator who spared no effort, time or expense in the attainment of the truth, Dr. Osborne accepted no result until it had been subjected to the test of rigorous and repeated experiment and all his publications bear the marks of meticulous editing, lest a statement should to the slightest extent pass the bounds of ascertained fact.

To those who were privileged to be associated with him in his work he was a rare stimulus, a formidable opponent in argument and an ever genial but just critic. He frequently closed a discussion with the remark that facts were to be found in the laboratory, not in the books. Naturally shy and retiring, the delivery of a public address or of a paper was a severe trial to which he looked forward with trepidation. But among a small group of friends he showed himself as a gifted conversationalist, who was equally able to discuss the latest achievements of science, the current political situation, the intricacies of the world of finance or the faults of the modern educational system.

The first public recognition of Dr. Osborne's exhaustive work came from Germany. V. Griessmayer, in 1897, published a book

[4] T. B. Osborne, *Z. physiol. Chem.*, **33**, 225 (1901).



on vegetable proteins that contained many extracts from Dr. Osborne's papers and stated in the introduction that it was his object "to bring to light these treasures buried in their American publications." This encouragement at a time when few of his associates or scientific friends had any conception of what his work meant, was of great assistance to him.

In 1900 he was awarded a gold medal by the Paris Exposition. In 1910 recognition came from Yale University in the form of the honorary degree of Sc.D., and in the same year he was elected a member of the National Academy of Sciences. Two years later he was made an honorary fellow of the London Chemical Society, and in 1914 he was made a fellow of the American Academy of Arts and Sciences.

In 1922 he received the John Scott medal and in the following year was made a research associate in biochemistry of Yale University with professorial rank. In 1928 he was the first to receive the Thomas Burr Osborne gold medal founded by the American Association of Cereal Chemists in recognition of his outstanding contributions to cereal chemistry.

Dr. Osborne's extensive investigations would have been impossible without generous financial support and encouragement. Throughout the early years, when results came slowly and their application was by no means apparent, the directors of the Connecticut Agricultural Experiment Station, in the early years Professor S. W. Johnson, and after 1900, Dr. E. H. Jenkins, with the coöperation of an enlightened board of control, allowed no interference or distraction to hinder the progress of the work. Since 1904 a large proportion of the financial burden has been borne by the Carnegie Institution of Washington, D. C., of which he was a research associate. Dr. Osborne's connections with both the experiment station and the Carnegie Institution of Washington furnish a striking example of the value to science of a policy of non-interference on the part of those in control of the distribution of funds for research. Except for routine annual reports he was never asked for statements of progress or for outlines of projects. The relationship was always one of the utmost mutual confidence and esteem.

The results of Dr. Osborne's investigations were summarized in a monograph, "The Vegetable Proteins," which first appeared in 1909 and was extensively revised in 1924. This slim volume has become the classical publication in the field. His extensive studies of wheat proteins were reviewed in "The Proteins of the Wheat Kernel" (1907), now a standard text among cereal chemists. Including these and a few public addresses and popular articles a complete bibliography of his publications reaches 253 titles, of which about two hundred are journal reports of his personal scientific work.

Dr. Osborne's most marked characteristic was, perhaps, the thoroughness with which his problems were investigated. In the early preparation work each protein was isolated in as many different ways as possible, the composition finally ascribed to it was deduced from a large number of carefully conducted analyses and, where the economic importance of the protein warranted it, he returned again and again to its study. The wheat and maize prolamins received extraordinary attention and the methods of preparing even these well-known substances were recently, with the aid of his assistants, materially improved. Time and again he discarded the whole of his painfully acquired results to make a fresh start, this time to "do it right," as he expressed it. His death removes one of the great pioneers of American biochemistry, a man whose name will always be linked with the subject he made peculiarly his own. He was more fortunate than most men in that advancing years, distinctions and scientific recognition did not bring with them administrative responsibilities that deprived him of the opportunity to share in the daily work of the laboratory. His time was always freely available for discussion, not only with his associates, but with the innumerable investigators from all parts of the world who came to New Haven to see him and ask for advice. Ever kindly and courteous, with keen insight into the problems of others and an extraordinary wealth of experience upon which to form his judgments, he has left a memory that will long be treasured by those who had the privilege of knowing him.

HUBERT B. VICKERY,
LAFAYETTE B. MENDEL.

# SELECTED PAPERS OF DR. OSBORNE

## OUR PRESENT KNOWLEDGE OF PLANT PROTEINS[1]

To the biological chemist few substances present so many features of interest as the proteins of plants. These lie at the very foundation of the nutrition not only of plants but of animals, and from them are derived a multitude of products directly connected with physiological processes. The study of chemistry of plant proteins, although it early interested several of the leading chemists of their time, has received in the aggregate so little attention that to-day our knowledge of this subject is but slightly advanced beyond what may properly be called a beginning. How slow the progress has been may be shown by a brief review of the literature that is on record.

### HISTORICAL

In 1746, Beccari announced his discovery of a peculiar substance which he obtained by washing wheat flour with water, that had all the properties which up to that time had been considered to be characteristic of animal life only. This substance, which we now know to be wheat gluten, appears to have been for more than fifty years the only form of vegetable protein that was known, for Beccari failed to obtain similar products from other seeds. In 1805, Einhof discovered that a part of the gluten of wheat was soluble in alcohol, and he described the existence of similar proteins in rye and barley. Einhof overlooked the fact that only a part of the gluten of wheat was dissolved by alcohol, and he considered this property to be characteristic of all plant proteins except the "Eiweiss," which he obtained by heating the aqueous extracts of seeds and other parts of plants. When, therefore, he later discovered in leguminous seeds another form of protein which was not soluble in alcohol, but had in pronounced degree the properties of "animal matter," he assumed that he had obtained a substance belonging to a distinctly different group but yet related to the gluten or "Kleber" that had been found in other seeds.

Taddei, in 1820, showed that only a part of the wheat gluten was soluble in alcohol and he applied distinctive names to each part; gliadin to the substance soluble, and zymom to that insoluble, in alcohol.

From this time chemists were more and more attracted to the

[1] An address delivered before the American Chemical Society at New Haven, Conn., July 1, 1908. Reprinted from *Science*, **28**, 417 (1908) by permission of the editor.

study of vegetable proteins, and among those thus engaged are found many of the most distinguished chemists of the earlier part of the last century, such as Berzelius, Dumas, De Saussure, Boussingault, Liebig and many of his pupils.

In 1841, Liebig reviewed the work done in his and other laboratories on the properties and composition of plant proteins. The state of knowledge which then prevailed respecting this subject is well illustrated by the following quotation from his review:

> Another, in number very limited, class of nitrogenous compounds is very abundantly distributed. There are four of these substances, of which one occurs, without exception, in all plants, while the others are only constituents of certain families of plants. These are the nitrogenous food substances properly known under the names of Vegetable "Eiweiss," Pflanzenleim and legumin. . . . These substances, to which a fourth must be added, which I will name Pflanzenfibrin, are the true food substances of the plant-eating animals.

In discussing these four proteins, Liebig asserted that each was identical with the protein of animal origin bearing the corresponding name. The identity of legumin with milk casein was claimed and this protein he therefore named plant casein.

The work undertaken by Liebig was continued for twenty years or more by Ritthausen, who was one of his pupils. Ritthausen, in 1860, began the first serious study of these important substances and devoted much time and care to the production of preparations of the highest attainable purity, and to accurate determinations of their ultimate composition. His work greatly extended the scope of the prevailing knowledge of the plant proteins, and made it plain that these substances exist in much more diverse forms than had before been supposed. He also added much to our knowledge of the decomposition products of vegetable proteins by showing that they yielded many substances already obtained from proteins of animal origin, and discovered glutaminic acid which is now recognized as a constitutent of practically all proteins, whatever their origin. He was also the first to obtain aspartic acid from the products of protein hydrolysis.

In 1877 Hoppe-Seyler and his pupil Weyl applied to seeds the then recently developed method of extraction by solutions of neutral salts. They showed that a large part of the protein of a number of different seeds was soluble in such solutions, and had the properties of the so-called globulins of animal origin. While the experimental work of these investigators was hardly more than qualitative and of very superficial character, the conclusions which they drew and the criticisms of Ritthausen's work which they put forth were generally accepted as final by most physiologists, and threw it into general discredit.

Although Ritthausen afterwards showed that a large part of many of his previously described preparations, which had been obtained by extraction with dilute alkalies, was soluble in solutions of neutral salts, and that the composition of many of the proteins which he had previously analyzed was the same as that of preparations obtained by extraction with solutions of sodium chloride, nevertheless physiologists continued to repeat the criticisms of Hoppe-Seyler, and the work of Ritthausen failed to receive the recognition which it deserved.



### REVIEW OF THE WRITER'S WORK

Since Ritthausen ceased his work with vegetable proteins little has been done in this field outside of my own laboratory. It is true that from time to time papers have appeared dealing with special questions in the chemistry of these substances, but no other connected and extensive investigation has been described, and as the work which I have been doing during the past twenty years has now reached a point where it can be profitably reviewed, I propose to take up some of its more important features and briefly discuss them.

As Ritthausen's researches were far from exhaustive and left the subject in such a state of confusion that it was impossible to form definite conclusions respecting much that he had described, it seemed best to me to direct attention chiefly to those seeds which had been previously studied by him and by others, and to try to clear up the existing uncertainties, rather than to add to them by describing new proteins. As a result, we now have about twenty-five different proteins of vegetable origin, the important characters of most of which have been studied by all means at present available. These proteins appear to represent the different types to be found in seeds and are, I think, sufficient in number to form a suitable foundation for the future study of their chemistry. All of these are constituents of seeds. A few of them represent constituents of the physiologically active embryo, but the majority represent the reserve food protein of the endosperm, and serve not only for the nutrition of the growing seedling, but also for the nutrition of men and animals. Of the protein constituents of other parts of plants very little indeed is known.

### CHEMICAL INDIVIDUALITY OF PROTEINS

In considering the position of our present knowledge of the seed proteins, the question of chemical individuality should first be considered. We are now well past the time when agreement in solubility, ultimate composition and color reactions, are to be accepted as evidence of the identity of two preparations of protein. It is not necessary to explain why it is at present not possible to demonstrate the chemical individuality of any single protein, for the reasons are evident to all who will give this question the slightest consideration from the standpoint of the organic chemist. While it is not possible to establish the individuality of any protein, it is possible to show differences between the various forms which can be isolated, and to establish a constancy of properties and ultimate composition between successive fractional precipitations which give no reason for believing the substance to be a mixture of two or more individuals.

On the basis that agreement in ultimate composition affords no evidence of identity of two similar proteins, but that distinct and constant differences in composition are conclusive evidence that they are not alike, I have endeavored to differentiate the several seed proteins that I have studied, and have since subjected them to careful comparisons in respect to their physical properties and the proportion of their decomposition products, so that those which are alike in their more apparent characters have been still further distinguished from one another. Whether these are in fact chemical individuals, must await the development of new methods of study. For the present they must be accepted as the simplest units with which we can deal.

## SUITABILITY OF SEED PROTEINS FOR A STUDY OF PROTEIN CHEMISTRY

The various proteins thus established furnish material for further study, and are characterized by wide differences not only in physical properties, but in the proportion of their decomposition products. They can be prepared in large quantity in a high state of purity, and, being a part of the reserve food stored up for the nutrition of the developing embryo, are by nature more stable than the animal proteins which form a part of physiologically active tissues. Furthermore, they are not associated with tissues and fluids rich in other forms of protein from which they are to be separated, and they are mostly obtained in the form of dense precipitates, often crystalline, which are little inclined to adsorb other substances from which they can afterwards be separated with difficulty. Although associated intimately in the seed with many forms of soluble and insoluble carbohydrates, they can, in many cases, be separated from every trace of the latter, as is shown by appropriate reactions.

It is my firm belief that a careful examination of them will ultimately afford a better knowledge of the chemistry of proteins in general than can be obtained from proteins of animal origin. Although the problems immediately connected with the animal proteins are of greater importance to physiology than those at present recognized as connected with seed proteins, there is no question but that definite knowledge of the chemistry of seed proteins will be directly applicable to many important problems of animal physiology.



## THE DIFFERENT GROUPS OF PROTEINS FOUND IN SEEDS

The seed proteins for the most part can be grouped in much the same way as the proteins of animal origin, but in so doing, it is necessary to modify to some extent the requirements to which the animal proteins belonging to some of these groups are at present assumed to conform. The necessity of some scheme of classification for the proteins is recognized by all who write or teach about them, and although the present method of classifying proteins according to their solubility is wholly unsatisfactory from a purely chemical standpoint, it is practically the only one now available. On chemical grounds there is no more reason for dividing the proteins into two groups of animal and vegetable proteins, than there is for making a similar distinction between the carbohydrates. I have, therefore, endeavored to assign the various forms of seed proteins to the commonly recognized groups established for those of animal origin, and have proposed to slightly modify the definitions usually given for these groups, but only so far as this is necessary.

1. *Globulins* form much the greater part of the reserve protein of all seeds except those of the cereals. By globulin is meant protein soluble in solutions of neutral salts but insoluble in water. This definition does not strictly apply to many of the seed proteins assigned to this group, for these behave as globulins only under certain conditions. As these conditions prevail during the extraction and isolation of these proteins and depend on the presence of free acid in the extracts, it is important to consider the relations of the proteins to this acid.

The behavior of seed globulins toward acid is shown by studies made in my laboratory on edestin. Crystallized preparations of edestin, obtained by dialyzing or cooling sodium chloride extracts of hemp-seed, frequently contain protein in three forms; one, soluble in pure water and also in strong saline solutions, another, insoluble in water but soluble in strong saline solutions, and still another, insoluble either in water or in saline solutions. The proportion of these products varies with slight differences in the conditions under which the edestin is isolated, and plainly depends upon changes in the protein which take place during its preparation.

The explanation of these changes has been found in the presence of a small amount of acid extracted from the seed together with the protein. The part of the edestin preparation just referred to, which is insoluble in neutral saline solutions, has been found to be a product of the hydrolytic action of the acids of the extracts. This product is not the result of a profound splitting of the edestin molecule, for the changes leading to its formation are so slight that they can be detected only by the altered solubility. For such primary products of protein hydrolysis, which were designated "albuminates" by Weyl, I have proposed the name "protean" and for the products derived from the individual proteins, a corresponding name ending with the affix *an*. Thus the product derived from edestin may be called *edestan*. The part of the edestin above referred to which is soluble in water contains more combined acid than the part insoluble therein. The preparation, therefore, contains a mixture of salts of edestin. These edestin salts contain some of all the anions present in the solution at the time of precipitation, that salt being predominant whose free anion was most abundant in the solution from which the edestin was last precipitated. When freed from this combined acid by making the preparation neutral to phenolphthalein, the edestin is wholly insoluble in water, but soluble in neutral saline solutions. Edestin has, consequently, the properties of a true globulin. Other seed proteins behave towards acids in a similar way, except that some of them, when neutral to phenolphthalein, are soluble in water. Many of these latter behave as globulins when in the form of salts, and as they are obtained as salts by the methods employed in preparing them, I have, for convenience, placed them among the globulins.

The fact that our protein preparations, as usually obtained, are protein salts is fundamental for a correct conception of their behavior under the conditions of isolation and purification, and for an explanation of many of their physiological relations.

The seed proteins which are described as globulins differ in some of their properties from some of those that are commonly assumed to characterize the globulins of animal origin. In this connection, however, the fact should not be overlooked that our knowledge of animal globulins is relatively small, and it is probable that further study will modify our present conception of them. It has become customary for physiologists to consider that all *globulins* are precipitated by adding to their solutions an equal volume of a saturated solution of ammonium sulphate, and of recent years it appears to have become an almost universal practise to designate as globulin all of the protein that can be thus precipitated. This practise is unfortunate and leads to confusion, for it wholly ignores the original conception of a globulin, namely, a protein soluble in neutral saline solutions but insoluble in water.

Globulins are commonly described as proteins that are coagulated by heat. This is doubtless true of the globulins of seeds if sufficient acid is present in their solutions. It is, however, difficult to add to the saline solutions of most seed globulins a sufficient amount of acid to cause complete coagulation on heating, for even a very minute quantity of acid in a strong saline solution alone precipitates a large quantity of the globulin.

The deportment of edestin in this respect is well illustrated by the experiments of Chittenden and Mendel,[2] who showed that a saline solution of edestin was only partly coagulated by boiling,

[2] Chittenden and Mendel, *J. Physiol.*, **17**, 48 (1894).



that the edestin remaining in solution could be recovered unchanged and in well-formed crystals, and that addition of acid to the solution filtered from the coagulum gave rise to a new coagulum on again heating.

2. *Prolamins*[3] form a unique and sharply differentiated group of proteins which occur in quantity in the seeds of cereals, but not in those of any other plant yet examined. These are soluble in all proportions in alcohol of 70-80 per cent., and are not affected by boiling their alcoholic solutions, even for a long time. They are practically insoluble in water and saline solutions, but are soluble in dilute solutions of acids and alkalis.

The prolamins are better characterized, from a chemical standpoint, than any of the other groups of seed proteins, for on hydrolysis they all yield a very small amount of arginine and histidine and no lysine whatever. On the other hand, they yield from 20 to 30 per cent. of their total nitrogen in the form of ammonia and also contain relatively large amounts of glutaminic acid. Gliadin from wheat and rye, and the related hordein from barley, yield about 37 per cent. of glutaminic acid, which is very much more than that found in any other protein yet examined, and zein yields nearly 20 per cent., which places it among the proteins relatively rich in this amino-acid.

Prolamins have been found in the seeds of all the cereals examined in my laboratory, namely—oats, wheat, maize, rye, barley and sorghum. That this form of protein is characteristic of the seeds of all grasses is rendered improbable by the recent report of Rosenheim and Kajiura,[4] who found none in rice. A detailed statement of their results, however, has not, to my knowledge, yet been published.

3. *Glutelins* constitute a large part of the proteins of all cereals that have been studied, and possibly occur in seeds of other kinds. These proteins are insoluble in all known neutral solvents, but are easily dissolved by very dilute acids or alkalis. Only one member of this group is known which is accessible to satisfactory investigation. This is the glutenin of wheat which forms nearly one-half of the gluten. Owing to the fact that glutenin can be separated from the other components of the seed as a constituent of the gluten, it is possible to make preparations of it of a fair degree of purity.

As the seeds of the other cereals yield no coherent gluten, the

[3] I propose this name for the group which heretofore has been simply called alcohol-soluble proteins. The name refers to the relatively large proportion of proline and amide nitrogen which they yield on hydrolysis. The English committee on protein nomenclature has very recently proposed to call these proteins gliadins, but as this name has long been used to specifically designate the prolamin obtained from wheat it seems to me important to have a distinctive name for this group.

[4] Rosenheim and Kajiura, *J. Physiol.*, **36**, liv (1903).

protein corresponding to glutenin can not be isolated from them, for the alkaline extracts of these seeds are too gummy to filter and the small amount of the preparations that can be obtained is very impure.

Whether glutelins are constituents of other seeds is a question not yet settled. Most seeds, when exhausted with the several neutral solvents, still contain a small amount of protein which can be extracted with alkaline solutions. It has not yet been definitely determined whether these products are residues of the other proteins extracted by the neutral solvents, or are actually different substances. It is quite conceivable that a part of these other proteins may form combinations with other constituents of the seeds which are not soluble in neutral solvents but are extracted by alkalies, and also that a part of the protein is enclosed in tissues which are dissolved by the alkali and the protein then brought into solution. It is also possible that much or all of this protein is the result of a change, whereby a part of the protein originally soluble in neutral solvents is converted into less soluble products, such as those which have been designated as proteans. The quantity of nitrogen which remains in the thoroughly extracted residues of the seeds is small in the case of most seeds other than the cereals, and it is not probable that many of these contain much, if any, protein belonging to the glutelin group.

4. *Albumins* are probably present in *very* small amount in nearly all seeds, and in none of those that I have examined are they present in large amount. The albumin is probably a part of the physiologically active embryo, and resembles the proteins of animal origin in properties, ultimate composition and proportion of the various products of hydrolysis, more closely than do most of the reserve proteins of the endosperm. While the albumins of seeds are like those obtained from animals in the essential properties of solubility in water and coagulability by heat, they differ in their precipitation relations towards strong solutions of inorganic salts.

It is at present almost universally assumed that albumins are not precipitated by adding to their solutions an equal volume of a saturated solution of ammonium sulphate, but this is not the case with all of the albumins from seeds. Many of them are also precipitated by saturating their solutions with sodium chloride or with magnesium sulphate, in which respect they differ from animal albumins.

5. *Proteoses* similar to those of animal origin have been obtained from all the seeds examined, and from some, proteoses closely resembling hetero-, deutero- and proto-proteose were separated. The amount of such proteose is small in all the seeds which have come under my observation, and it is possible that all of this is formed by enzyme action during isolation of the other proteins of the seeds.



There are several groups of proteins which occur in animal tissues, which have not yet been proved to exist in plants. The most important of these are those which contain phosphorus. In the yolk of eggs and in the milk of mammals, a large part of the protein which nourishes the developing animal contains phosphorus which appears to be intimately concerned in the structure of its molecule. No similar phosphorus-containing proteins have been found in seeds, although by analogy such might be expected to occur. It has been asserted that such proteins are found in leguminous seeds, but an examination of the literature will show this assertion to be founded on very little experimental evidence. Czapek, in his "Biochemistry of Plants," describes the proteins of seeds as vitellins which doubtless contain phosphorus. This view, however, has no evidence to support it and is quite incorrect.

The existence of nucleoproteins, that is of compounds of nucleic acid with protein, is a different question and involves consideration of the chemical nature of these substances as now described. The nucleoproteins are, as far as I know, always described as phosphorus-containing proteins, and the phosphorus seems to be generally considered as a constituent of their molecules. This, of course, is strictly true even if the combination be only that of a base and an acid, but from the standpoint of protein chemistry it makes a great deal of difference whether this union is that of a salt, or one in which the phosphorus-containing groups are in intimate organic combination within the protein molecule. That true nucleic acids exist abundantly in seeds has been demonstrated by investigations made in my laboratory on the wheat embryo. In these investigations a great deal of attention was devoted to the protein compounds of the nucleic acid, but all the evidence obtained indicated very plainly that these were simply protein nucleates, the composition of which depended solely on the conditions prevailing at the time of precipitation. That *similar* combinations exist within the embryo is practically certain, but that any of the combinations actually isolated were *identical* with the combinations that exist in the seed, I consider highly improbable. Whether the nucleoproteins that have been described from animal tissues are more definite and intimate combinations between the nucleic acid and the protein than are the protein nucleates just mentioned, I am not prepared to say, but I think that nucleoproteins deserve more consideration from this point of view than they have received.

Whether, or not, true glycoproteins are contained in seeds, remains to be demonstrated. That a large part of the seed proteins are entirely free from any carbohydrate yielding group, is proved conclusively by the fact that these yield no trace of the Molisch reaction. That those that give the Molisch reaction contain a carbohydrate group as a constituent of their molecule is seriously to be questioned, for it is not possible to obtain even traces of furfurol from them.

If one considers how small an admixture of carbohydrate gives a very strong reaction with the Molisch test, it may well be asked whether this reaction is not sometimes caused by a slight contamination. The possibility of this is so great in the preparations of proteins extracted from seeds containing a great variety of carbohydrates, glucosides and nucleic acids, that conclusions drawn from the results of the Molisch reaction have value only when this turns out negatively.

In plants no representative has yet been found of the group of albuminoids which form in animals so large a part of the skeleton, connective tissues, the skin and its appendages.

Although the nucleated cells of the wheat embryo are rich in nucleic acid which closely resembles in its properties and structure the nucleic acids obtained from the nucleated cells of animals, no substances have yet been found in plants which resemble the protamines which, in combination with nucleic acid, occur so abundantly in the spermatozoa cells of animals. Such substances are to be sought in the pollen cells of plants, but as yet no attempt has been made to isolate them, owing to the difficulty of obtaining a sufficient supply of material, and the fact that the nucleus of the cell forms so small a part of the whole structure.

## PRODUCTS OF HYDROLYSIS OF SEED PROTEINS

Of the known primary products of protein hydrolysis all but one (diamino-trioxydodecanic acid, as yet obtained only from casein) have been isolated from seed proteins, and there is no indication that any essential difference exists in the general character of the structure of the proteins from these two forms of life. Some of the seed proteins, like some of those from animals, lack one or more of the amino-acids; and zein, from maize, lacks glycocoll, tryptophane and lysine. The crystalline globulins, which are possibly more definite chemical individuals, have yielded on hydrolysis as complicated a mixture of amino-acids as any of the amorphous preparations. These, therefore, furnish no ground for the assumption that the several proteins, as we now know them, are mixtures of less complex substances.

Of twenty-three different seed proteins which have been hydrolyzed, all have yielded leucine, proline, phenylalanine, aspartic acid, glutaminic acid, tyrosine, histidine, arginine and ammonia. Five have yielded no glycocoll. Two yielded no alanine which could be positively identified, but did yield impure products which left little doubt but that this amino-acid was present. Four yielded no lysine, and one, no tryptophane. Four of these proteins yielded extremely small quantities of cystine, three others, none. The



remaining sixteen have not yet been examined for this amino-acid on account of the difficulties encountered in separating small quantities of it. No attempt has yet been made to isolate isoleucine. If this amino-acid is yielded by the seed proteins it will probably be found in the mixture of undetermined substances from the third fraction of the esters, which has not been converted into products suitable to weigh. Glycocoll, lysine and tryptophane are the only amino-acids that have been proved lacking in any one of these proteins.

In respect to the quantitative relations of the amino-acids, the fact must not be overlooked that the determinations of many of them are to be regarded only as approximations to the amounts actually yielded by the protein. The determinations of the mon-amino-acids by Fischer's method are doubtless comparable within certain limits, if sufficient care is exercised in conducting the analysis. The quantities of these amino-acids recovered are unquestionably less than those actually present, for esterification is never complete and the losses incident to the separations by fractional crystallization are not inconsiderable. Under uniform conditions, however, losses are nearly uniform and the figures representing the quantities of amino-acids found give a good idea of differences and similarities between the different proteins. Such figures are in most cases comparable to within perhaps one per cent. of the protein, and probably represent about seventy-five per cent. of the total quantity of the amino-acids which are determined that were originally formed by hydrolysis, providing that these amino-acids are first subjected to two well-conducted esterifications. Most uncertainty attaches to the results obtained for valine and serine, which are separated from associated substances with such difficulty that the determinations of them must be regarded as simply qualitative. Alanine also is difficult to separate in a condition fit for weighing, and no importance is to be attached to differences in the amount of this amino-acid unless these are pronounced.

A very extensive experience, however, with determinations, of arginine, histidine and lysine has convinced me that it is possible to make quantitative determinations of these bases which are very accurate. The results of these determinations can be controlled by comparing the amount of nitrogen contained in the quantities found with that precipitated by phosphotungstic acid under definite conditions which have been worked out in my laboratory. The amount of ammonia yielded by hydrolysis can be determined with such accuracy that differences of only a very few hundredths of a per cent. occur between determinations made on different preparations of one and the same protein. These four determinations are the most reliable that we now have for comparing proteins with one another, and make it possible to detect differences between them which would otherwise escape notice.

Glutaminic acid can be determined in most cases with a close approximation to its true amount, but there are some proteins, especially those from leguminous seeds, from which it is not easily obtained. Experience has shown that by the ester method alone about seventy-five per cent. as much glutaminic acid is usually obtained as by direct separation as the hydrochloride. It is possible, therefore, to control to a certain extent the results of direct determinations by comparing them with those obtained on a larger scale by the ester method.

Although the methods available for thus quantitatively analyzing the products of protein hydrolysis leave much to be desired, it must not be forgotten that only recently have we been able to make any comparison whatever of the proportion of these products.

A striking feature of these analyses, to which Professor Chittenden directed attention in his address before this society last January, is that the total quantity of the substances determined falls far short of one hundred per cent. The majority of successful analyses foot up between sixty and seventy per cent., and of this a part is made up of water which has been introduced by hydrolysis. Calculation shows this amount of water to be approximately equivalent to the losses that may be assumed to occur through incomplete esterification and separation of the acids, so that the summation of well-conducted analyses may be taken as representing somewhere near the total quantity made up by all the different substances determined.

Nothing is known of the undetermined residue which forms from twenty-five to thirty-five per cent. of the protein. There is no reason to believe that, in the seed proteins, undetermined carbohydrate forms any part of this, for those proteins which give no Molisch reaction give no higher summation than do those that do.

If the amount of nitrogen contained in the quantities of the amino-acids stated in the analyses is subtracted from the total nitrogen of the protein, it is found that this undetermined nitrogen forms about fourteen per cent. of the undetermined part of the protein. This is a higher proportion of nitrogen than is found in any of the monamino-acids that are known to be yielded by proteins, except glycocoll, alanine, serine and tryptophane, even if the proportion of nitrogen is calculated for them as united with one another in polypeptide union. It is improbable that this undetermined residue is made up of these four amino-acids, and we may expect to find still undiscovered substances among the protein decomposition products.



## COMPARISON OF THE PROTEINS OF DIFFERENT SEEDS

The results of this comparative study of the seed proteins shows that no two seeds are alike in respect to their protein constituents. Similar proteins are found only in seeds that are botanically closely related.

The cereals are alike in the proportion and general character of their proteins. The seeds of each of these, with the probable exception of those of rice, contain a small amount of proteose, albumin and globulin, and relatively considerable quantities of prolamin soluble in alcohol, and of glutelin insoluble in neutral solvents. With the exception of the nearly related wheat and rye, the proteins soluble in alcohol from each of the cereals are distinct substances. Although no certain difference has yet been detected between the gliadin of wheat and of rye, their glutelins are not alike.

The leguminous seeds are similar in the general character of their proteins, but marked differences exist between the proteins of the various groups. Thus *Lupinus, Vicia* and *Phaseolus* present marked differences in their proteins, whereas the proteins of the species of each genus are very much alike. The proteins of *Lupinus luteus* and of *Lupinus angustifolia* differ slightly but in their physical properties are clearly distinguished from any of the other seed proteins. Although similar proteins are obtained from the horse bean, lentil, pea and vetch, these are distinctly different from the proteins obtained from other leguminous seeds. These seeds are not alike, however, in the proportion of their several proteins. The chief protein of *Phaseolus vulgaris* appears to be identical with that of *Phaseolus radiatus,* but the small amount of other protein was found to be different in properties and composition in each of these seeds.

The cow pea (*Vigna*) and soy bean (*Glycine*) contain distinctly different proteins which, however, are similar to but different from those of *Vicia*. The globulins of the seeds of *Corylus* and *Juglans* are much alike, but not identical, while those from *Juglans regia, nigra* and *cinerea,* so far as they have been compared, show no differences. The proteins of other seeds show marked differences, but the botanical relations of these seeds are not such as to permit of further discussion of this subject.

Although the data for generalizations are as yet few, those that are available plainly indicate a close connection between the chemical constitution of the seed proteins and the biological relations of the plants producing them.

That similar differences exist between homologous proteins of different species of animals is becoming evident from the facts which are gradually accumulating, and these strongly suggest a chemical basis for the multitude of diverse forms of animal and vegetable life.

## THE CHEMISTRY OF THE PROTEINS[1]

The recent advances made in our knowledge of the chemistry of the proteins have attracted wide attention and excited much interest on account of the important connection which they have with many of the fundamental problems of physiology and biochemistry. These newer discoveries have been the subject of many excellent reviews and are now familiar to most of those who are interested in the various branches of biology. On the other hand, there are aspects of protein chemistry which have received but little notice during recent years, although they have an important bearing on the application of these discoveries to physiological problems. These seem well worth bringing before you this evening.

Attention has of late been largely centred on the salient features of the constitution of the proteins as revealed by the brilliant work of Fischer and of Kossel, and many elaborate attempts have been made to apply the ideas suggested by their discoveries. These have at last given us a conception of the constitution of these substances which, while far from complete, has been of the greatest help in dealing with chemical and physiological problems in which the proteins are involved.

The two most important of these new discoveries in protein chemistry are that the proteins consist essentially of combinations of amino-acids joined with each other by a union between the carboxyl group of one with the amino group of another, and that many of the various forms of protein differ widely in their constitution. That the proteins are composed, at least in large part, of combinations of amino-acids can be accepted as proved by the fact that the only substances which have been isolated from the products of their complete decomposition are amino-acids, and a small proportion of ammonia. That these amino-acids are united in the way just stated is proved by the presence among the products of partial hydrolysis of combinations of amino-acids which are identical with synthetic products of known constitution. Whether those amino-acids which are now obtained from the proteins are their only constituents is still undetermined, for in no case, if we except one or two of the protamines, have the recovered products of hydrolysis been even approximately equal to the amount of protein which yielded them. All who are familiar with the methods employed in making these analyses have regarded the values obtained for many of the amino-acids as minimal, but some of these, as, for instance, those for glutaminic

[1] A lecture delivered February 4, 1911, before the Harvey Society and reprinted with the permission of the J. B. Lippincott Company, Philadelphia, publishers of the Harvey Lectures, and of the secretary of the Harvey Society.



acid and tyrosine, have been considered, notably by Abderhalden,[2] as approximately correct. So long as much of the protein cannot be accounted for in products of definite character, uncertainty will prevail as to whether many of the apparent differences between the individual proteins are in fact real or only due to imperfections in the analytical methods, and the uses to which these analyses can be applied will be very greatly restricted. Thus to give a concrete example: from gliadin, which constitutes a large part of the protein of wheat, upwards of thirty-five per cent. of glutaminic acid can easily be isolated, whereas from milk casein, under similar conditions, only about eleven per cent. can be obtained. Since about one-half of the products of casein are as yet unknown it is quite possible that among these is a quantity of glutaminic acid that, for some undiscovered reason, is held in solution, and this may be quite sufficient to make up for the apparently great difference between gliadin and casein.

We have now come to the point where the chemical individuality of our protein preparations is a matter of much importance for future studies, both chemical and physiological, and it will be well to review briefly the data which can help us to form some conclusions concerning this question. As this is the logical starting point for a discussion of the chemistry of the proteins I will take it up first.

A large number of protein substances are now on record to which special designations have been given, but about many of these we know at present comparatively little. To a few of them much attention has been directed, but unfortunately many of those who have worked with them have had little experience with such substances and their efforts have led to so much confusion that it is almost impossible to form any estimate of the value of the recorded data.

As the animal organism consists for the most part of protein, and as each individual protein occurs associated with many others, it has been especially difficult to isolate products of definite properties from such tissues. The animal proteins are the ones with which the majority of those interested in protein chemistry are familiar, and it is not surprising that the definite character of our so-called individual proteins is regarded with much more than suspicion. Very little really serious work has been done with any protein of animal origin except ovalbumin. This is the only one which has been subjected to careful fractional crystallization, whereby the constant chemical and physical properties of successive fractions have been established. In regard to crystallized serum albumin less is known than of ovalbumin.

In the case of the hæmoglobins the matter stands even worse,

[2] Abderhalden and Samuely: *Z. physiol. Chem.*, **46**, 196 (1905).

for no extensive study of the products of fractional crystallization has yet been made, and some of the recorded data as to ultimate composition are manifestly wrong in consequence of analytical blunders. These, however, are still quoted as evidence of the uncertain composition of this substance, and it seems to be generally believed that it is impossible to make two preparations of these beautifully crystallizing substances which are alike.

The seeds of many plants afford the best material from which to obtain preparations of definite character, for in these we find a relatively large proportion of reserve protein, which is in a sense the excretory product of the protoplasm of the cells of the ripening seed. This reserve protein is far more stable than that from animal tissues, and usually can be subjected to extensive fractional crystallization, or precipitation, without showing any detectable change in properties. As such protein has the characteristic structure shown by the animal proteins it is the best material now at our disposal for a study of the chemical and physical characteristics of proteins in general, and apparently furnishes the best preparations for experimental studies of nutritional and other physiological problems. The knowledge gained by such study will to a large extent be applicable to proteins of animal origin.

In regard to the chemical individuality of any of the proteins nothing definite can be said, but there are good reasons for believing that many of those from seeds consist of but a single substance, as the methods which have readily shown the presence of two or more proteins, in preparation from some seeds, have not given the slightest evidence of an admixture in those from others.

The crystalline globulin edestin, which is obtained from hempseed, has been the subject of a most extensive fractionation under a great variety of conditions, and has yielded fractions which have not shown any differences which exceeded the limits of error of observation in ultimate composition, in the partition of nitrogen, or in specific rotation.[3] These facts are important, for edestin yields on hydrolysis just as complex a mixture of amino-acids as do any of the proteins yet analyzed, and hence affords no basis for the belief that the individual proteins, as we now know them, are mixtures of relatively simple polypeptides, each containing but a few of the amino-acids. It is impossible after my experience to believe, as Fischer suggests, that many of the seed proteins are mixtures of several substances of simpler constitution. If this view were correct, it would seem improbable that a substance which crystallizes readily in definite form would resist all possible efforts to break up the mixture to at least some extent. This

[3] Unpublished results obtained by the author.



question deserves still more critical study, and such work is now in progress in my laboratory.

I have gone into this question of the possibility of obtaining preparations of probable chemical individuality, because there is a widespread belief, largely founded on the indefinite character of the preparations of animal origin, that it is impossible to make protein preparations which are worthy of the consideration of the chemist.

To secure a few well characterized proteins is important to the future progress of protein chemistry, for our next task is to subject some of the best defined of these to exhaustive investigation of all their properties. It seems to me that only in this way can we ultimately acquire definite information which can be applied to proteins in general and thus obtain a secure foundation for physiological experiments and conclusions. In the process of differentiating the proteins the efforts of the earlier investigators were directed toward discovering similarities between those of different origin, for it was assumed that there were in nature only a comparatively small number of forms. As the means for differentiation were developed it gradually became apparent that the number of individual proteins was very great. The recently discovered precipitin and anaphylaxis reactions made it probable that an almost infinite number of chemically distinct forms occur in different animal and vegetable tissues, but the evidence was not conclusive that these reactions were actually due to the proteins contained in the different fluids and extracts which had been used in obtaining these reactions until Wells reported his anaphylaxis experiments, made a short time ago with carefully recrystallized ovalbumin. Some experiments with plant proteins, just published by Wells and myself, fully confirm this conclusion, and indicate very strongly that the specificity of the anaphylaxis reaction is intimately connected with the structure of the protein.

One series of our experiments are of direct interest in this connection, as they indicate that this reaction can be used to determine the relation of one protein to another, when these are so nearly alike that differences between them cannot be recognized by a most careful comparison of their physical and chemical properties. Preparations of globulin from the seeds of hemp, flax, squash, and castor-oil plant are obtained which are so nearly alike in ultimate composition, crystalline form, solubility and physical properties that only the most minute examination has revealed any differences whatever between them. We found that while all these proteins showed a strong anaphylaxis reaction, only those from the flax-seed and castor-bean showed any tendency whatever to react with one another, and between these the reaction was of a doubtful character. On the other hand, gliadin from rye reacted strongly with gliadin from wheat, a result in accord with the fact that by chemical or physical means no differences have been detected which were sufficient to indicate that these gliadins were different substances. Likewise legumin from the pea reacted with the apparently identical legumin from the vetch. No reactions were obtained between proteins of distinctly different structure nor between those from seeds botanically unrelated.

From these facts it is evident that structural differences exist between very similar proteins of different origin and it is interesting to note that chemically identical proteins apparently do not occur in animals or plants of different species, unless these are biologically very closely related. In this respect the proteins are in marked contrast to the other constituents of plants and animals, for not only do identically the same sugars and fats occur in many species of plants and animals, but many of these are common to both forms of life. It thus appears that the chemical constitution of the proteins is closely connected with the biological relations of the forms of life which produce them, and that the morphological differences between species find their counterpart in the protein constituents of their tissues. A similar differentiation has recently been made by Reichert and Brown[4] on the basis of the crystalline form of the hæmoglobins, since the measured angles of the crystals show close generic relations.

We have thus far merely considered the fact that differences exist between the proteins, but for the present problems of physiology the extent of these differences is of much more importance, for it is only within the last ten years that we have come to realize that the differences in the structure of many of the proteins, especially some of those extensively used for food, are so great as to require a complete change in our views of digestion and assimilation.

The first observation of an important qualitative difference was made long ago on gelatin, which by its failure to give more than feeble Millon's reaction, was known to contain no tyrosine. This protein was, however, not regarded as a typical one, but was assigned to the group of albuminoids containing those protein-like substances which compose the greater part of various specialized tissues having little, if any, physiological activity. Since none of these substances were regarded as capable of supplying protein to the tissues when taken as food, no special importance was attached to the fact that gelatin was deficient in one of the common constituents of food proteins, although it was known that it was capable of replacing a part of the protein in a maintenance diet.

[4] Reichert and Brown: Carnegie Inst. Wash. Pub. No. 116 (1909).



Attention was first directed in 1900 to the chemical constitution of food proteins, in their relation to nutrition, by Kossel and Kutscher,[5] who found that the alcohol-soluble proteins, which form a large part of the protein of wheat and maize flour, contained no lysine. These had long been used with success in feeding both men and animals, and the question of their nutritive relations was at once raised. I also found that zein, the alcohol-soluble protein of maize, which Kossel had found to yield no lysine, fails to give the Hopkins-Cole reaction, and therefore contains no tryptophane.[6]

In respect to quantitative differences between food proteins a series of determinations of the partition of nitrogen, made by Harris and myself[7] in 1903, showed that such wide differences in their structure existed that if these had equal values in nutrition a very considerable change in constitution must be effected in the process of assimilation which would involve much more elaborate synthesis than, at that time, was supposed to take place in the animal organism. A striking discovery, made in my laboratory, which showed to what extent quantitative differences might occur in proteins of recognized food value, was that gliadin from wheat flour yielded over 35 per cent. of glutaminic acid.[8] This observation was shortly followed by analyses of the products of hydrolysis of a large number of proteins from many sources, which have given us a general picture of the main peculiarities of most of those which are commonly present in our foods. In these analyses important differences in the proportion of each of the amino-acids have been revealed, especially among the reserve proteins of seeds. Thus through the gradually developed recognition of the fact that our food proteins differ widely in their constitution, entirely new aspects of the problems of digestion and assimilation have been raised, which are still the subject of investigation and controversy.

The physiologist may well ask, are these differences between the various food proteins as great as they appear to be? This question is justified, for, as I have already said, in these analyses hardly more than one-half of the total protein has been recovered in the form of definite products. Although there is no doubt that, in many respects, very considerable structural differences actually exist between many of the proteins commonly used for food, the degree of the accuracy of our present analyses should be considered in detail, so that the actual quantitative value of the determination of each of the amino-acids can be definitely ascertained.

[5] Kossel and Kutscher: *Z. physiol. Chem.*, **31**, 165 (1900).
[6] Osborne and Harris: *J. Am. Chem. Soc.*, **25**, 853 (1903).
[7] Osborne and Harris: *J. Am. Chem. Soc.*, **25**, 323 (1903).
[8] Osborne and Harris: *Am. J. Physiol.*, **13**, 35 (1905).

As a critical study of these methods has been in progress in my laboratory for some time, it may be a matter of interest to you to know some of the results already obtained. Not only our own work, but that of other laboratories, has shown that the amount of ammonia yielded by hydrolysis is uniform for each protein, and can be determined with accuracy. The proportion of the protein nitrogen obtained as ammonia has thus been found to be four times greater in some proteins than in others. The amount of arginine, histidine, and lysine can be estimated by Kossel's method with a relatively high degree of accuracy and can be controlled by determinations of the quantity of nitrogen precipitated by phosphotungstic acid under definite conditions. The results of the direct estimations of the basic amino-acids have been found to be very nearly equal to the amount of these substances actually present, and to be strictly comparable with one another. The only uncertainty attaching to carefully made determinations is caused by incomplete hydrolysis of the protein; this can be controlled by estimating the proportion of nitrogen precipitable by phosphotungstic acid, after hydrolyzing with hydrochloric acid for different periods of time.

From the results that we have obtained from a number of food proteins it has been found that the proportion of arginine or histidine is about ten times as great in some as in others. The proportion of lysine varied from none to 6.43 per cent. of these proteins while the lysine, obtained from the crude muscle substance of chicken and halibut, reached nearly 7.5 per cent. of the dry material, indicating that the pure proteins of these tissues yield an even greater quantity.[9]

Tyrosine, which has always been isolated by direct crystallization, can probably be estimated with a reasonable approximation to accuracy, although, according to my experience, it can never be so completely separated from the mixture of the amino-acids as Abderhalden assumes, who has stated that it is possible to thus separate it completely and regards its determination as one of the most accurate of those employed in analyzing the products of protein hydrolysis. If only pure tyrosine is weighed it seems possible to determine its proportion with a close approximation to the truth, but it is not always possible to determine the purity of the products weighed by some of those who have published such estimations. The amount of tyrosine obtained from food proteins falls between 2 and 4.5 per cent., although as much as 10 per cent. has been obtained from some of the albuminoids.

It has been commonly assumed that glutaminic acid in the form of its hydrochloride can be almost completely separated from the mixture of decomposition products by the method of Hlasiwetz and Habermann. Abderhalden has used this determination in order to show the relations of various proteins to one another, and has stated that the results are more nearly quantitative than those obtained for any of the other mono-amino-acids, with the exception of tyrosine. Confidence in the accuracy of these determinations has been largely founded on the close agreement between different determinations. Thus several investigators independently obtained from 10.5 to 11 per cent. of glutaminic acid from casein, and a like agreement was also obtained with several other proteins. In making these determinations the question whether the protein was completely hydrolyzed or not received little attention, for it was formerly assumed when the products of hydrolysis ceased to give the biuret reaction that the union between the amino-acids had been completely broken down.

Some time ago I found that a considerable quantity of an insoluble product was formed by hydrolyzing gliadin for several hours with twenty-five per cent. sulphuric acid, and that this, on subsequently boiling with strong hydrochloric acid, yielded relatively large quantities of glutaminic acid and cystine. The most direct evidence of the existence within the protein of a highly resistant union between two amino-acids was exhibited by the di-peptide of proline and phenylalanine which was obtained by Clapp and myself[10] from gliadin which had been boiled with 25 per cent. sulphuric acid for many hours. This di-peptide was completely hydrolyzed only by heating in a closed tube to a relatively high temperature for some time with strong hydrochloric acid. We thus have every reason to expect combinations of amino-acids which will require very energetic treatment with acids before they can be completely decomposed. These observations have led me to determine the output of amino-acids after prolonged boiling with strong hydrochloric acid, and as a result I have obtained from several proteins much more glutaminic acid than had formerly been isolated from them. Thus after doubling the time of hydrolysis of casein I have recently found, in five closely agreeing estimations, 15.5 per cent. glutaminic acid, or 50 per cent. more than was previously isolated. Zein, gliadin, and edestin have also yielded distinctly larger quantities than after the shorter hydrolytic treatment to which they had been previously subjected.

Before the results, thus far reported, in respect not only to glutaminic acid, but also to all of the other amino-acids obtained by Fischer's ester method can be accepted as final, they must be confirmed by new determinations made after boiling the proteins with strong acids until the hydrolysis is complete.

[9] Cf. Osborne, Leavenworth and Brautlecht: *Am. J. Physiol.*, **23**, 180 (1908).

[10] Osborne and Clapp: *Am. J. Physiol.*, **18**, 123 (1907).

Heretofore we have had no means whereby we could satisfy ourselves that the union between all of the amino-acids had been broken apart and the acids set free. Sörensen's method of determining this by adding methylene to the amino-nitrogen, and estimating the proportion of free carboxyl groups by titration, does not yield satisfactory results in practice, as the endpoint of the titration is too uncertain. The method recently proposed by Van Slyke[11] for determining the proportion of free amino groups yields good results, and by its use the progress of the hydrolysis should be easily and accurately followed.

Although the yield of amino-acids can be increased by making the hydrolysis complete, the errors incident to the processes employed in isolating them involve losses which contribute largely to the deficit shown by the total of the products obtained in definite form. As no data were on record from which these losses could be even roughly estimated Jones and I[12] made a mixture of amino-acids in the proportion in which they had been obtained from zein, and analyzed it according to Fischer's ester method. We recovered only a little more than 80 per cent. of the leucine, about 70 per cent. of the proline and phenylalanine, and 40-50 per cent. of the alanine, valine, and aspartic acid, and none of the serine. In making this test analysis, ill-defined products similar to those observed in the course of an ordinary protein analysis were formed, showing that decomposition of the esters took place during the distillation.

By correcting our analysis of zein for corresponding losses 92.7 per cent. was accounted for as consisting of those amino-acids which are now recognized as protein decomposition products. Hence nearly all of the deficit shown by the analysis of zein may fairly be attributed to analytical errors, for the presence of 0.6 per cent. of sulphur shows that a part of the substance, still unaccounted for, belongs to some sulphur-containing complex, and also a part unquestionably to serine which, we are convinced, must have been present in much larger amount than that isolated. We cannot apply corresponding corrections to the analyses of other proteins until these have been subjected to further careful study, for differences in the constitution of the mixture of amino-acids may lead to losses quite different in extent. From the experience gained in this case, however, the way appears open for further investigations which should give us a more definite conception than we now have of the constitution of some of the more important food proteins.

Proteins which, unlike zein, give a strong Molisch reaction and contain carbohydrates, deserve especial consideration, for in the

[11] Van Slyke: *Ber.*, **43**, 3170 (1910).
[12] Osobrne and Jones: *Am. J. Physiol.*, **26**, 30 (1910).



analysis of these the carbohydrate complex may have a pronounced influence on the results. It is generally assumed that carbohydrate complexes form an integral constituent of the molecules of many of the proteins. An amino-carbohydrate has been obtained from ovalbumin, ovomucoid and some of the mucins, but attempts to isolate any such substances from many other proteins have failed. The fact that most protein preparations give the Molisch reaction has led to the assumption that these contain some carbohydrate, but my experience has led me to believe that in most cases this reaction is caused by impurities in the preparation and not by a constituent of the protein molecule. This is certainly true for many of the plant proteins, from some of which every trace of carbohydrate can be easily removed, while from others this can be done only with difficulty.

Of the proteins which contain phosphorus we have two types—the nucleoproteins and the phosphoproteins.

Little need be said concerning the constitution of the nucleoproteins, other than that these are natural or artificial combinations of simple proteins with nucleic acid. The constitution of the nucleic acids has been revealed largely by the brilliant work of Levene and Jacobs,[13] but as these form no part of the protein molecule a discussion of their decomposition products lies outside the scope of this lecture.

The phosphoproteins, which like milk casein or ovovitellin, contain phosphorus, but not nucleic acid, present a wholly different problem, for in these the phosphorus appears to bear some relation to the protein molecule. No non-protein, phosphorus-containing group has yet been obtained from these proteins, and it cannot be assumed that these are combinations of phosphorus-free protein with such a complex, although the fact that the total quantity of decomposition products accounted for in analyzing both casein and ovovitellin is small indicates that this may be the case.

This brief review will have little interest for you unless in connection with it I consider some of the problems which have been presented to the physiologist by the recent investigations in the field of protein chemistry.

The most important of these problems have been raised by the discovery that many of the proteins which are extensively used for food differ much in constitution, not only from the tissue proteins of the animal, but also from each other. In consequence of this the older views of protein assimilation have been abandoned, and a multitude of new questions now demand an answer. Since we can no longer assume that the food protein is but slightly changed in the process of digestion before conversion into the

[13] Levene and Jacobs: *Ber.* **43**, 1 (1910).

animal tissues, we must consider in how far it is decomposed by the digestive enzymes and to what extent a re-synthesis is effected in the process of assimilation.

A number of distinct and independent problems are thus raised, each of which must be settled before these questions can be answered.

First: To what extent is the protein decomposed by the normal process of digestion?

Second: To what extent does the animal synthesize the products of protein hydrolysis?

Third: What is the minimal protein requirement of the animal? In other words, how much of the food protein actually replaces protein waste in the tissues, and how much is burned, without ever being converted into tissue substance?

Fourth: To what extent do intestinal bacteria take part in these processes?

All these questions have been the subject of investigation and discussion, but a conclusive answer has not yet been obtained to any of them.

It has long been known that some of the ultimate products of protein hydrolysis occur in the intestine, although the importance of the earlier observations has only recently been recognized. Thus Koellicker and Müller,[14] in 1856, found leucine and tyrosine there, and later Kühne[15] confirmed their observation, but considered these to be by-products of the action of trypsin. As you all know, Kühne assumed that under the action of trypsin the proteins can be decomposed into nearly equal parts, which he called respectively hemi- and anti-peptone, and by the continued action of trypsin the former is completely converted into amino-acids, but the latter is resistant to any further action of this enzyme. He, however, did not believe that in the normal digestion the decomposition of the hemipeptone was carried to the amino-acid stage.

In 1901 Kutscher and Seemann[16] found that protein was normally converted into amino-acids in the intestine and supposed that these served as the material from which the new body protein was constructed. At the same time Cohnheim[17] showed that the intestine contained the enzyme, erepsin, which, although without action on native proteins, converts the proteoses and peptones formed by pepsin and trypsin completely into simpler products, among which amino-acids are abundant. Thus almost at the very

[14] Koellicker and Müller: *Verhandl. physik.-med. Ges. in Würzburg*, **6**, 507 (1856).
[15] Kuhne: *Arch. path. Anat. (Virchow's)*, **39**, 155 (1867).
[16] Kutscher and Seemann: *Zentr. Physiol.*, **15**, 275 (1901).
[17] Cohnheim: *Z. physiol. Chem.*, **33**, 451 (1901).



time when chemical investigations made it necessary to assume that the food protein is decomposed into amino-acids and new protein reconstructed from these products of hydrolysis, physiological investigations showed that the animal organism was equipped with enzymes able to accomplish this result.

However, it still remains undecided whether decomposition of the food protein, under normal conditions, is actually carried to a complete conversion into amino-acids, for Fischer and Abderhalden[18] consider this to be highly improbable, and suggest that it is possible that, after a certain proportion of amino-acids are split off, a nucleus may remain to serve as a basis for the construction of new protein.

The question of in how far the animal is able to synthesize protein from the products of protein hydrolysis has been put to a direct test. Loewi,[19] Lesser,[20] Abderhalden and Rona,[21] Henderson and Dean[22] and others have found that not only nitrogen equilibrium but even a distinct nitrogen retention could be obtained by feeding animals with the products of tryptic digestion, but not with the products of acid hydrolysis.

It has been thought that the products of tryptic digestion serve to maintain the animal better than do those of acid hydrolysis because they contain undecomposed polypeptide complexes which may serve as a nucleus to which amino-acids of the proper kind and in the right proportion are added. It has also been supposed that the products of acid hydrolysis fail to maintain the animal because of the destruction of some one, or more, essential constituent of the protein through secondary decomposition caused by the acid, for it is known that such occur, notably in the case of cystine and tryptophane.

The question of the dependence of protein synthesis on the structure of the food protein has been investigated by Abderhalden and Samuely,[23] who sought to detect a change in the glutaminic acid content of the serum albumin of a horse after feeding large quantities of wheat gliadin, from which several times as much glutaminic acid can be obtained as from serum albumin. As no change in the composition of the blood albumin could be discovered they concluded that the composition of the food protein had no influence on the composition of the blood proteins.

The same question was also experimentally tested by Michaud,[24]

[18] Fischer and Abderhalden: *Z. physiol. Chem.*, **39**, 83 (1903).
[19] Loewi: *Zentr. Physiol.*, 590 (1902); *Z. Biol.* **46**, N.F. **28**, 113 (1904); *Arch. exp. Path. Pharmakol.* **48**, 303 (1902).
[20] Lesser: *Z. Biol.* **45**, N.F. **27**, 497 (1904).
[21] Abderhalden and Rona: *Z. physiol. Chem.*, **52**, 507 (1907).
[22] Henderson and Dean: *Am. J. Physiol.*, **9**, 386 (1903).
[23] Abderhalden and Samuely: *Z. physiol. Chem.*, **46**, 193 (1905).
[24] Michaud: *Z. physiol. Chem.*, **59**, 404 (1909).

who founded his experiments on the assumption that the animal requires for the construction of its body proteins a definite proportion of each of the amino-acids which enter into their constitution. He therefore thought that an animal could be maintained in nitrogen equilibrium by a smaller amount of protein consisting of a mixture of the tissues of an animal of the same species than of protein of distinctly different constitution. He accordingly fed dogs on a mixture of minced dog tissue, and compared the nitrogen balances with those obtained with food mixtures which contained the same quantity of nitrogen in the form of gliadin, edestin, nutrose, casein, dog serum proteins or horse flesh. The results which he obtained were very striking. The minced dog tissues were far more effective in preventing loss of nitrogen than either gliadin or edestin, and distinctly more effective than casein. The differences obtained with dog serum proteins, or with horse flesh, were too slight to lead to any definite conclusions.

The question of protein synthesis by the animal has also been studied by aid of the so-called "incomplete proteins." The numerous older experiments with gelatin, which lacks tyrosine, have led to the belief that this alone cannot support life, but that when added to a food containing other proteins it is capable of replacing a considerable part of the protein required to maintain nitrogen equilibrium.

Wilcock and Hopkins[25] found that zein, which lacks glycocoll, lysine, and tyrosine, failed to keep mice alive for more than a few days, but that if tryptophane was added they lived somewhat longer.

Henriques[26] fed rats with zein and also with gliadin, which lacks glycocoll and lysine, and found that he could not secure nitrogen equilibrium with zein but could do so with gliadin if fed in sufficiently large quantities. He concluded that probably the absence of tryptophane rendered zein incapable of supporting an animal, but the absence of lysine from gliadin was not of essential importance.

Definite data concerning the minimal protein requirement of the animal are lacking. In complete starvation a considerable quantity of nitrogen is eliminated which is much reduced if the energy requirements of the animal are satisfied by feeding sufficient carbohydrate. Michaud's experiments have shown that this quantity can be still further reduced by interposing a period of feeding with a minimal quantity of protein and then again feeding with nitrogen-free food, but his experiments left him in doubt as to whether or not the output of nitrogen thus found corre-

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[25] Wilcock and Hopkins: *J. Physiol.*, **35**, 88 (1906).
[26] Henriques: *Z. physiol. Chem.*, **60**, 105 (1909).



sponded to the destruction of tissue actually necessary to maintain the physiological functions of the body. This is of importance in connection with the question of the synthesis of body protein from food protein, for we must know how much of the latter is required for this purpose if we are to interpret the results obtained in feeding animals with proteins of different constitution. From Michaud's results it is evident that only a small part of the food protein commonly consumed is necessary to supply the tissue waste incident to the performance of the purely physiological processes required to support life, and that consequently, under normal conditions, a synthesis of new protein probably occurs to only a small extent.

The part which intestinal bacteria may play in the synthesis of body protein from food protein deserves much more attention than it has received. It is well known that bacteria are present in large numbers in the intestine, for from 30 to 40 per cent. of the fæces may consist of the bodies of these organisms.

Before we can accept as conclusive any of the evidence that has been offered that the animal actually synthesizes tissue proteins from the constituents of its food, we must carefully consider the data just set forth, not only in connection with each other, but also in connection with some other facts which have been recently discovered.

From Michaud's experiments it is evident that only a small part of the food protein normally consumed is used for the construction of tissue protein, and that consequently when the animal receives an abundant supply of food a deficiency in one or more of the essential constituents of the protein may not become apparent for a long time. Furthermore, such a deficiency may be supplied by the animal's own tissues, for we know that the muscles form a reserve supply which furnishes the necessary protein required during long-continued starvation and also serves for the construction of new tissues, under normal conditions, as shown by the development of the reproductive organs of the salmon.

It is, consequently, probable if the synthesis of the animal proteins is affected by a recombination of amino-acids that the deficiency of any one of these in the food protein will become apparent only when the experiments are carried on for much longer periods than has thus far been done in testing the proteins in respect to their relations to protein synthesis in the animal body.

All the experiments in this direction which have been made with the incomplete proteins are wholly inconclusive because similar experiments made with complete proteins have likewise failed, with the exception of one by Röhmann, in which he used a mixture of several proteins.

The fact that a nitrogen balance is not obtained in such experiments is no evidence that the fault lies in the constitution of the protein, as I shall soon show. Also a retention of nitrogen obtained for a time with a protein or its decomposition products is not evidence that these have been utilized in the construction of new tissue.

That the products of tryptic digestion maintain the animal for a short time while the products of acid hydrolysis fail to do so is not evidence that some essential amino-acid has been destroyed by boiling the protein with strong acid, for the failure of the latter may as well be due to the presence of some more or less toxic secondary decomposition product, as is indicated by the digestive disturbances noted by all those who have fed such substances.

Michaud's discovery that proteins which in constitution closely resemble the body proteins, prevent loss of nitrogen from the body better than do proteins which differ widely in their constitution from the body proteins, is the best evidence that we have that amino-acids from the food protein are actually used for the construction of the tissue proteins. This, however, is not wholly convincing, for Michaud's experiments are, in fact, a comparison of the nutritive effect of animal tissue substance with the nutritive effect of a mixture of isolated protein and other substances. It is also to be noted that he makes no mention of the addition of inorganic constituents to these mixtures. It is not surprising, therefore, that he should have obtained the best results with the tissue feeding, for the comparative failure of the isolated proteins may have been due to other causes than differences in their constitution.

In none of the experiments thus far discussed has consideration been given to the possible influence that bacteria may play in the transformations that are required to convert a protein of wholly different constitution from the tissue proteins into the substances which compose the body of the animal. The capacity of these organisms to effect profound chemical changes is quite sufficient to transform a considerable part of the amino-acids which result from digestion of the food protein into forms of totally different constitution. By this means an excess or deficiency of one or another amino-acid may be compensated and the animal supplied with an entirely different combination of amino-acids from that originally fed to it. To what extent such changes occur in the intestine, or to what degree the substance of the bacteria is digested and assimilated, we do not know. The fact that animals in cages on restricted diets are prone to eat their own fæces indicates that they thereby secure some element of food which they crave, and is suggestive that the bacteria may have more influence in feeding experiments than has heretofore been supposed.

After all that has been said and written concerning the synthesis of the body protein by recombination of the amino-acids from the food proteins, it must not be forgotten that in the process of digestion the amino-acids themselves may be deaminized and converted into wholly different substances, and that from these new products the amino-acids required by the animal may be later reconstructed.



Many facts have indicated that this may happen, but the most important indication has very recently been given by Embden and Schmitz, who have found by perfusing the excised liver with blood to which pyroracemic acid or lactic acid had been added that alanine is formed. They also obtained tyrosine and phenylalanine after adding oxyphenylpyroracemic acid or phenylpyroracemic acid respectively.

In reviewing the literature of feeding experiments made with a view to determine the possible synthesis of protein by the animal, it is evident that these have been much too brief and have been made without sufficient consideration of many important factors. In most of these the ages of the animals have not been given, in others the isolated proteins have been commercial products of doubtful purity or have been prepared in the laboratory by hasty methods which do not yield products of definite character; no sufficient consideration has been given to the requirements of the animal for inorganic constituents, and none whatever, so far as I can find, to changes caused by intestinal bacteria in the constitution of the nitrogenous elements of the food. Each of these factors may have an important influence and must be the subject of special investigation before final conclusions can be reached. Such investigations must be made along many lines before a foundation can be secured from which conclusions of value can be drawn. These problems are among the most complex that have been presented to the physiologist, and it needs but a little reflection to show that a solution can be reached only by long-continued and patient work.

A beginning in this direction was made about a year and a half ago by Mendel and myself with the hope that in time we may secure some data which may ultimately be of help in solving some of these important questions of nutrition. Our experiments, which have thus far been conducted with rats, have already yielded some interesting results.[27]

From a large number of experiments with many different proteins, singly and in combination, we have learned that the cause of failure in most of the previous experiments is due to an unsuitable choice of the inorganic constituents of the food. By using an inorganic salt mixture similar to that used by Röhmann, in the only approximately successful artificial feeding experiments heretofore reported, we have succeeded in keeping rats, not only in

[27] Carnegie Inst. Wash. Pub. No. 156 and No. 156, Part II.

positive nitrogen balance, but in full weight and perfect health over long periods of time. Thus in our most successful experiment we have kept a rat for ten months; for the first two months on a mixture containing milk casein and wheat glutenin, and for the succeeding eight months on one containing wheat glutenin as its only protein. Many other rats have been kept in fine nutritive condition for long periods with casein or mixtures of casein with other proteins. When the conditions for such experiments are well established we expect to extend them to the many forms of food proteins with the hope of learning something more definite than is now known of the effect of differences in the constitution of the food protein on nutrition.

One of the most interesting results of our experiments has been the discovery of the fact that while a mature rat can be maintained on a food containing the isolated proteins, a young rat, on the same food, fails to make more than the slightest growth. Three young rats which weighed from 60 to 70 grams each have been fed for more than three months with the same glutenin food, which fully satisfied all of the requirements of the mature rat just mentioned. All of these have remained nearly stationary in weight, although during the entire period the food intake has been fully equal to that of other rats of similar weight which were in full normal growth. Many experiments with other proteins, including milk casein, have given a similar result, and we have also found that such stunted animals when transferred to a normal mixed diet, or to one containing milk powder, at once grew normally. Future investigations must show whether or not this means that a mature animal actually constructs little if any new tissue protein from its food protein, and that a growing animal, which must do so, is unable to utilize proteins of widely different constitution from its tissue proteins for this purpose. The possibility that this may be so is suggested by the interesting experiments by Aron,[28] who finds that dogs which are kept on such a restricted quantity of mixed food that they do not increase in weight during long periods grow in size at the expense of their muscular tissues, so that their skeletons are equal in weight to those of normally nourished dogs which have doubled their weight during the same time. Although we have not yet measured the different parts of our stunted rats it is evident from their appearance that their skeletons have not developed to any marked extent. They look exactly as if tissue growth had entirely ceased from the beginning of feeding with the single protein, and, if this is so, it is possible that they cannot make new tissue from the pure protein of their food. The slight growth made by some animals when thus fed can easily be attributed to the activity of intestinal

[28] Aron: *Biochem. Z.*, **30**, 207 (1910).



bacteria which convert a small part of the food protein into other forms from which new tissues could be constructed. This possible participation of bacteria immensely complicates the conduct of such feeding experiments, and renders the interpretation of the results difficult, for even if the fæces are in some way collected so that the animal cannot eat them we have no assurance that dead bacteria may not be digested within the intestine and thereby supply the animal with substances which have been carefully excluded from the food.

## WHAT AND HOW MUCH SHOULD WE EAT?[1]

### I

Under normal conditions of supply and normal conditions of health, little attention is given by the great mass of mankind to the question what or how much should be eaten. They simply eat what they want and as much as they want, and then stop and go about other business. They know nothing of the dietary elements which the nutrition expert tells them are so essential for their well-being, and even for their very existence.

How can they long survive in such ignorance? Why does the community allow them to endanger, not only their own lives, but those of posterity? The only possible answer is that they are endowed with instincts which guide them so well, that under normal conditions of life they escape the many dangers that until recently they were unconscious of.

In view of the successful part played by instinct in dealing with the problems of nutrition,—which modern science is beginning to show are among the most complex that the human mind has ever yet undertaken to investigate,—perhaps it might be well to pay a little more respect to instinct than has lately been the fashion, and at the same time see if by observation some useful hint may be obtained which will help in interpreting the results of investigations in the laboratory.

Even the pig knows how to protect himself against dangers arising from indiscretions in eating, not only as to quantity, but as to the proportion of the various food-constituents. This is shown by Evvard's experiments. He allowed pigs to feed themselves *ad libitum* with corn, meat-meal, oil-meal, salts, and the like, from separate hoppers. During early growth, when new tissues were being made rapidly, these pigs ate much larger proportions of protein than when growth became slower. Later, when smaller amounts of corn were eaten, the protein deficiency

[1] Reprinted from *The Atlantic Monthly* for September, 1918, by permission of the editor.

thus caused was met by an increase in the amount of meat-meal eaten. Under these conditions of free-choice feeding the pigs grew faster than any previously recorded which had been fed on mixtures made for them by the combined talent of agricultural experts, trained both in the science of nutrition and in the practice of the art of feeding.

Similar experiments made in my laboratory with albino rats gave much the same results. These animals were given their choice between two food-mixtures, one adequate for growth, the other inadequate, owing to the deficiency, or absence, of some one factor essential for growth. Although these foods were alike in physical properties, and so nearly alike in their constituents that it was difficult to believe that the rats could distinguish between them by any of their senses, nevertheless, all but one of the several rats so chose their food as to make practically normal growth. How they did this is one of the wonders of nature.

Considered solely from the standpoint of a supply of energy,—that is, of fuel for the maintenance of the body as a running machine,—the food-problem has long been the subject of very carefully and accurately controlled experiments. These have shown that, for the expenditure of a given amount of energy in the performance of physical work, a corresponding amount of potential energy in the form of food is required. In other words, the law of conservation of energy applies to the animal machine as strictly as it does to the machine in the factory.

The practical conclusion to be drawn from this is that the animal body must be supplied with enough energy, not only to keep it running, but to perform the work done by it. Recently we had an illustration of what happens to the machinery of our industries when the supply of energy in the form of coal runs short; and we may soon have an illustration of what will happen to the labor employed in these industries if the supply of energy in the form of food suffers similarly.

Let us first consider the question how much energy is really needed; or, to put it the other way, how little food can we get along on and still do the work necessary for the successful conduct of the war? As already stated, the relation of food eaten to the energy expended has been very carefully established by exact experiments which, under the conditions studied, are beyond criticism. How can these studies be applied to the needs of daily life? It is obviously impossible to determine the energy expended by a blacksmith working on a battleship, or an engineer running a locomotive, or a horse ploughing a field. None of these can be put to work in a calorimeter and the heat value of their work measured, nor can any imitation of such working conditions be reproduced whereby even an approximate estimate might be made. Nevertheless, authorities on nutrition furnish us with tables showing how much energy must be supplied in the form of food for those who are engaged in a very wide variety of occupations, and these tables are largely used in determining suitable rations under different conditions.



It may fairly be asked, if it is impossible to measure the energy expended, how have such tables been made? They have been made by carefully studying the amount of food actually eaten by large numbers of people engaged in all sorts of occupations, and determining the calorific value of these foods. The energy expended in the various occupations was not measured directly by scientific methods, but indirectly, on the assumption that it is the habit of people, as well as of animals, to eat according to their calorific requirements. If men and animals were not endowed with instincts that enable them to adjust their food intake to the energy expended in maintaining their bodies, as well as in doing their work, they would be constantly suffering from the ills of over-eating or of under-nutrition.

That nature provides protection against many misfortunes which may befall an individual in the course of life, has been pointed out most interestingly by Dr. Meltzer in a paper on "The Factors of Safety in Animal Structure and Animal Economy." From the numerous examples set forth by Meltzer it seems probable that the ills following over- or under-eating are, in some way, also provided against. It has long been recognized that underfeeding is temporarily guarded against by a conversion of sugar into a substance similar to starch,—glycogen,—and storage of this in the liver and muscles. The potential energy thus husbanded is readily drawn on or replenished according to the minor fluctuations in demands for more, or for less, energy, which may be made necessary by the daily variations in physical activity, or the daily changes in external temperature. Larger demands, extending over longer times, are met by the reserve of fat and muscle-tissue, which in every normally nourished individual is sufficient to supply enough energy for a not inconsiderable time.

Are these the only means of dealing with inequalities in energy output, or food-supply? It is conceivable that, in addition, the speed at which chemical changes go on within the body may vary, to adjust consumption to requirements. Allen and DuBois state that the profound effect of confinement and under-nourishment on heat-production has never received the attention it deserves. If reducing the body weight, by lowering the food-intake below the amount which instinct prompts, reduces the rate of metabolism,—that is the sum of the chemical changes which are taking place within the body,—we should expect the converse to be true, and to find that increasing the food-intake above the amount that can be met by storing glycogen and fat is further met by an increase in the rate of metabolism. If it should turn out that a change in the rate of metabolism thus provides a hitherto unrecognized factor of safety, the whole question of over-eating will have to be considered from a new angle.

It has been generally held that over-eating, except within narrow bounds, is impossible, for the subject will either grow fat, which of course has its limits, or will feel badly and cease to eat in excess until a normal condition is reëstablished, or will dispose of the surplus food by exercise. According to this view, those who cannot live in comfort without a game of golf or some other agreeable form of activity are habitually over-eating, in so far as fuel needs are concerned. There are other factors, however, involved in the exercise problem, which we will consider later.

If surplus food above that needed for the daily tasks of life can be disposed of by an increased rate of metabolism, we ought to know more about it than we now do if we are to deal with the problem of the most efficient use of our food-supply. Can any important amount of food be wasted in this way? A certain rate of metabolism is required to support the body functions and temperature, and a corresponding quantity of food is necessary to continue that metabolism, if body tissues are to be maintained. If more than this amount of food is eaten, it is wasted, if it serves no other purpose than to produce useless heat which must be gotten rid of in some way.

In my own case it has seemed that an unaccustomed plethora of food has been followed by a continued sensation of heat, and efforts to dispose of this extra heat by reducing my clothing below that habitually worn. If subjective sensations of this kind are to be trusted, it would seem that under such conditions surplus heat is being eliminated by radiation in consequence of dilation of the capillary blood-vessels. This agency is provided to rid us of the excess of heat incident to physical work; and it would seem not improbable that it might be called on to dispose of surplus heat produced by increased metabolism caused by an excess of food.

The extra heat eliminated after eating protein, which Lusk properly regards as a result of stimulated metabolism, is an example of wasted energy of the same kind that may result from a plethora of other kinds of food. Another example is the increased rate of metabolism caused by caffein, which may explain the extensive use of coffee and tea. So long as carbohydrates or fats are assimilated only in amounts in excess of the maintenance and energy requirements which can be met by storage in the form of glycogen or fat, no evolution of heat can be expected; but when the amount is greater than can be thus cared for, the plethora must be burned, if bodily health is to be maintained.

To what extent a surplus of food can be disposed of by such an increase in the rate of metabolism, or whether such a stimulation of the metabolism can be frequently endured without sensations of discomfort, are questions which have been so little studied that definite answers cannot be given to them. My own observations have led me to suspect that there may be a wider difference in the capacities of individuals thus to meet the dangers involved in occasional over-eating than has heretofore been supposed. Possibly those who are said to have "good digestions" are those whose metabolism is easily stimulated, so that they are able to oxidize promptly whatever surplus food they may happen to eat. If such should prove to be the case, the ills commonly attributed to indigestion may in many cases not be due to a failure to digest food, but may, on the contrary, be the result of assimilating food which has already been digested in greater quantity than the body-cells are capable of oxidizing promptly.



Waste of food, if in fact there is any, from this source is doubtless small, and quite likely is fully compensated for, because a large proportion of the "good feeders" are among the most efficient in every community. While many seem to think that high thinking and plain living are essential to good living, it does not by any means follow that a high plane of metabolism does not imply a high plane of both mental and bodily efficiency. Certainly, among cold-blooded animals the increased rate of metabolism which results from raising the temperature of their environment leads to marked evidences of increase in physical efficiency.

## II

Leaving this question for future investigations to settle, let us consider whether we have at present any better means of determining how much food—how much energy—is needed under given conditions than our present one founded on observations of what people actually eat when guided solely by their instincts?

It is very generally assumed that those who are in a position to do so eat too much, probably because all of us are tempted to eat when confronted with an abundance of attractive food. Although many do yield to this temptation, few fail to eat less at subsequent meals, and soon reduce their consumption, even if enticing food is continually put before them. A millionaire could not possibly eat as much in a week as a coal-heaver, unless he engaged in exercise more severe than would be agreeable. How much more than is necessary can be eaten without discomfort? Does over-eating cause a waste of food sufficient to justify the efforts necessary to control it? Can a man over-eat habitually, without either growing very fat, or becoming a dyspeptic? Does not this evil usually cure itself? Here are questions which are difficult to answer positively. Plenty of people will answer them with assurance; but have they good reasons for their answers?

It is difficult to fatten animals beyond a certain limited degree, and even then it takes a long time. If too much tempting food is supplied, they "go off their feed." Even pigs, as has already been stated, can successfully feed themselves from hoppers with concentrated foods. They apparently do not eat too much. Occasionally cattle or horses which by chance get access to the feedbin will eat so much that they die; but such cases are probably nutritional accidents, where fermentations cause decomposition of the food before it can be digested. During parts of the year almost all animals in a state of nature have the opportunity to eat too much, but we have no reason to believe that they do so. In a long experience, gained by feeding many hundreds of albino rats whose food-intake was limited only by their instincts, I have never suspected that any one of them ate too much. Successful stockmen make their animals eat all they will, in order to obtain maximum production and profit.

Excess of food results in accumulations of fat, but these form comparatively slowly. Chickens or Strasburg geese are fattened more rapidly by force-feeding than in the natural way, because thus they can be made to consume more food than their instincts will permit. Pigs can easily be made very fat; but these animals have been bred for generations with the purpose of developing a breed having a capacity for accumulating fat beyond the normal. Taking the country over, fat men are not very numerous, and most fat women have spent years in becoming so. There is probably far less over-eating, as measured by accumulations of fat above the normal, than is popularly supposed; but that there is some is evidenced by the not inconsiderable number of fat people, especially women, seen in our large cities.

Since the records of what people on the average actually do eat when left entirely to their instincts have been demonstrated to be on the average very nearly what they should eat for the proper maintenance of their bodies, it appears that in general there is not much, if any, over-eating. Such as may occur can be controlled by the scales; for if one is not obviously fat or gaining weight, he is presumably not over-eating. There is evidently little food saving to be expected from efforts directed to suppressing over-eating.

If the food supply is to be conserved by reducing the amount of food below that now eaten under the direction of instinct, what will be the result? The first effect will obviously be a loss of weight and consequently a reduction in the amount of food needed to move the body, as in walking, getting out of bed, or rising from a chair—a very small fraction of the total needed for maintaining the bodily machine and performing the tasks of daily life. It will not reduce materially the amount of food needed to do the work of daily life; for, as Anderson and Lusk have recently



shown, the energy requirement for work done is exactly the same whether the animal is well fed or starved. All that is saved by reducing weight is merely the fuel needed to do the mechanical work involved in moving the smaller load imposed by body weight. Experiments to show the reduction of energy resulting from reduction in weight have been made chiefly on men or animals whose work consisted in lifting the body, as in walking, or hill-climbing. Under such conditions a diminution of energy expenditure is involved which is almost proportional to the reduction in body weight. Under the conditions of activity of the great mass of our population, no corresponding saving can be expected, for few are engaged in occupations where lifting the body comprises more than a very small part of the mechanical work which they do.

Loss of weight involves loss of the factor of safety which nature provides in the form of fat; for even those who are not commonly regarded as "fat" have a very considerable amount of fat in the various tissues of their bodies. It may also involve a loss of substance from the muscle-tissues, if the reduction in weight is carried far, or if the subject was at the outset supplied with fat below the normal. Just what effect it has on the easily mobilized supply of glycogen which is needed to maintain uniformity in daily metabolism, I do not know. It would seem as if this too might be reduced to a minimum inconsistent with efficiency. There is no doubt that a certain amount of reduction in weight can be endured by the vigorous for a considerable time, but not without serious loss in efficiency, if long continued. In every community there are many men below the normal weight, and these are always looked upon with suspicion by insurance companies and enlistment officers, even though no pathological cause can be found for their underweight.

Restriction of the food-intake means the loss of a factor of safety other than that furnished by body fat—one that is in the food itself. Food furnishes more than fuel for the body: it supplies, in addition, the materials needed to renew the wear and tear incident to life, and also those mysterious substances called vitamines, the absence of which in a food renders it incapable of supporting life. No one knows what vitamines really are, for as yet they have not been isolated. Their presence is revealed only by the effect they produce upon nutrition. They are not uniformly distributed in the various parts of the plants and animals we use as foods; and in rejecting a part of an animal, or by over-refinement in milling, we may throw away these indispensable substances. The germs of wheat, rice, and other seeds, the liver and kidney of animals,—all of which are composed of highly active cells,—and the cells of yeast, contain a far larger proportion of vitamines than do the endosperm or berry of wheat and rice, or the muscle-tissue of the animal. Addition of a very small quantity of the germ of the wheat-kernel to a vitamine-free but otherwise adequate mixture of nutrients, renders it capable of sustaining life; whereas a very large addition of white flour scarcely suffices.

Whenever the food-intake is cut down, the supply of vitamines is reduced, with how serious an effect no one as yet knows. That the need for vitamines is quantitative has been demonstrated within the last few months. The weight and health of animals fed on a diet free from vitamines, but otherwise fully adequate, can be maintained so long as they are supplied each day with a small but definite amount of yeast or wheat-germ or some other substance rich in vitamines. If the daily dosage is gradually reduced, a point is reached at which body weight begins to fall and the health of the animal is impaired. Further reductions in the amount of vitamines are followed more rapidly by these evidences of malnutrition. Body weight and health can be restored at once by increasing the daily supply. While in general, for the animals of a given species, the necessary amount of vitamine-containing material is nearly the same, there are individuals who require a larger or a smaller quantity. Vitamines seem to act as if they were stimulants to the metabolism, and individuals seem sensitive to this stimulus in different degrees. Do not vitamines play a part worthy of consideration in connection with restricted food-supplies?

An apparent example of the mysterious way in which instinct guides human beings to secure a supply of vitamines is shown by those tribes of Eskimos who eat the contents of reindeer stomachs as a delicacy. Doubtless the lack of this necessary element in the Eskimo dietary, which is largely made up of meat and fat, is the reason why the vegetable tissues gathered in their roamings by reindeer, and collected in their stomachs in an easily obtainable form, are regarded by the Eskimos as tidbits.

It is not at all improbable that many delicate people of sedentary habits, who eat but little, suffer chiefly from a deficient supply of vitamines, enough of which in the diet appears to impart physical vigor. Here we may have a clue to the reason for the benefit which exercise seems to confer upon people who otherwise lead physically inactive lives. The more these exercise, the more they eat; hence, the more vitamines they get, the better they feel. Those who never take exercise, but are always well, are perhaps persons so constituted that they react readily to a relatively small proportion of these life-giving substances.

## III

How much protein should be included in the daily diet, is a question which has been the subject of contention among physiologists and nutrition experts for a long time, and as yet no agreement appears to be in sight. That those who can afford to buy the expensive foods which supply this element customarily eat more protein than they actually need to maintain their bodies in seemingly good condition, has been demonstrated by the well-known experiments of Chittenden, who showed that men can live for several months without apparent detriment on diets containing about one-half the amount of protein usually eaten. That similar low-protein diets can be used continuously, is shown by the fact that many eastern races habitually live on such.



The low-protein diets of the masses in Japan are unquestionably the result of necessity, for the more prosperous classes in that country provide themselves with foods very similar to those common in America. This change in habits is more likely to be the result of instinct than of a desire to imitate Europeans. It is a matter of common experience that dietary habits which satisfy the promptings of instinct are among the most difficult to change; whereas those which do not satisfy instinct are very easily changed. That more protein should instinctively be eaten than is absolutely necessary, is in accord with the plan of nature of averting danger by providing a factor of safety. Too little protein leads to inevitable disaster, too much (within reasonable limits) can be disposed of without apparent harm.

Physical well-being can be maintained within very wide limits of protein intake. Just where the minimum, and where the maximum lies, is not certain, but that these limits are avoided by normal persons is certain. I have known a number of individuals who lived with enthusiasm for quite a time on low-protein diets, and who thought that their health was thus improved. All but one of these are now eating the normal amount.

There is no denying the fact that mankind in general instinctively eats more protein than the physiologist tells us is needed for actual maintenance. Why should this be so? One reason has been discovered since the experiments were made on which this dictum was founded, and this is, that all proteins do not have the same nutritive value. A quantity which fully suffices for all the bodily needs when one kind of protein is eaten, may be insufficient if another is eaten in its stead. To guard against this danger, we all instinctively eat a variety of foods, hence a variety of proteins; and it is curious how the selection thus made agrees with what our new knowledge shows to be desirable. Experiments have demonstrated that combinations of the cereal proteins with those of milk, meat, or eggs are much more efficient for promoting the growth of young animals, and for renewing the tissues of adults, than are the cereal proteins alone; and these are the very combinations which mankind eats whenever opportunity makes it possible.

Protein is decomposed in the process of digestion into fragments called amino-acids. Nearly all proteins yield in varying proportion eighteen different amino-acids. In some proteins one or more of these may be absent. When new protein is required by the body, for the growth of the young or for the replacement of broken-down tissue in the adult, amino-acids derived from food are recombined into the protein of the new tissue. As the proteins of our food do not contain the same proportion or amount of the different amino-acids needed to construct the new-tissue proteins, there easily may be available too much or too little of any one of them. If any one amino-acid is furnished in too small quantity, then growth or repair will be retarded. The greater the quantity of protein eaten, and the greater the variety, the less danger there is of running short of the necessary quantity of any one essential amino-acid. Whatever surplus may remain is easily disposed of; so that the danger lies on the side of too little protein rather than too much. We must avoid too near an approach to the protein minimum in our diet until we know more about the chemistry of proteins and their true value in nutrition. Our instinct assures us of a margin of safety which is doubtless wider than is necessary, but how much wider, no one knows.

It is not at all improbable that another feature is involved in the question of the protein minimum, for it may well be that the greater efficiency of the meat-eating nations, which has often been used as an argument against a low-protein regimen, may be thus explained. It has long been known that an increase in the amount of protein consumed above that needed to protect the body-tissues from loss of nitrogen is accompanied by an increase in the amount of heat given off by the animal. This occurs only when the protein eaten is greater in quantity than can readily be stored in the body cells. A similar increase in heat-output does not take place when carbohydrates or fats are eaten in quantities above those needed for maintenance. Rubner considered this extra production of heat to be peculiar to proteins, and called it their "specific dynamic action." He assumed that the activities of the body-cells as a whole were constant, and consequently required a constant supply of energy from the food to maintain their normal functions; and that any quantity of protein above what was needed for these normal functions was simply burned up with evolution of heat, but with no effect on the cellular metabolism.

Amino-acids resulting from the digestion of protein cause an extra evolution of heat when fed to animals. This has been interpreted by Lusk as due to a stimulation of metabolism, for the heat developed is greater than could be caused by combustion of the amino-acids supplied.

If protein stimulates metabolism, its effect on the well-being of an organism, especially of one so highly developed and sensitive as man, may well be very considerable. Under the influence of this stimulus the output of work, both physical and mental, may easily be increased. Certainly the known relative efficiency of the meat-eating nations compared with the seed-eating nations of the Orient is not inconsistent with such a possibility. The efficiency frequently shown by men on experimental low-protein diets, which might be cited as evidence against this view, has often been attributed to psychological causes; for the enthusiasm of converts to new cults often leads them to most remarkable accomplishments.

Whatever the truth may be, the instinct of the great majority leads them away from a low-protein diet; and, in view of the many wonderful ways in which instinct saves us from nutritional disasters of other kinds, attention certainly ought to be given to the amount of protein which man instinctively eats when not restricted by available supplies, or by poverty.



## IV

Reviewing our recently gained knowledge from the standpoint of one seeking information by which to regulate his own dietary habits, we find that the chemical requirements of nutrition can be met only by the use of a variety of food-products, and that instinct, which impels man to crave this variety, saves him under normal conditions from the dangers involved in a too-restricted choice.

Those of us who habitually eat an unduly large or unduly small proportion of any particular kind of food will do well to alter our habits in this respect, and conform more nearly to the practice of the average American, whose daily ration consists of about three and a half ounces of sugar, four and a half ounces of fat, eight and a half ounces of flour, and three and a half ounces of protein.

The widely different sources that may be drawn on for the protein in this ration permit the needed variety. Protein is furnished by milk, eggs, meat (including poultry and all kinds of sea-food), and, to a limited extent, by vegetables and fruits. Proteins from these different sources do not have equal value in nutrition, but instinct leads the normal man to eat the very combinations which science proves to be the best. Young rats in my laboratory grew very slowly when wheat-flour furnished all the protein of their diet; but when meat, milk, or eggs supplied one third and flour two thirds of the protein, they grew rapidly. Bread and milk, bread and meat (sandwiches), and eggs on toast are combinations evolved by human instinct long before science discovered a chemical explanation of their efficiency. Man's natural desire for a varied diet thus takes account of even the fine points of the chemistry of the proteins.

Lusk has recently published a long list of foods, natural and manufactured, with their retail prices, calculated on the basis of the amount of fuel they furnish to the body for the performance of its daily work. It is curious to see how uniform these prices are for the foods which are eaten chiefly for their fuel-value. A higher, but fairly uniform, price is paid when protein is the chief factor furnished by the food. Far more costly than either of these are the vegetables and fruits which furnish very little that formerly was considered essential for nutrition. This is an impressive demonstration of the accuracy of man's instinctive judgment as to the relative values of the food-products he buys; and when we see how he has learned through instinct to combine the things he eats, and realize the underlying necessity that prompts his apparent extravagance, we cannot fail to be impressed by the very high price that he is willing to pay for vegetables and fruit.

Flour and meat contain relatively little, and sugar and fat contain none, of the vitamines which must be in every ration in sufficient amount, if life is to be sustained. The amount of vitamines contained in milk and eggs is too small to render it probable that they alone will supply enough when consumed in the amounts ordinarily eaten. That man does live and, in general, flourish on the kind of food he instinctively eats, demonstrates beyond question that the supply of vitamines in his usual diet is sufficient for his needs. The only conclusion to be drawn from this is that vegetables or fruits, probably both, supply this most important food-factor, and that for this vital need man is ready to pay a good round price.

At the present moment science can add very little definite information on this most important aspect of our food problem. Until investigations now in progress are completed, we can give only general advice. In the meantime, I believe that instinct is a safe guide, that it is prompting us to eat the kinds of food we should.

In general, we eat very nearly the amount of food that we really need. He who does hard physical work needs to eat more than does the sedentary brain-worker whose labor involves no expenditure of energy that must be supplied by extra food; and so he who works with his brain instinctively eats less than he who works with his muscles. The old belief that different foods were of widely different digestibility has yielded place to the knowledge that what was formerly called indigestion really arises from a failure to completely assimilate the full amount that has been digested. Some foods—sugar, for instance—are so concentrated and so readily digested that it is easy to overload our metabolic processes with the products of their digestion. The muscle-worker can more easily oxidize and dispose of a surplus of food than can the brain-worker. Both need, however, the same kind of food in differing proportions. The sedentary man needs proportionately less sugar, fat, and cereal products than does the muscle-worker.



We are now confronted by restricted supplies, and nearly all of us have been compelled to modify our dietary habits so that we are no longer protected by instinct. While the war lasts, we shall have to adjust our habits to conditions more and more. Already, what and how much we shall eat has become a very practical problem.

Science can help much in meeting this emergency; but, like every other agent which is being employed to win the war, it has its limitations. Unless dietitians fully realize the limits imposed by our present imperfect knowledge, and heed the lessons to be learned from instinct, we shall encounter, not only nutritional difficulties, but serious social discontent.

Fortunately the United States has a Food Administrator, surrounded by a body of expert advisers who are not only alive to all that science can do to aid them in dealing with their serious problems, but are also awake to the necessity of carefully considering the part played by instinct in the food-habits of the individual. Hard times are ahead of us, but we may be sure that such advice as the Food Administrator gives will be the best that any nation has had. No one will suffer in health or efficiency by following his directions. During the war, we must trust him. After the war, we must learn more about this important subject.

## MIGRATIONS OF BIRDS[1]

Nature provides many ways by which the rigor of winter may be met by different living beings, few of which follow during this season the course of life pursued in summer.

Most of the quadrupeds hibernate in holes in the ground or in trees from which they rarely come for food until spring, spending the winter in sleep and slowly assimilating the substance of their bodies. The reptiles bury themselves in the ground or in mud beneath water, where they remain out of reach of frost in a state of helpless torpor. Many of the insects which live over the winter present a problem that was brought to my attention one day this winter. Although it is not connected with the subject of bird migration it may be of sufficient interest to consider for a moment.

One cold day in January, a wasp which had in some way become warmed up, crawled on to my laboratory table, having come probably from under the roof of the building. I at once wondered how, under ordinary circumstances, such an insect could find a place where it could pass the winter without freezing, and as I

[1]A paper read before the Friday Night Club, New Haven. This and the following paper are posthumous manuscripts published here to illustrate Dr. Osborne's interest in biological science.

could not believe this possible, I put the wasp into a small bottle with a thermometer and put it out of doors, where the thermometer, whose bulb touched the wasp, soon marked below 20° F. After leaving the wasp at this temperature for a couple of hours, much more than long enough to have frozen the entire bottle full of water, I took it out and, though at first apparently dead, in a few minutes it was flying about the room.

Now the question is, if its fluids were frozen and circulation thereby stopped, why was not vitality entirely suspended, and how, if this was so, could life be resumed on thawing out, unless vitality is nothing more than a chemical phenomenon? That is, given the proper chemical conditions, does not life follow as a consequence? But to return to our subject.

As you know, nearly all of the species of birds breeding in temperate regions go to the south in winter to escape the cold. Only forty-three species are recorded as resident throughout the year in this state and most of these are rare. Of the common species thus resident, by far the greater number of individuals go south in winter or north in summer. For instance, a very few robins and blue birds sometimes stay with us during the winter and a very few chickadees and nuthatches remain during the summer to breed.

What causes the birds that have gone south in winter, where they find plenty of food and comfortable weather, to start north at the approach of spring is a question that has caused much speculation on the part of ornithologists, but has never been satisfactorily explained. It cannot be that the conditions of life, at the south, become unsuitable, for individuals of a majority of the migratory species remain to breed far south of the northern limits to which others of the same species wander in their spring migration.

Many believe that sentiment is the main cause which prompts the bird to undertake the long journey,—in many cases more than a thousand miles—that the bird is impelled by an overpowering love for the home in which it was reared to return each year and renew the pleasant associations of the past. This seems to be an absurd explanation for, so far as I have observed, birds are absolutely devoid of sentiment and affection, their actions being wholly controlled by blind instinct. No birds seem to have more affection for their home, their mates or their young than domestic pigeons, but any one who has studied their habits can manage them in such a way as to make them do many things that an affection of this sort would render impossible.

The true motive leading to migration is an instinct which cannot be explained any more than those instincts which lead a human being to cry with pain or grief, and laugh with joy. It is simply a fact of nature that must be accepted as such. The most striking feature of bird migration is the regularity with which it takes place, a regularity far greater than most people who have not kept annual records of the arrival of birds would realize.



The date at which the first individual of most species appears in the spring varies very little from year to year and is independent of the condition of the season, that is, whether the spring is early or late. Thus, I have noted the arrival of the first oriole for many years and have never known him to come before the fourth of May nor later than the ninth, while in the great majority of years I have seen the first one on the seventh. During these years I have kept a record of the first blossom on a particular cherry tree, which shows that the oriole arrives with a far greater regularity than the flower, the bird varying but five days while the flowers varied fourteen.

It seems at first thought surprising that birds should be so exceedingly regular in their movements, but I think this can be easily explained on purely physiological grounds. The period of gestation and of menstruation among all animals, even when domesticated, are extremely regular, recurring at perfectly definite periods for almost every individual of each species. With birds, definite periods of sexual activity exist for males as well as females, and it seems almost certain that, with the return of the sexual activity, the impulse to migrate develops and incites the bird to undertake the journey. We can thus understand how it happens that they arrive in the spring with such regularity, although we have no explanation of why this sexual activity should cause them to move north. As to the southward migration, this theory, of course, offers no aid, for there is no apparent reason why the bird should be impelled at a certain fixed time to start south when sexual activity ceases.

That each species leaves at nearly the same time in the fall is well established, but that they move with the same regularity as in the spring is not demonstrated. It is far easier to recognize the arrival of the first individual of each species in the spring than the departure of the last, or even of the majority, of a species in the fall. Further, as there must necessarily be many weak individuals remaining, who are unable to take long journeys, their presence would always cause uncertainty in regard to the actual date of fall migration.

Such evidence as we have, however, indicates pretty plainly that the fall migration is more leisurely than the spring, though the great bulk of it seems to take place within a few days. Every sportsman recognizes the fall flight of woodcock, which takes place about the first of November, during which a place that has been hunted thoroughly the night before and found destitute of woodcock may be full of them the next morning and almost any other favorable spot will also abound with them. These flights last but three or four days, and often do not occur, the birds doubtless passing rapidly by and not stopping at all. Such was the case in this vicinity last fall, when almost no woodcock, except those raised about here, were shot by anyone.

In accord with the idea that the birds are started north by a return of sexual activity, we find in many species that the males precede the females by a week or more. Thus, while the meadows may be filled with red-winged blackbirds, one may search in vain for many days before a single female can be found.

During migration most species move at night, though in no sense nocturnal in their habits. Such include most of our smaller birds, as sparrows, warblers, thrushes, vireos, blackbirds and many others, while hawks, swallows, robins, ducks and others, go by day and some go indifferently by night or by day. That birds migrate at night has been proved in a variety of ways. Anyone interested in birds can hardly have failed to hear their calls at night while passing overhead during the season for migration. In this way many species can be recognized by their notes. I have frequently interested myself, when trying to get to sleep, in listening to their calls and trying to identify them.

It is well to know that during migration large numbers of birds are attracted to and killed by flying against lighthouses. In this way much has been learned of their nocturnal movements. From the dead birds found about the lights it is evident that most, perhaps all, the species migrate in flocks of their own kind. Even those species which are never seen in flocks during the day associate in large numbers when they migrate. It is only in cloudy and thick weather that the migrating birds come to the lights, for on clear nights they evidently fly high.

Several interesting observations have been made regarding their mode of travel by watching them with a telescope as they pass across the face of the moon. At Princeton, Mr. Scott (October, 1880) saw a large number of birds through an astronomical telescope fly across the face of the moon at a height estimated to be from one to three miles. These birds passed at the rate of from four to five a minute. Among them many were recognized as warblers, woodpeckers and blackbirds.

Later, F. M. Chapman, also a well-known ornithologist, in three hours saw 262 thus fly across the face of the moon, at heights of from 1,500 to 15,000 feet. Five of these birds were Carolina rails, that were flying at a height of more than 2,000 feet above the earth. To one acquainted with these birds upon the marshes this seems a most extraordinary statement, for Carolina rails are rarely seen to fly at all unless driven from the grass at high tide by pushing a boat almost on top of them. When thus forced to fly, they spring up, fly heavily for a few rods and drop again



into the grass. Often it seems as if even this exertion were too much for them, and they so quickly drop upon the marsh as to make it nearly impossible to shoot them.

An interesting account of similar observations was published in the *Auk* by Libby, who watched the migration for three successive nights at Washburn Observatory, September 11, 12 and 13, 1897. During these observations, 583 birds were counted, 358 being seen on one night, and 45 passed during one period of 15 minutes. These observations indicated that the greatest number passed before midnight, and up to this time nearly all the birds were flying directly south. After this hour the direction varied much; birds passed in all directions, though two-thirds still flew south.

If one considers how small a portion of the air is under observation when looking in this manner at the moon, the number of birds that pass over the whole heavens above the United States will far exceed the number of wild pigeons about which you are so skeptical. That birds so small as were a very large proportion of those recognized, should thus fly thousands and thousands of feet up in the air when migrating, is most extraordinary, especially as most of the species noted fly but short distances by day, and seem incapable of sustained flight. It is possible that they find it easier to fly at first nearly perpendicularly until they have reached a great height and then, as it were, slide down hill to their destination. This is indicated by the apparent fact that their migrations high in the air take place early in the night, and that later they are seen flying in directions other than south as though looking for a suitable resting place. Such observations as we have upon the rate at which the migrating flocks advance also make this probable, for it would appear that the daily advance is much less than would be expected, if the birds ascended so high in order, afterwards, to follow a horizontal path.

Brewster has observed that small birds preparing to cross from Point Lepraux to Campobello, about twenty miles away, would mount upwards in a spiral until about 500 feet high and then take a direct course for their destination. This, however, may have been simply for the sake of getting to a better position from which they could see to follow their course.

In 1884 and 1885 an extended series of observations upon bird migration in the Mississippi valley were undertaken by the division of economic ornithology of the United States Department of Agriculture, a report of which was published by W. W. Cooke. A large number of observers were found who volunteered to keep uniform records of the arrival and departure of birds throughout the valley. At the same time meteorological records were carefully kept and weather maps made upon which the progress of the migrations and the condition of the weather were recorded. The results of this study were not so valuable as might have been expected, apparently largely because many of the observers were either incompetent or had not sufficient time to watch the birds as closely as they should have done. One interesting point, however, seems to have been established, and that is that most of the smaller birds during the spring migration advanced only about 25 to 30 miles a day, a distance much smaller than I had supposed. It also appeared that the bulk of the migration took place when the barometer was falling and the wind was south. As the south wind usually rises when the barometer falls, the former condition was doubtless the chief factor. It was not demonstrated whether the direction of the wind or the warmer weather which usually accompanies a south wind was the cause of the northward movement. The bird migration weather maps showed that northern points were sometimes reached before other points to the south of them, since the birds followed the area of warmer weather with south winds, as it pushed its way north in a sort of peninsula with colder weather lying on both sides of it. These places to the east and west were afterwards filled by the birds coming into them from all sides.

How it is that birds find their way over such great distances is a matter of dispute among ornithologists. The only theory that has many adherents is that they are directed by sight, being guided by rivers, mountain chains and coast lines, which they have learned to follow by having passed over the country before, the young and inexperienced being guided by the older ones. In this country many of the well-known ornithologists hold this view, but in England and on the Continent it is not accepted. This disagreement is due to the fact that, in this country, observers believe that they have proved that most of the older birds go south first, but that enough remain behind to act as guides for the young, while in Europe the contrary is considered to be demonstrated. Of course if the young go first they cannot find the way by recognizing landmarks with which they are not familiar. It would be remarkable if European birds found their way south in a different manner from the American.

There is much in favor of the theory that birds are guided by the sight of natural objects. In the first place, carrier pigeons are believed by all familiar with them to be so guided, and it is necessary to train them for long flights by taking them gradually greater distances from home, and flying them over a course until they become familiar with it. In the second place, it is believed on what is considered good authority that river valleys, mountain ranges and coast lines form the main paths along which most of the migration takes place.

That migrating birds follow the coast, can be seen by anyone here in New Haven who takes the trouble to watch the migrating birds day by day, especially in the fall. In October large numbers of hawks and swallows may frequently be seen passing, all moving west. It is a curious thing that large flocks, especially of hawks, are most often seen when the wind is strong from the northwest. At such times they force their way up into the wind and make evident efforts to avoid being blown to sea. It is supposed that they work up into the wind and fly along the coast well inland in order to avoid being blown out to sea. With a south wind, which might be supposed to blow them inland, they feel no danger and fly freely over the water.

Some think that in migrating birds are governed simply by a sense of direction and that, as savages have a more fully developed sense of direction than civilized men, birds may be still keener. As an illustration, which I have not seen given, but which seems to me a good one, the bee line made by the honey bee flying to its nest, might be mentioned. It does not seem probable that a bee finds its way by observing surrounding objects, but it gets there all the same.

It has been suggested that the magnetic pole in some unexplained way attracts them north, but those who have advanced this theory seem to have forgotten that they go south in the fall. They ought to have extended this theory by supposing that when in a condition of sexual activity they were magnetically attractive, but at other times repulsive.



## THOUGHTS ON BIOCHEMISTRY[1]

A few weeks ago the Connecticut Agricultural Experiment Station celebrated the fiftieth anniversary of its founding and in the evening a dinner was given in honor of Dr. Jenkins, who had been Director of the Station for many years and a member of its staff from the beginning. At that dinner I sat next to Professor Johnston and had a very pleasant evening, probably chiefly because he let me do most of the talking. A few days later he came into my office and invited me to attend the exercises in this laboratory to-day. Why he did this to me I don't know, unless, on the basis that misery loves company, he wanted you to suffer as he had done. In reply to his invitation I read him an answer I had just that moment written to Professor H. C. Sherman of Columbia, who had invited me to deliver a lecture on proteins in a course of lectures to be given during the coming summer on "Modern Chemistry."

Even this letter did not get me out of my scrape because Professor Johnston insisted that it was my duty as a member of

[1] An unpublished paper read before the chemistry seminar at the Sterling Chemistry Laboratory of Yale University, New Haven, in November, 1925.

the faculty to take part in at least one university function before I retired. As he told me I might talk on any subject I might choose, I am going to say something about biochemistry, not because I know much about it, but because the experience of a lifetime in the laboratory has given me points of view which I find some chemists do not yet appreciate and which I want you as chemists to think about.

In the first place there ought to be no such thing as "biochemistry," for the problems which the biochemist deals with are in fact *chemical* problems, pure and simple. When I first began my work with proteins, there were no biochemists, those working in this field being called physiological chemists. This was due to the fact that practically all investigators of the chemical aspects of physiology were trained as physiologists primarily and as chemists incidentally. Most of them were not trained to think as chemists and had little appreciation of what the chemist regarded as proof of the chemical identity of the substances they isolated from plant or animal tissues. As a consequence the literature is filled with much that is worthless and much that is of doubtful value.

I remember that, early in my career, my father-in-law, Professor S. W. Johnson, who was the Director of our Experiment Station here, and one of the first professors of chemistry in the Sheffield Scientific School of Yale University, said to me that progress in physiological chemistry would not be made until *chemists* entered this field. This opinion was soon confirmed by Emil Fischer, who solved the problems of the purines, which up to that time had been in a state of confusion. Soon after, he did the same for the sugars and later did more than all others who had been working with proteins to give us an insight into the structure of these complicated molecules. Without question Emil Fischer was the greatest biochemist who ever lived and he was this because he was a great chemist. It is impossible to measure the extent of his contribution to biochemistry. Certainly not the least was the psychological effect produced among organic chemists. Before this time most organic chemists regarded the physiological chemist almost, if not quite, with contempt. They were poor dubs working with messes which rarely yielded crystalline products, and when they did, these poor fellows did not know enough chemistry to identify them. There was much to justify this attitude, but the fault did not lie so much with the physiological chemist as with the organic chemist who was too proud, or too lazy, to help solve the important problems of the chemistry of life.

I can well remember the superior attitude of most of my chemist friends during the early years of my work with proteins. It was not until Emil Fischer began his work in that field that they seemed to regard me as quite fit to associate with. Now what I have said of biochemistry applies to all the other kinds of chemistry, organic, physical, inorganic, agricultural, immuno and the other various branches of chemistry. These are all chemistry, pure and simple, and none is wholly independent of the other; each needs contact with and help from the other, but none more so than biochemistry. In this field we have problems of every kind and of the most extraordinary complexity. Satisfactory progress cannot be made until all kinds of chemists unite in the attack.



The organic chemist can shut himself up in his laboratory and study single problems of structure, or synthesis, and succeed without the help of others. The physical chemist or the inorganic chemist can do likewise, but not so the biochemist; at every turn he meets new problems in the other fellow's field. He must be an intellectual phenomenon who can do much alone. The variety and profundity of the knowledge needed to cope properly with most of even the simple problems is greater than one man can have. Even keeping up with the literature of a limited field takes so much time that there is little left for the laboratory, to say nothing of golf or tennis.

The only escape from these difficulties, as I see it, lies in coöperation, not between individual biochemists, but between groups of real chemists. This is an age of specialists who are rapidly becoming more and more circumscribed in their fields. There is great danger in this, because contacts are becoming fewer and fewer when they ought to be becoming more frequent.

Now what I am coming to is this, that here at Yale we have an opportunity for coöperation in chemistry which could be utilized to great advantage in promoting biochemistry although this would not in any way impede the progress of the several departments in their own fields.

It is quite logical that an effective biochemical group be developed at Yale, for a beginning was made here before the Sheffield Scientific School was founded. As early as 1847, J. P. Norton, who came here to be a professor of chemistry in Benjamin Silliman's laboratory, was engaged in studying chemical problems of agricultural interest. Norton was a man of no mean ability and, had he not died as a young man, would have filled an important place in the history of biochemistry. He was followed by Professor S. W. Johnson who was trained by Erdmann, von Kobel, Liebig and other leading European chemists. Johnson's interest in chemistry was chiefly in its relation to agriculture and it was largely through his efforts that the first American agricultural experiment station was established in Connecticut. For several years the laboratories of this station were furnished by the Scientific School in South Sheffield Hall. Although Johnson would not be called an agricultural chemist, he was a true chemist in every sense of the term. Chittenden, one of Johnson's pupils, for many years brought fame to Yale through his many researches in physiological chemistry. More recently Wheeler, Johnson (T. B.), Mendel, Underhill and Henderson have done their full share in maintaining the traditions of Yale in this field of science. This work is now being continued by the younger associates of these men with every promise that the high standards of the past will be maintained in the future.

You thus see that we have here at Yale a biochemical background continuing without a break for more than 75 years. A long time; for remember we have not yet celebrated the 100th anniversary of the first organic synthesis, Wöhler's production of urea being the first demonstration that a natural organic substance could be produced in the laboratory.

As an old man, I might be content with this recital of past achievements, but I am not yet too old to look forward to the possibilities of the future with more satisfaction than I do to the achievements of the past.

It seems to me that we have here in New Haven exceptional opportunities which have not yet been developed. We have a fine chemical laboratory equipped for work in all branches of pure chemistry, we have another laboratory in the Sterling Hall of Medicine equipped for work in biochemistry and we have a small laboratory at the Experiment Station with special equipment for work in protein chemistry. In these various laboratories we have men who are masters in their various fields, capable of conducting research of a high order of excellence. Heretofore all these laboratories have coöperated in a friendly spirit, but I do not think this coöperation has reached the limits of its efficiency. I recognize that each laboratory has its own problems in which it is especially interested and I do not suggest that anything should be considered which would interfere with work now in progress.

It has occurred to me that it might be possible for us all to get together some time and see what might be done to help each other. A beginning might be made in arranging the subjects for theses of some of the graduate students so that their work might fit into a scheme which, as it developed, would contribute to the solution of some of the problems which are already the subject of continuing investigations. Thus in my own field there are many lines which we are unable to deal with, both through lack of knowledge and experience, as well as through lack of facilities and personnel.

For example, we greatly need to know the physical constants of the amino-acids. We can make reasonable quantities of several of these, but we are not in a position to study them properly. We cannot expect the department of physical chemistry to undertake such investigations unless a suitable supply of amino-acids is available. Might it not be possible to give one or more graduate students a problem in this field and let us supply him with material and help him in any way we can with such knowledge and experience as we may have? I believe that if a student had a problem of this kind which he knew might yield results of definite use to those working in protein chemistry, he would be more interested in it than if he had a problem of only general interest. Furthermore it would bring him in contact with those working along lines quite different from those he encounters in the laboratory of physical chemistry, and so give him a fuller realization of the importance of his work. In this way some good physical chemists might get interested in the biological field, in which there are a multitude of problems for them to study.



In a similar way we need to know much that the organic chemist can find out for us. Very little work has been done with most of the amino-acids and here is a large field in which the organic chemist can do most useful work. In our attempts to separate quantitatively the products of hydrolysis of proteins we are constantly blocked by a lack of knowledge of properties of the various amino-acids. Now that most of these products are known qualitatively, it ought to be possible to make derivatives which would enable us to estimate quantitatively some of them more accurately than is now possible. As an example, if we could find a way to separate leucine and phenylalanine, or to estimate phenylalanine in a mixture of these two amino-acids, the whole process of analysis could be greatly simplified. Also the oxyamino-acids present difficulties which I feel sure a better knowledge of their properties would do much to overcome. Serine, oxyproline and oxyglutaminic acid are important constituents of many proteins, but these have been so little studied that at present we have no means for determining, even in the crudest way, the amount of any one of these yielded by a protein. From this you can easily appreciate that there is a great deal of purely chemical work to be done by the organic chemist before the biochemist is in a position to do what he is now attempting to.

Beside the chemical questions which group themselves about the proteins, there are multitudes of others which concern the environment in which the protein exists within the living cell. Although physiologists have long been interested in this subject, almost nothing supported by chemical evidence has been learned. After the necessity in nutrition of those substances now called vitamines was recognized, it became important to know more about the soluble constituents of living cells, because some of these are the so-called vitamines. Having been attracted to this subject by the need of preparations for feeding which would introduce into the diet as little as possible of constituents of unknown nature, I was soon brought face to face with the problem of cell chemistry. This same problem was presented from another side when we attempted to isolate protein from green leaves. In this work we found it possible to obtain the juice of the leaves free from all of the formed elements which seemingly exist in a colloidal state, presumably for the most part protoplasm. Since, for several reasons, we wanted to know the nature of the substances present in this juice, our laboratory undertook to apply available methods for isolating definite substances from it. While an enormous number of well-defined substances have been isolated from one plant or another, apparently no one has ever attempted to get even an approximate idea of the relative proportions of the various groups of compounds which might be present in a single plant. The same applies equally to animal tissues. In other words we have at present almost no knowledge of cell chemistry, the very foundation of both plant and animal physiology.

For the past three or four years we have been working at this subject, applying all the available methods with astonishingly little success; a result we foresaw, because we looked at the problem from a purely chemical standpoint and realized the difficulties to be encountered. One immediate aim, however, was to demonstrate to those of our fellow workers, especially in the experiment stations, how futile it usually is to continue making so-called analyses by indirect methods supposed to show the chemical nature of the materials analyzed, when in fact they furnish no evidence whatever that a real chemist would consider for a moment. I call our work from this aspect a fool-killing research, from which, if nothing else results than the saving of time and money at present going into the accumulation of comparatively worthless data, I feel that our work will be worth all it costs. However, I am much more hopeful than this, because I have a firm faith that good work in a field of such importance to science cannot help but prove to be of ultimate value. We also hoped that when our results demonstrated how appallingly little is known of the constituents of cells, other chemists might be stimulated to help us. I think that Professor T. B. Johnson appreciates this point of view, because in his work with the chemistry of the tubercle bacillus he has encountered the same difficulties.

Until a beginning has been made to explore such fields, the nature of the problems in organic and physical chemistry which must be studied will never be appreciated. The kind of work needed requires men of special training, each in his own field, but with contacts with each other that will not only make their efforts effective, but interesting and inspiring.

The biochemist, that is, the chemist who does this pioneer work of exploration, seldom has the technical experience to deal as successfully with his many problems as those who are trained along narrower lines. He has so many kinds of questions to struggle with that he is usually a Jack-of-all-trades and master of none. He needs the sympathetic help of specialists, not their contempt, which in the past has so frequently been accorded him.



In concluding my appeal for help I want you to understand that I am not addressing it to the heads of the departments, or to the professors and instructors only, but to the students as well. Unless the student is interested, little in the way of coöperation can be expected, for those participating must have a real interest in the work. If the student is really interested he can force a reluctant professor to aid him in attaining his ambition far more easily than the professor can force a reluctant student.

Just how coöperation can be secured remains to be determined. My idea is that at first one or more students might be given some of the simpler problems for their thesis work. The experience which the student gains will inevitably be shared by his instructor who, another year, may find himself in a better position to direct the work of other students. In this way it seems to me that a mutual interest in each other's work will develop between the different professors and instructors and that these will cause a bond of union in their work which will do much not only to stimulate research in the department of chemistry, but to contribute to the application of chemistry to biology.

There are two aspects of engaging in coöperative work of this kind that deserve consideration. First, the relation of such research work to the future career of the student. For the organic chemist and doubtless also for the physical chemist some of the simpler problems may be just as good as any other as far as giving him experience is concerned. If his ambition is to specialize later along biochemical lines, either as a teacher of premedical courses or in medical schools, such a subject is eminently suitable. There are, however, relatively few positions in this field which offer inviting possibilities of reward, hence the student who specializes too narrowly in such work runs some risk of disappointment. There is an increasing demand in research institutes and medical schools for men who are capable of doing good work and perhaps the chance of success for such men as are really competent is as good as in any other field of scientific research.

This brings us to the second consideration, namely, what provision can be made for the post Ph.D. student who attempts such work? Good research work on many of the most important biochemical problems will not allow much, if any, time for teaching or the other duties for which the new fledged Ph.D. is usually paid. I believe that if a start can be made with graduate students working on biochemical subjects which contribute to the progress of some major continuing investigation, it will be possible to secure funds sufficient properly to endow fellowships and to support their work. If we here at Yale are in a position to demonstrate that the appointees to such fellowships can make good, I do not believe it will be hard to secure the necessary funds. My own experience has been that financial support followed accomplishments about as fast as I was in a proper position to receive it.

## NOTES ON THE NEST BUILDING HABITS OF THE PIPE ORGAN WASP[1]

The nest consisting of three tubes cemented together is a part of one of originally five tubes, two of which were broken when removed from a partition in a stable at Washington, Conn., about August 22, 1916. This was fastened to a smooth board in a nearly vertical position with the opening downwards, as indicated in the drawing. About three feet away another nest was being built. When first noticed, this was about one inch long, at 11 A. M. Two wasps were engaged in constructing this nest. One, smaller than the other, and apparently browner in color, was inside; the other, black with a blue lustre, worked on the outside, collecting clay and putting each portion in place. The clay was brought moulded into a strip about three-fourths inch long and one-sixteenth inch in diameter. This strip, as near as I could see, was carried on the front leg and held by one end with the jaws. This end was applied to the crotch at the median line of the nest and then rapidly attached to the edge of the piece which had previously been put in place. Apparently it was moulded by the jaws and pressed into position until the end of the strip reached the end of the preceding portion and there came into contact with the board to which the nest was attached. The end was then flattened out against the board, the jaws and fore feet being used to make it adhere firmly. During this process, the wasp inside made a buzzing sound and seemed to be engaged in maintaining a proper sized bore for the tube under construction. When the clay was attached the larger wasp went inside the tube and the two set up a loud buzzing for a few seconds. It then came out and flew away to return after two or three minutes with another strip of clay which was put in place on the opposite edge of the opening of the nest. This process was continued. Each time the outside wasp returned it struck the wall about three or four feet from the nest, but located the nest after a few seconds by flying about on one side or the other, coming gradually nearer each time as though attracted to it by some invisible force. After every four or five trips by the outside wasp the inside wasp would come out and fly away. When it returned it struck the wall much further away than did the outside wasp and had more difficulty in finding the nest. Whether or not it brought anything with it I could not see. At any rate, whatever it carried was very small. On returning, this wasp went directly into the nest and stayed there until the outside wasp had put three or four more strips of clay in place. I did not see the first tube finished or the second tube begun for I had to go away when the former was about two inches long. About 9 A. M. the next morning the first tube was approximately three inches long and a second tube had been made which was about one and a half inches long when I first saw it. I watched the construction of the second tube until 11 A. M. when it was as long as the first. When it reached this length the inside wasp set up a very loud buzzing when the outside wasp came back with more clay and apparently made such a fuss that it did not dare attempt to put the clay in place. After attempting several times to do so the outside wasp flew off with the clay and came back again, after a few minutes, apparently without any clay and went inside the nest. It then made regular trips coming back with such small quantities of clay that I was unable to see that it carried anything. When it entered the nest, clay must have been brought because after several trips a partition had been built across the lower end of the tube. I did not see any spiders put into the tube before the partition was completed, but I did not watch them continuously and this may have been done while I was away or it may have been done during the trips of the inside wasp, but I think I would have seen the spider when it came back to the nest if it brought any. A heavy thunder shower put an end to the work for the day. The next day, no more work seemed to be done and the outside wasp was not seen. One, or both, were in the nest in the afternoon as evidenced by the buzzing which followed on putting a straw into the tube. The tube first made had a partition about one-half inch from its mouth. It probably had two others lower down. Both tubes were attached to the wall in a vertical position with the mouth opening downwards.

[1] During the summer of 1916, Dr. Osborne, head of the Department of Biochemistry of this Station, spent his vacation in Washington, Conn., and became interested in watching some mud wasps construct their nest on a board of the barn. On returning to New Haven he brought me one of the wasps, the nests, and the notes and said that I might use them in any way I saw fit. The wasp was identified by Dr. H. T. Fernald, Amherst, Mass., as *Trypoxylon albitarse* Fabr. (male). The nests were provisioned with spiders which were sent to Mr. J. H. Emerton, Boston, Mass., who reported as follows: "The spiders from wasps nests are all *Epeira trivittata* Keyserling, all females, and half of them adults. They make round webs and live in the tall grass and bushes all over the country." W. E. Britton.

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## HONORS AND MEMBERSHIPS

### THE GOLD MEDAL OF THE PARIS EXPOSITION, 1900

In 1900 Dr. Osborne sent a number of preparations of seed proteins to the Paris Exposition. He received a gold medal with the following diploma.

RÉPUBLIQUE FRANÇAISE

MINISTÈRE DU COMMERCE, DE L'INDUSTRIE, DES POSTES ET DES TÉLÉGRAPHES

EXPOSITION UNIVERSELLE DE 1900

LE JURY INTERNATIONAL DES RÉCOMPENSES DÉCERNE UN DIPLÔME DE

MÉDAILLE D'OR

à Monsieur *T. B. OSBORNE*, STATION AGRONOMIQUE DE CONNECTICUT, À NEWHAVEN

GROUPE VII.—CLASSE 38. ETATS-UNIS.

LE COMMISSAIRE GÉNÉRAL
*A. Picard*

LE MINISTRE DU COMMERCE, DE L'INDUSTRIE, DES POSTES ET DES TÉLÉGRAPHES
*A. Millerand*

PARIS, LE 18 AOÛT 1900

### HONORARY DEGREE FROM YALE UNIVERSITY

The degree of Doctor of Science *honoris causa* was awarded to Dr. Osborne on June 22, 1910. The presentation by the Public Orator was made in the following words:

"It is wholly a New Haven life which is honored in Dr. Osborne. Here he was born, here he was educated, and here for twenty-four years, as chemist at the Connecticut Agricultural Station, he has patiently carried on those laborious and minutely exacting studies on the albuminous constituents of plant forms and the chemical structure of the proteins which have received the support of the Carnegie Institution and found wide recognition



both in America and Europe. He sacrificed the certainty of large financial gains for a secluded life spent with rare devotion in the solution of the most intricate and difficult scientific problems. His success has brought no pecuniary rewards and little public heralding, but is all the more genuine. An honorary degree cannot restore to him the library, the laboratory equipment, or the invaluable preparations which perished in the recent fire at the Station; but it can assure him that his University, his teachers and his townsmen are proud of him."

### HONORARY FELLOWSHIP OF THE CHEMICAL SOCIETY

In March, 1912, Dr. Osborne received the following communication:

CHEMICAL SOCIETY

BURLINGTON HOUSE,
Piccadilly, London W.,
March 7th, 1912.

SIR,

I have the honour to inform you that at a meeting of the Chemical Society held this day you were elected an Honorary and Foreign Member of that Body.

I have the honour to be, Sir,

Your Obedient Servant,

ARTHUR W. CROSSLEY,
*Honorary Secretary*

To
Dr. Thomas Burr Osborne
Newhaven (Conn.)

### THE JOHN SCOTT MEDAL

At a meeting of the Board of Directors of City Trusts (Philadelphia) held March 8, 1922, the following resolution was adopted:

*Resolved*—Upon the recommendation of the Advisory Committee, that the John Scott Medal and Certificate, with Premium of $800, be awarded to Thomas B. Osborne, for "his researches on the constitution of the vegetable proteins."

#### HISTORY OF THE MEDAL

The John Scott Medal Fund was established under the will of John Scott of Edinburgh, Scotland, and is administered under a

Power of Attorney dated April 2, 1816. The will contains the provision that ".... the interests and dividends .... be laid out in premiums to be distributed among ingenious men and women who make useful inventions; but no one of such premiums to exceed twenty dollars, and along with which shall be given a copper medal with this inscription 'To the most deserving.'"

A decree of the Court of Common Pleas of Philadelphia states: "And now, this nineteenth day of February, A.D. 1919, the Report of the Master having been duly filed and no exceptions having been taken thereto, it is adjudged and decreed that the same be confirmed, and that the Board of Directors of City Trusts, having in charge the Trust created under the will of John Scott, deceased, be authorized and directed in the administration of said Fund to distribute the income arising from the Fund as it stands with its accumulations as of the date of this Decree, in premiums to be distributed among ingenious men and women who make useful inventions, but no one of such premiums to exceed Eight Hundred Dollars ($800.00) in value; and along with such premium shall be given a copper medal with this inscription 'To the most deserving' conformably to the tenor of the Will of the said Testator.

"It is further ordered and decreed that in the selection of the recipients, the said Trustees shall be at liberty to make such rules and regulations for enabling them to make a wise selection of beneficiaries either by the selection of an advisory board or otherwise, as they may deem best. The premiums shall be awarded for useful inventions which shall include any inventions that will be useful to mankind in the advancement of chemical, medical or any other science or in the development of industry in any form; the test being that the invention is, in the judgment of the Trustees, definitely accomplished, and that it may add to the comfort, welfare, and happiness of mankind."

A resolution adopted by the Board of Directors of City Trusts states:

*Resolved*—That the award of medals under the John Scott Medal Fund be made hereafter upon the recommendation of an Advisory Board, to consist of five persons, to be appointed by the Board of Directors of City Trusts; three to be nominated by the National Academy of Sciences, one by the University of Pennsylvania, and one by the American Philosophical Society.

This Advisory Committee is constituted as follows:

*National Academy of Sciences*—H. H. Donaldson, Theobald Smith, W. B. Scott;

*University of Pennsylvania*—Arthur W. Goodspeed;

*American Philosophical Society*—Samuel M. Vauclain.



## THE THOMAS BURR OSBORNE MEDAL

ADDRESS OF THE PRESIDENT OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS AT THE PRESENTATION OF THE THOMAS BURR OSBORNE MEDAL

JUNE 7, 1928

It has long been the desire of many of the members of the American Association of Cereal Chemists to honor those scientists who have contributed signally to the advancement of our knowledge in this field of specialization. This desire took definite form at the time of the 1926 convention in Denver when President Clark proposed in his presidential address that provision be made for the presentation of a medal to be periodically awarded to those who contribute unusual papers based upon cereal chemistry research. The association referred this recommendation to the executive committee which was empowered to outline a plan and make the other necessary arrangements for the award of such a medal. The executive committee gave careful attention to this new and important project and it was decided that rather than award such a medal at regular stated intervals, the award be made only at such times as were justified by unusually meritorious contribution. The president of the association was requested to appoint a jury of awards whose duty it should be to scrutinize the development in cereal chemistry and select the medalists. The promulgation of rules governing the basis on which awards are to be made was delegated to this jury, and in all matters respecting the medal their decision was to be final.

Basing his action upon the recommendations of the executive committee, President Clark appointed the following jury of awards:

Dr. Carl L. Alsberg, Chairman, The Food Research Institute, Stanford University, California,

A. W. Alcock, Western Canada Flour Mills Co., Ltd., Winnipeg, Canada,

Dr. R. A. Gortner, University of Minnesota, University Farm, St. Paul, Minnesota,

Paul Logue, The Provident Chemical Works, St. Louis, Missouri,

Washington Platt, The Merrell-Soule Co., Syracuse, New York.

The executive committee also decided that it would be appropriate to name this medal in honor of some well-known American chemist who had made notable contributions to cereal chemistry. The jury of awards took this recommendation under advisement and later requested of Dr. Thomas Burr Osborne the privilege of naming the medal in his honor. Dr. Osborne very graciously acceded to this request with the result that this medal will be known for all time as the Thomas Burr Osborne medal.

Later the jury selected Dr. Osborne to be the first recipient of the medal which has been named in his honor. This happy selection has very evidently proved acceptable to the members of the Association.

Dr. Alsberg, chairman of the jury of awards, engaged an artist to prepare the design of the medal. From this design the necessary dies were manufactured under Dr. Alsberg's direction. The medal bears the medallion portrait of Dr. Osborne in low relief on the obverse, and a suitable inscription on the reverse. In notifying Dr. Osborne that this medal had been awarded to him, he was cordially invited to attend this convention at Minneapolis as a guest of our Association, but to our regret he was forced to decline the invitation because of ill health. He designated as a proxy to represent him on this occasion, Dr. Carl L. Alsberg, who accordingly has come here to-day as the personal representative of Dr. Osborne.

Dr. Alsberg, will you please come forward. In behalf of The American Association of Cereal Chemists I take great pleasure in handing you this gold medal which you in turn will present to Dr. Osborne with our best wishes.

LESLIE R. OLSEN.

### ACCEPTANCE OF THE MEDAL

*Mr. President and Members of the American Association of Cereal Chemists.*

I greatly regret that conditions are such that I must delegate to another the acceptance of the medal with which you have honored me. This recognition from your Association is particularly gratifying to me in view of the almost total lack of recognition my work received during the many years in which I was chiefly occupied in studying the proteins of the cereals. If it had not been for the warm support of Professor S. W. Johnson, then director of the Connecticut Agricultural Experiment Station, and that of the later director, E. H. Jenkins, as well as my own firm conviction that anything that could be learned about the chemistry of cereals was important, I am quite sure I should have been discouraged. During those years none of my fellow chemists seemed to take any interest in my work; in fact many of them intimated pretty plainly that I was wasting my time working in a hopeless field. Consequently you can realize that I am greatly pleased to find that, as my active life is closing, your Association thinks that what I have done is so well worth while as not only to deserve a gold medal, but one named after me, and of which I am the first recipient. Gentlemen, I thank you.

As I contrast the conditions prevailing in agricultural chemistry today with those prevailing at the time I first began to work with cereals, and realize that now the workers in cereal chemistry alone are sufficiently numerous to form your relatively large Association, I can hardly believe that this has all come to pass. When my first papers on the vegetable proteins were written, we did not dare print them in the reports of the Connecticut Agricultural Experiment Station lest, when the question of our appropriation should come up, some witty member of the legislature should ridicule the papers and their author on the ground that there was no apparently practical application of the results that would be useful to the farmer. Those first papers were published in the *American Chemical Journal,* edited by Ira Remsen. After he had received three or four of them he plainly intimated that more would not be received with joy. Then I sent the next to the *Journal of the American Chemical Society,* which accepted it with some signs of appreciation. This encouraged me and I continued to publish there until the *Journal of Biological Chemistry* was founded. Since then my papers have appeared in this publication.

It is interesting to recall that the first real signs of appreciation of this line of work came from Germany, where all of the papers which I had printed during several years were gathered together, translated into German and published in a volume. After that it was much easier to carry on, and more and more chemists became interested in this work. I must confess that I had not found it easy to be working in such an isolated field and the reception of some recognition was decidedly helpful. Looking back to this beginning, you can readily see how gratifying it is to me to receive this medal today.

I have no recently completed research to offer you, according to the custom on occasions like this. Instead, I wish to call your attention to some present-day problems in the work you are engaged in. Under conditions prevailing today it is far easier to devote oneself to research in a field that offers little promise of immediate practical application than it was when I began, and I therefore hope that what I have said of my experience will inspire other workers to take up new lines of work with the confident expectation that whatever may be learned and definitely established in regard to the chemistry of cereals cannot fail sooner or later to be of use and to be worth all that it costs in time and money. When I see in how many different directions the results of the work which I started have been applied, I am astonished. Many of these applications have been in fields in which these results could not have been expected to be of any use. This is particularly true in their application to problems in medical science. In fact for many years men engaged in research in the biological sciences were the first to make real use of my work, and I found myself better known among biologists and physicians than among agricultural chemists.

In the field of cereal chemistry there are still many problems awaiting investigation. With modern facilities in experiment stations, research institutions and universities, and improved apparatus and available funds, it ought to be possible to learn much that will be useful and of broad application. We do not yet know by any means as much about the proteins of the cereals as we ought to know. This is particularly true of wheat gluten.

The nitrogen content of thoroughly washed gluten indicates a larger proportion of non-protein substance than has as yet been accounted for. It is possible that a part of this may be combined with protein as a compound neither basic or acid, and hence not soluble in either dilute acids or alkalies. That such a protein complex may occur in the seeds of cereals is indicated by the relatively small proportion of the nitrogen which can be brought into a clear solution with alkalies. We have heretofore assumed that the protein precipitated by neutralizing such a solution made from wheat gluten represents the whole of the protein insoluble in alcohol which has been designated wheat glutelin, but that such is the case has, by no means, been proved.

My former colleague, Dr. D. B. Jones, has recently made a study of the glutelins in several of the cereals and has obtained such small yields of purified preparations that it seems hardly credible that these represent all of the residual nitrogen, unless a very considerable part of the protein of the cereals exists in some such combination as I have suggested.

It ought to be possible to get some evidence as to the approximate proportion of the residual protein nitrogen by properly conducted hydrolyses. Heretofore, when studying proteins we have all tried, as far as possible, to avoid causing any changes in them through the action of reagents. Here we seem to have a case where perhaps we could learn something by the opposite procedure. Now that we know so much about the products of hydrolysis of proteins it is possible that we might get some good indirect evidence as to how much of the relatively insoluble nitrogen may belong to protein by studying these products. Through such a procedure we might learn something more about those proteins of which we now know so little.

The first cereal with which I worked was the oat kernel and I have long wished that someone would explain the unusual behavior of the proteins of this seed. In all my experience I have never found a seed containing proteins behaving towards solvents as these do.

Proteins are by no means the only constituents of cereals that are important. Now that we know the part played in nutrition by insignificant quantities of the so-called vitamines, we must isolate and chemically define every possible constituent of the cereals. Those of you connected with the industries may have exceptionally good facilities to procure material for special studies that is better than any heretofore obtainable.



The embryos of wheat and corn are full of all kinds of things the nature of which is little known. These two products afford opportunity for chemical research of the highest order and both scientific and practical importance. Your Association of Cereal Chemists is in a position to promote such investigations successfully. In these days of modern science coöperation is essential. It is no longer possible in such a field as yours for one man to work alone effectively. Cereal chemistry involves far more than one would at first suppose, for not only are carbohydrates, proteins, fats and inorganic salts included in this field but also many other groups of substances which occur in smaller proportions.

The importance of a knowledge of the chemistry of these minor constituents of our food has only recently been appreciated. What is it in the wheat germ that renders an animal fertile which would otherwise be sterile? Why is the commercial wheat germ meal rich in the so-called vitamine B, while the pure germ appears to be practically destitute of this essential food factor?

Here are only two of the many problems that the cereal chemist has before him and these have not only scientific, but practical importance. To solve these problems requires the coöperation of many among you who have exceptional opportunities both in chemical training and mechanical facilities.

Chemists have done much for the industries and it is now time that the industries should appreciate this and be generous in paying their debt.

Gentlemen, I again thank you for the honor you have done me and congratulate you on the opportunities that lie before you for important contributions to science and industry.

T. B. Osborne.

## MEMBERSHIPS

Dr. Osborne was a member or a fellow of the following learned societies:

American Chemical Society,
American Physiological Society,
American Society of Biological Chemists,
Society for Experimental Biology and Medicine,
National Academy of Sciences,
The Chemical Society,
American Academy of Arts and Sciences,
American Association for the Advancement of Science,
Société Royale des Sciences Médicale et Naturelles de Bruxelles,
American Philosophical Society,
Die kaiserlich deutsche Akademie der Naturforscher zu Halle,
Sigma Xi.

# RETIREMENT

## LETTER FROM THE STATION STAFF

Dr. Osborne retired from the active direction of the Biochemical Laboratory of the Connecticut Agricultural Experiment Station on June 30, 1928. The following action was taken by the Station staff:

Dr. Thomas B. Osborne,
Connecticut Agricultural Experiment Station,
New Haven, Conn.

Dear Doctor Osborne:

We have recently learned of your expressed desire to be relieved of active direction of the Department of Biochemistry and to continue service in the capacity of Consulting Biochemist. This we understand has now been arranged.

Since this arrangement does not remove you from our midst, but merely marks a change from one form of activity to another, it does not greatly disturb us. But it does give us an opportunity to express our appreciation of your brilliant career in your chosen field of endeavor. We are proud of your long record of outstanding scientific achievement and of your fine example of devoted public service.

But we are moved by feelings far deeper than those of mere pride in your success. Above all we cherish that friendship which has grown up between us and endured so long; and we rejoice in the prospect of a long continuance of those personal contacts which have been so uniformly pleasant in the past. We hold you in our admiration for what you have done, and in our esteem for what you are.

You have our best wishes for complete enjoyment of that leisure which you richly deserve and which lightened responsibility will bring.

Very sincerely yours,

YOUR FRIENDS AND COLLEAGUES ON
THE STATION STAFF

October, 1928.



## MINUTE OF THE BOARD OF CONTROL

In the retirement of Thomas Burr Osborne from active charge of the Biochemical Laboratory, the Connecticut Agricultural Experiment Station loses one of the ablest and most valued members of its Staff.

In the forty-two years which he has served on the Staff, he has won distinction for himself and the Station, and he is today one of the acknowledged leaders in his chosen fields of study, the structure of proteins and the newer aspects of nutrition. His mind has always been raising questions which he was able to define with rare precision and then with equal discernment he has devised means for their experimental investigation and solution.

The members of the Board, in testimony of their recognition of his valued services, of their respect for his abilities, and of their high personal esteem, enter on their records this minute of their hearty appreciation. The members of the Board further rejoice that from time to time the Station may still have the benefit of his personal suggestions and advice.

G. A. HOPSON,
*Secretary.*

Adopted by the Board
October 25, 1928.

# OBITUARIES

## MINUTE ADOPTED BY THE STATION COUNCIL

The death of Dr. Thomas Burr Osborne on January 29 brought deep sorrow to his friends and colleagues on the Station staff. Identified with this Station during all of his long and productive career, his conspicuous achievements in a difficult field have reflected great credit upon this institution which he has served so well.

In 1889 at the suggestion of Professor Samuel W. Johnson, then Director of the Station, he undertook a study of the nitrogenous substances contained in the kernels of oats. This marked the beginning of an intensive and sustained study of vegetable proteins which was to become the major project of his life work. For almost forty years he devoted his creative genius, his analytical skill and his powers of critical interpretation to the intricate problems of protein chemistry and of animal nutrition. Two hundred and forty-nine published papers and monographs, many of them of a pioneer character, represent the fruits of his labours. This vast and important work from the time of its humble beginning to its brilliant conclusion was pursued in all modesty and in keeping with the best traditions of unselfish public service.

Abundant recognition of his substantial contributions to the advancement of scientific knowledge has come to him and to the Station at the hands of colleagues in his own field of endeavor, both at home and abroad; and it is most gratifying to us all that these testimonials came while he could enjoy them as he deserved to do.

We who have been associated with him in his active service do not fail to appreciate his scientific worth; but above that comes our deeper sense of personal loss born of years of pleasant associations and of our esteem for the many admirable qualities of the man.

February 4, 1929.

## CARNEGIE INSTITUTION OF WASHINGTON

## REPORT OF THE PRESIDENT[1]

Through the death of Thomas B. Osborne on January 29, 1929, the Institution loses one of its most distinguished associates in research. Dr. Osborne was connected with work of the Institution from May 1902 until his retirement from active investigation

[1] Reprinted from Year Book No. 28, 2 (1929) by permission.



in July 1928. He was a pioneer in the development of our knowledge of the chemistry of the cell, and the nature and nutritive properties of vegetable proteins.

The thoroughness with which Dr. Osborne and his associates carried on their investigations brought results of exceptional scientific value. His accomplishments greatly advanced the scope and improved the methods of biochemistry and laid foundations for the important work now being continued by Dr. Lafayette Mendel and Dr. Hubert Bradford Vickery.

It is interesting to note that the studies through which Dr. Osborne and his colleagues have so ably advanced physiological chemistry have now direct relation to the biochemical investigations included in the program of the newly organized Division of Plant Biology.

## JOURNAL OF BIOLOGICAL CHEMISTRY[1]

We regret to record the death, on January 29th, 1929, of Thomas Burr Osborne who was associated in an advisory editorial relationship with *The Journal of Biological Chemistry* since its foundation in 1906 and became a member of the Editorial Committee when the latter assumed responsibility for the general conduct of the Journal.

Dr. Osborne was born in New Haven, Connecticut, on August 5th, 1859, the son of Arthur D. Osborne (B.A., Yale 1848) and Frances Louisa Blake Osborne, daughter of Eli Whitney Blake, of New Haven. Thomas B. Osborne was prepared for college in the Hopkins Grammar School, and was graduated from Yale College with the degree of B.A. in 1881. He received the degree of Ph.D. from Yale in 1885, after having pursued postgraduate studies in chemistry there. The honorary degree of Doctor of Science was conferred upon him by his Alma Mater in 1910.

Dr. Osborne's earliest activities in the academic field were in the domain of analytical chemistry. He became a member of the Research Staff of the Connecticut Agricultural Experiment Station at New Haven in May, 1886, continuing active association therewith until his retirement last year. Throughout his long scientific career Dr. Osborne retained his affiliation with the Connecticut Station, during most of this period being in charge of a laboratory specially devoted to his own research interests.

Dr. Osborne's name will long remain associated with his pioneer investigations of proteins of plant origin. The first contribution (1890), dealing with the albuminous components of the oat kernel, was followed in rapid succession by a series of related studies which were summarized in his classic monograph on

[1] Reprinted from **81** (1929) by permission of the editor.

*The Vegetable Proteins,* in 1909. A revised edition appeared in 1924. The descriptive consideration of a large group of plant proteins was followed by investigations of the amino-acid derivatives of various purified proteins. Presently Dr. Osborne enlarged the scope of his research interests to include the biological properties of these substances. In collaboration with Lafayette B. Mendel and with continued generous support of the Carnegie Institution of Washington, of which he was a Research Associate since 1904, he directed some of his energies to the problems of nutrition, from 1910 until the time of his death.

During his scientific career Dr. Osborne published 253 papers and monographs, most of which deal with proteins and their derivatives. He was appointed a Research Associate of Yale University with professorial rank in 1923.

Recognition came to him from many sources through election to learned societies and through the award of medals for scientific distinction. The soundness of his chemical work was recognized by his election as an Honorary Fellow of the Chemical Society of London. Within the past year the American Association of Cereal Chemists instituted the periodical award of the Thomas Burr Osborne medal for distinction in the field of cereal chemistry research, Dr. Osborne himself being the first recipient.

Those who were privileged to enjoy a personal acquaintance with Dr. Osborne soon learned to appreciate his many sterling qualities as a man. An unusual enthusiasm for research which exhibited itself in more than one field of human inquiry; never-failing patience in the execution of experimental work; rigorous critique applied to his own results as well as the work of others; vigorous opposition to sham in any form; rare appreciation of the best contributions to science and industry; delightful companionship and deep loyalty to his friends—these were some of the characteristics of our respected colleague.

## MINUTE ADOPTED BY THE BOARD OF DIRECTORS OF THE SECOND NATIONAL BANK OF NEW HAVEN[1]

It is with great sorrow that we record in our minutes the death of Thomas Burr Osborne, a member of this Board, which occurred at his home in New Haven on January 29th, 1929.

Dr. Osborne's grandfather, Judge Thomas B. Osborne, was a director of this bank from the time of its organization in 1864 until his death in 1869; his father, Arthur D. Osborne, was a director from 1869 to 1916, was its President for seventeen years of that time, and Dr. Osborne himself succeeded his father as director December 28th, 1916. Both grandfather and father were lawyers.

[1] Printed with the permission of the president of the Second National Bank.



Dr. Osborne soon after his graduation from Yale engaged in research work in chemistry and devoted himself especially to study of the chemistry of nutrition and growth—biochemistry, in which he won great distinction. Yale gave him the honorary degree of Doctor of Science and appointed him research associate with rank of Professor, he served as member and officer of learned societies, was made honorary member of learned societies abroad, was awarded medals both here and abroad, and assisted in editorship of scientific journals—the story of his discoveries is known the world over. Pausing occasionally to publish his results, he has given his fellow-scientists new ground from which to work and contributed much to the physical well-being of all. Applause, however, he scarcely heard, for by the time it reached his ears he had eagerly resumed his quest for further truth. He was modest but realized the value of his own work—his modesty was that of the earnest man who regards success as a new foothold for further progress.

We, his associates on this Board, however, knew him in the broader relations of life. We respected him for his achievements in science, but we also came to realize and respect his knowledge and understanding of business, especially in its relation to government finance. He brought to the service of the bank a natural and inherited interest in its business, an understanding of its relation to the community and a lively interest also in public affairs and the larger problems of finance, which were considered by him with the relentless searching logic of the scientist, who must be sure of his premises. We have found him a real friend and have shared with him his sympathetic interest in the life of those around him. As directors we have been helped by his sound and kindly counsel. We gratefully acknowledge his service to this bank and the community.

Attest:

E. G. Allyn,
*Secretary.*

## THE YALE JOURNAL OF BIOLOGY AND MEDICINE[1]

The death of Thomas Burr Osborne on January 29, 1929, removes one of the most distinguished figures in American biochemistry. Descended from a long line of Yale men, himself a graduate of the class of 1881, his passing will be lamented by all who were associated with him, as well as by the many scientific investigators who have been influenced by his work.

Dr. Osborne's entire life was devoted to research in what was,

[1] Reprinted from 1, 187 (1929) by permission of the editor.

at the beginning of his labors, an almost unexplored field. The origin of his interest in chemistry may be traced to his friendship and association with Samuel W. Johnson, who was, for many years, Professor of Agricultural Chemistry in the Sheffield Scientific School and Director of the Connecticut Agricultural Experiment Station. After graduation, Osborne continued the study of chemistry and in 1885, received the degree of Ph.D., being the tenth man to obtain this degree in chemistry from Yale. His dissertation was entitled "The Quantitative Determination of Niobium," a subject certainly far enough removed from what later became his life work. This investigation had been preceded by studies on the analytical separation of zinc and was followed by a number of others also dealing with analytical problems. The foundation of his career was thus laid upon a thorough knowledge of analytical chemistry.

In 1886, Dr. Osborne was invited by Professor Johnson to join the staff of the Connecticut Agricultural Experiment Station, and he thus formed a connection which was maintained until his death. Professor Johnson had become interested in the work of Ritthausen upon the proteins of seeds, and, in 1888, he suggested that further study in this field might lead to useful results. The selection of the oat kernel as the first seed for investigation was probably influenced by some early work of J. P. Norton. That the choice was perhaps unfortunate is indicated by a statement made in Dr. Osborne's address on the acceptance of the Thomas Burr Osborne medal on June 7, 1928. "The first cereal with which I worked was the oat kernel, and I have long wished that someone would explain the unusual behavior of the proteins of this seed. In all my experience I have never found a seed containing proteins behaving toward solvents as these do." In spite of the extraordinary difficulties presented by the material chosen, he succeeded in isolating the proteins of the oat in a pure form, one of them, a globulin, in crystalline condition. This paper was followed by a series of investigations extending in almost unbroken sequence for ten years, in which preparations of the proteins from more than thirty different seeds were described. These descriptive studies were followed by several papers dealing with the nucleic acid of the wheat embryo and with the basic character of the protein molecule; papers which are among his most important contributions to science. In them he announced the discovery of a nucleic acid and showed that it contained the purines, guanine and adenine, in molecular proportions. He made it clear that preparations described in the literature as nucleoproteins were in reality salts of proteins with nucleic acid, and that the highly variable proportions of phosphorus in such preparations were to be accounted for by the fact that nucleic acid and proteins may unite with each other in variable proportions since proteins may behave as polyvalent bases, while nucleic acid is a polyvalent acid.



He next showed that edestin from hemp-seed could unite with hydrochloric acid in two different proportions forming definite and reproducible compounds, the compositions of which, with respect to the acid, were in the simplest possible stoichiometric relationship to each other. This was an accomplishment of the highest significance, since it indicated that proteins behave in accordance with the laws which govern the behavior of other and simpler basic substances.

This investigation initiated a second phase of Dr. Osborne's work in which the chemical properties and composition of proteins were primarily considered. Perhaps the best known of these studies is that which deals with the different forms of nitrogen in proteins (1908), in which it was shown that a definite part of the protein nitrogen is found, after hydrolysis, as ammonia, and that the amount of ammonia is so related to the proportions of glutaminic acid and aspartic acid derived from the proteins as to lend great weight to the view that these acids must occur as amides in the protein molecule. A further proportion of the nitrogen of proteins can be precipitated by phosphotungstic acid after hydrolysis and, therefore, probably belongs to basic substances. Dr. Osborne found that this proportion is very close to that to be expected from the sum of the amounts of arginine, histidine and lysine yielded by these proteins. He further demonstrated that the additional quantity of ammonia obtained when proteins were hydrolyzed by means of alkali, over that secured when acid hydrolyzing agents were used, could be closely accounted for by the secondary decomposition of arginine. This paper is one of the most widely quoted of Dr. Osborne's contributions to protein chemistry. In it he allowed himself almost the only prophecy to be found in his work. With respect to the proteins of the cereal grains he says, "they in some ways differ in structure from all the others which have been examined, and ........ they may possibly contain some other dibasic acid not yet isolated from their decomposition products." This prophecy was fulfilled ten years later by Dakin's brilliant discovery of oxyglutaminic acid in several of the proteins to which Dr. Osborne had referred.

Beginning in 1906, and continuing for about six years, with the aid of a number of collaborators, Dr. Osborne carried out a series of analyses of the amino-acid composition of proteins. These analyses set a standard for such work, surpassed only since the introduction, in recent years, of greatly improved methods, and laid the foundations for the studies of the nutritive properties of proteins begun in collaboration with Prof. Lafayette B. Mendel in 1909, and continued until 1928. He had become greatly interested in the physiological properties of proteins, and a series of papers, in collaboration with Prof. H. G. Wells of Chicago, led to a clear understanding of the anaphylactogenic relationships of vegetable proteins.

The results of the work on nutrition problems are well known. A technique for the study of various diets, using rats as experimental animals, was perfected. Studies on the relation of amino-acid composition to the nutritive value of proteins showed that tryptophane and lysine were essential for growth and maintenance. The presence of an accessory food factor in butter-fat, subsequently designated as vitamin A, was discovered independently and this finding was published in 1913. In addition there were many studies on the nutritive value of isolated proteins and upon the mutual supplementation of various foodstuffs with respect to their protein composition. One of the most useful results of the experiments upon the vitamin requirements of animals was the recognition of the peculiar value of cod liver oil in nutrition, and an at least partial explanation of the high esteem in which this oil has long been held by the medical profession.

Osborne and Mendel have also contributed widely to the knowledge of the distribution of the vitamins in natural foodstuffs, and to the factors influencing the phenomena of growth, in particular to the study of dietary regimens resulting in the suppression of growth or in its acceleration.

One of the results of the study of vitamins was a clear conception, in Dr. Osborne's mind, of the importance of an investigation of the constituents of living cells. This led to a vast amount of labor upon the composition of green leaves, much of which did not reach the stage of publication. He enthusiastically coöperated in the labors of his assistants in this field and the work strikingly demonstrated the complexity of the chemical environment in which the life process takes place. Dr. Osborne's labors in the field of protein chemistry were summarized in his classical monograph "The Vegetable Proteins," first published in 1909, and extensively revised in 1924. His monograph on "The Proteins of the Wheat Kernel" (1907) is a standard text among cereal chemists. His published work includes nearly 250 journal reports as well as public addresses and more popular articles.

Dr. Osborne was one of the fortunate leaders of science in a highly technical field to whom recognition came in his own lifetime. He was awarded the honorary degree of Sc.D. by Yale in 1910, and in the same year was elected a member of the National Academy of Sciences. He was made an honorary fellow of the London Chemical Society in 1912, and a fellow of the American Academy of Arts and Sciences in 1914. He was an associate member of the Société Royale des Sciences Médicales et Naturelles de Bruxelles, a member of the American Philosophical Society, and of many other American and foreign learned societies. In 1923, he was made a Research Associate in Biochemistry of Yale University. In 1900, he was awarded a gold medal by the Paris Exposition, and in 1922, received the John Scott Medal. In 1928, he was the first recipient of the Thomas Burr Osborne Gold Medal of the American Association of Cereal Chemists; a medal founded in recognition of his outstanding contributions to cereal chemistry.



Dr. Osborne was one of the most distinguished pupils of Prof. S. W. Johnson, and through him traced his intellectual ancestry back to Liebig, the founder of agricultural chemistry. The enormous increase in interest in the chemistry of proteins in this country, particularly in recent years, is to no small degree due to his direct influence. He was a painstaking, careful investigator who spared no effort, time, or expense in the attainment of the truth. He accepted no result until it had been subjected to the test of rigorous and repeated experiment, and all his publications bear the marks of meticulous editing lest a statement should to the slightest extent pass the bounds of ascertained fact.

To those who were privileged to be associated with him in his work he was a rare stimulus, a formidable opponent in argument, and an ever genial but just critic. He frequently closed a discussion with the remark that facts were to be found in the laboratory, not in books. He was naturally shy and retiring; the delivery of a public address or of a paper was a severe trial to which he looked forward with trepidation; but among a small group of friends he showed himself as a gifted conversationalist, who was equally able to discuss the latest achievements of science, the current political situation, the intricacies of the world of finance, or the faults of the modern educational system.

It has been said that the value and significance of a man's work is, in the long run, in no way influenced by what is said of it: ultimately it stands alone upon its intrinsic merit. The work of Thomas Burr Osborne is founded upon the basic principles of accuracy, honesty, and a desire to be of service to his fellow men. No more enduring monument to his memory can be erected than this.

HUBERT BRADFORD VICKERY.

## EXPERIMENT STATION RECORD[1]

The career of Dr. Thomas Burr Osborne, ended by his death on January 29, 1929, personifies in an unusual degree the ideals of scientific research at the agricultural experiment stations. Entering the service of the Connecticut State Station in 1886, Dr. Osborne soon began a study of the vegetable proteins which became the major project of his life work and continued for almost 40 years. In this relatively intricate and difficult field he did a notable work and achieved wide recognition as an outstanding authority. As one who followed his studies closely from the

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beginning has recently written, "he exemplified in the best sense the courage and perseverance of the investigator, coupled with the skill and creative ability so essential to discovery. His contribution was an unusually large one, and has been very far-reaching in its effects on our thinking and understanding."

Dr. Osborne's entire life was spent in the city of New Haven, where he was born on August 5, 1859. He was graduated from Yale University in 1881 and received the degree of doctor of philosophy from the same institution in 1885. His early interests were in the field of analytical chemistry, and for three years he was an assistant in that subject in Yale.

The enactment by the Connecticut Legislature of a law to protect the dairy industry and the general public from the increasing sale of unlabeled imitation butters made possible an increase in the chemical staff of the State Experiment Station in 1886, and it was in connection with this control work that he was given his original appointment. His service as a routine analyst, however, was brief and was supplemented almost immediately by studies of analytical methods. The report of the station for 1886 includes notes from his pen on the filtration of crude fiber and the filtration and weighing of silver chloride, and in the following year he gave much attention to devising methods of mechanical soil analysis.

The Connecticut State Station had been established with the immediate objective of providing a defense against fraud, but its aim, as stated in the act of incorporation, was "to promote agriculture by scientific investigation and experiment," and the station was not permitted to develop as either an exclusively control station or as one content with the simpler and more immediately useful forms of testing. Largely because of the broad vision and high ideals of those in whose charge its destinies had been intrusted, scrupulous care had been exercised so to organize its inspection service that it would not hamper the progress of research, to rest it at all times on the soundest basis which science could provide, and to develop as far as possible the more fundamental inquiries. Accordingly, in 1888, just as the Hatch Act was coming into operation, Director S. W. Johnson proposed an investigation of the vegetable proteins, and the station report for the following year tersely announced that "much time has been given by Dr. Osborne to a study of the nitrogenous matters contained in the kernels of maize and oats."

In this modest fashion began a series of investigations of outstanding importance. The studies were undertaken at a time when work in this field was known to be much needed, but the opportunity was being neglected. The first serious examination of the vegetable proteins had been instituted in 1860 by Ritthausen, who had demonstrated the occurrence of many diverse forms in the different seeds and indicated some of the difficulties and complexities of the subject. His work had been far from exhaustive, however, and with the contributions of Denis and Weyl the matter had been left in much confusion. Because of its intricacy the subject was being regarded by chemists in general with some trepidation.



Dr. Osborne first directed his attention to a reinvestigation of the matters dealt with by Ritthausen. Utilizing and devising improved methods and working with characteristic thoroughness and care, he was soon able to show that the number of distinctive vegetable proteins is far greater than Ritthausen had supposed. Ultimately pure specimens of the proteins from no fewer than 32 different seeds were prepared, usually by several methods, and comprehensive descriptions formulated. Many of the proteins previously grouped together were found to be distinct substances. Specific designations were thereupon given them, and the use of older terms much restricted. As Vickery and Mendel, two of his former colleagues, have pointed out in a recent tribute in *Science,* "this clarification of the nomenclature has been of immense assistance in bringing a semblance of order into an almost hopelessly confused subject."

This phase of Dr. Osborne's activities continued for about 10 years and led logically to an investigation of the proteins as a group, their structure and their properties. Here again he was delving in a pioneer field, and again he was equal to the occasion. In the words of a resolution of appreciation adopted by the station board of control at his retirement from active service late in 1928, "his mind has always been raising questions, which he was able to define with rare precision, and then with equal discernment he has devised means for their experimental investigation and solution." By analysis and reanalysis he patiently and persistently advanced the boundaries of knowledge of the fundamental chemistry of the proteins and established a basis for the third and culminating stage of his research, a study of their nutritive values.

This study was begun in collaboration with Dr. L. B. Mendel in 1909, and involved among other requirements the development of a technique for feeding individual small animals diets containing the pure isolated proteins which he now had available. Unexpected difficulties arose in obtaining normal growth with young animals on what were supposedly adequate rations, but when these were overcome by the use of a "protein-free milk" prepared by removing the casein and lactalbumin from milk serum and evaporating, wide differences in the efficacy of the various proteins were revealed. For example, the animals grew well on wheat glutenin and edestin, but failed rapidly on zein and gelatin, while maintenance but not growth was possible on hordein and rye and wheat gliadin. Further work showed that by the addition of certain amino-acids the deficiencies could be rectified and growth made possible.

The great value and immediate practical bearing of these findings were generally recognized, but even more important observations were to follow. These observations grew out of the use of the "protein-free milk" employed in the feeding experiments and indicated that there occurs in butter a substance essential for animal growth. Similar discoveries were reported at about the same time by McCollum and Davis, using an ether extract of egg yolk and of butter, and the essential substance was later designated vitamin A. Subsequently, Dr. Osborne and his associates noted the value of cod liver oil as a growth stimulant and particularly as the curative agent for the xerophthalmia regularly encountered in the animals receiving the deficient diets.

In 1911 Drs. Osborne and Mendel showed that the "protein-free milk" was much more efficient in inducing growth than was a corresponding mixture of lactose and pure salts or milk ash, thus implying the presence of some water-soluble organic growth-promoting substance. This early inference was later confirmed, and the studies contributed considerably to the development of our knowledge of the distribution of such a vitamin in foods and its significance in normal nutrition, particularly in connection with growth.

Many other extensive contributions were also made, as indicated in the following summary by Vickery and Mendel: "Much labor was devoted to the study of the nutritive value of the proteins of the commercially important foods, and this work gave a rational explanation of many practices which empirical experience had shown to be advantageous. The distribution of vitamins A and B in natural food products was studied, and considerable success was attained in an effort to prepare a vitamin-rich concentrate from yeast. The phenomena of growth, its suppression and acceleration under various regimens, the effect of the individual inorganic constituents of the diet, these and many other topics received attention at different times."

An idea of the extent of Dr. Osborne's labors may be gathered from the fact that a complete bibliography of his publications is said to reach 253 titles, of which about 200 are contributions to journals reporting his personal scientific work. This large number is the more remarkable in view of his conservatism in announcing his findings and his rigid insistence that no result must be made public that had not been verified by careful, thorough, and repeated experiment. Perhaps because of what has been termed his "meticulous editing," none of his published works are of great length, the most extensive probably being his monograph of 154 pages on The Vegetable Proteins, first issued in 1909 and extensively revised in 1924. This monograph and his report of 119 pages on The Proteins of the Wheat Kernel (1907) have long been regarded as classics in their respective fields.

The success of Dr. Osborne's work may fairly be considered a resultant of his personal efforts, characteristics, and qualifications,



and his favorable environment. To an unusual degree he represented the "exceptional investigator," of whom much is heard in discussions of research and research workers. He was well equipped by training and temperament to utilize to the full his advantages and to profit by his congenial surroundings. Assigned as a young man to a highly complex and difficult problem, he grew with his opportunity. Beginning in a small way, devising and adapting his tools for the task, he worked logically, patiently, and sanely. Progress was neither spasmodic nor spectacular, but it was steady and sure, with little lost motion and even less of following of blind trails and retracing of steps. Gradually the mosaic was assembled, and the work little understood or appreciated in its beginnings was impressively revealed.

Without detraction from the achievements of the central figure in the execution of this important project, it may be pointed out that much credit also accrues to his associates, his colleagues and coworkers, and especially to those who have formulated and executed the policies of the institution under whose auspices the work has been done. Outstanding among these have obviously been Director Johnson, at whose instigation and under whose enlightened leadership the investigation was originally conceived and gotten under way, and his successor, Director E. H. Jenkins, who without the incentive of project authorship assumed the responsibility for its continuance and suffered no interference with its progress. Nor should there be overlooked the consistent coöperation and support of successive boards of control, manifested through the years when results came slowly and their applications to practical farming seemed remote and improbable. If it is recalled that even after the passage of the Hatch Act the entire resources of the station did not exceed $20,000 per annum for several years, that the experiment station itself was on trial in Connecticut as elsewhere, with its usefulness as an aid to agriculture still to be fully accepted, and that a host of relatively simple problems of undoubted economic importance and popular appeal were pressing for solution, the courage and the vision of Dr. Osborne's supporters become manifest. When the contention is heard, as happens from time to time, that the agricultural experiment stations are too hard pressed for results of practical value and for immediate application to be looked to for systematic and long-time research along fundamental lines, the maintenance of Dr. Osborne's work year after year may well be included in the many instances which may be cited in rebuttal.

From various aspects, the story of Dr. Osborne intrigues the imagination and supplies a unique inspiration. Fortunately it is not only a story with a moral but a tale with a happy ending. Public recognition came slowly, and first of all, according to Vickery and Mendel, by way of Germany, when Griessmayer in 1897 published a treatise on the vegetable proteins that contained many extracts from Dr. Osborne's papers and stated in his introduction that it was his hope "to bring to light these treasures buried in their American publications." By 1904, however, the fundamental character of the work had been so thoroughly established as to enlist substantial financial support from the Carnegie Institution of Washington, and this support has subsequently been continued without interruption as one of the comparatively few projects carried on at an experiment station which have ever received such aid. In 1908 the work was also accepted by the Office of Experiment Stations as an appropriate project under the recently enacted Adams Act, and this relationship likewise continued without material modification for nearly 20 years.

Personal recognition was ultimately accorded in generous measure. Yale University conferred the honorary degree of doctor of science in 1910, and in 1923 appointed Dr. Osborne a research associate in biochemistry with professorial rank. In 1920 he was elected a member of the National Academy of Sciences, in 1912 an honorary fellow of the Chemical Society of London, and in 1914 a fellow of the American Academy of Arts and Sciences, and he was long a member of numerous other societies at home and abroad. For many years he was associate editor of the *Journal of Biological Chemistry*. Three medals were awarded to him, the gold medal of the Paris Exposition in 1900, the John Scott medal in 1922, and (as the first recipient) the Thomas Burr Osborne gold medal established in his honor in 1926 by the American Association of Cereal Chemists in commemoration of his "notable services to cereal chemistry."

Late in 1928 and at his own request, he was relieved of active charge of the biochemical laboratory, at which time he was given the title of consulting biochemist by the board of control, with appropriate resolutions of appreciation. In the few weeks which followed, the memory of these honors and the many expressions of esteem of his colleagues and others doubtless brought him much pleasure, yet the guess may be hazarded that his highest satisfaction came from his own realization that he had achieved the goal of every true investigator, a lifetime profitably and productively spent in the elucidation of a worth-while problem. As Vickery and Mendel have well said, "his death removes one of the great pioneers of American biochemistry, a man whose name will always be linked with the subject he made peculiarly his own."

## AMERICAN JOURNAL OF SCIENCE[1]

By the death of Thomas Burr Osborne on January 29, 1929, at the age of 69, modern biochemistry has lost one of its most fruitful investigators. Few students of science have devoted them-

[1] Reprinted from 17 (April, 1929) by permission of the editor.



selves more wholeheartedly, uninterruptedly and effectively to a few definite research objectives. Dr. Osborne served for a time on the teaching staff of the Chemical Laboratory at Yale. A number of his early contributions dealt with problems of analytical chemistry. In 1886 he became attached to the Connecticut Agricultural Experiment Station, then under the directorship of Prof. S. W. Johnson, and presently began a series of fundamental investigations on the occurrence and properties of proteins in plants, notably in the cereal seeds. These have been summarized in his monograph on *The Vegetable Proteins,* which has become the classic book of reference in its field. Subsequently in collaboration with a number of assistants he devoted himself to analytical studies of the structure of the proteins, whereby he was enabled to make fundamental contributions to our knowledge of the amino-acid makeup of the nitrogenous foodstuffs. The large experience and information thus secured served to awaken Dr. Osborne's interest in some of the biological properties of the proteins and bore fruition in outstanding investigations (in collaboration with Prof. H. G. Wells) on the anaphylactic properties of many plant proteins. Furthermore during a period of nearly 20 years he was engaged, in collaboration with Prof. Lafayette B. Mendel of Yale University, in elaborate investigations of the comparative nutritive value of proteins. Observations made in the course of these studies further led to various discoveries regarding those nutritive properties of foods now designated as vitamins. The physiology of growth likewise became a subject for extensive consideration. Dr. Osborne's various contributions presented in more than 250 scientific papers brought recognition and distinction to him from many sources. Few chemists have been privileged to follow the dictates of their interest so long and successfully without the interruptions or distractions that may retard the progress of the devotees of science.

L. B. M.

## JOURNAL OF THE CHEMICAL SOCIETY[1]

Thomas Burr Osborne was elected an honorary Fellow of the Chemical Society in 1912 and his death on January 29th, 1929, removes one of the most distinguished figures in American biochemistry. The Chemical Society has seldom honoured with its honorary Fellowship investigators whose work has been concerned chiefly with the biological side of chemistry, thus Osborne's election was an exceptional tribute to the scientific worth of his labours.

Osborne's scientific life was entirely centered around New

[1] Reprinted from page 2974 (1929) by permission of the editor.

Haven. A student of Yale University, he received the degree of Ph.D. for a thesis on "The Quantitative Determination of Niobium." In the year following graduation he was invited by Professor S. W. Johnson to join the staff of the Connecticut Agricultural Experiment Station, thus forming a connexion which he maintained throughout life. Up to this time Osborne's work had been entirely concerned with analytical chemistry, and the cause of his deflection to biological chemistry may not improbably be referred as much to the heart as to the head. His devotion to Johnson, himself a pupil of Liebig and for long one of the outstanding leaders in agricultural science, and his subsequent marriage to Professor Johnson's daughter combined to make the transition an easy one.

In broad outline Osborne's contributions to biochemistry may be considered in three main groups. First, the preparation of many proteins, especially those found in vegetable seeds, in a state of relative purity quite unattained by previous investigators. Many of these proteins were obtained in crystalline form and characterized in a thoroughly convincing fashion. Having the command of relatively pure proteins in large amounts, Osborne devoted the second phase of his work to the analysis and identification of their products of hydrolysis: the results are of permanent value and are constantly utilized by others, but it may be conceded that the methods made use of were chiefly worked out by Kossel, Fischer, and others and that Osborne's own contributions to methods of protein analysis seem modest in comparison with his other outstanding accomplishments. The third and certainly the most striking part of Osborne's work dealt with the biological properties of his highly purified proteins; first of all in relation to their specific antigenic properties and their ability to produce that extraordinary phenomenon known as the anaphylactic reaction—and subsequently their rôle in animal nutrition. The latter phase of Osborne's work brought into prominence the importance, from the standpoint of nutrition, of minute amounts of substances associated in varying degree with certain foodstuffs which are now grouped under the name of "vitamins." In particular he contributed largely to the discovery of the substance present in butter fat which was later distinguished as vitamin A and is essential for animal existence.

In the following year the important observation was made that the same stimulation of growth could be secured by the addition of cod liver oil to a diet of purified food substances and protein-free milk, a discovery which served to focus attention upon the value of this oil, in particular as a curative agent for the peculiar eye condition known as xerophthalmia, which was regularly encountered in animals on the deficient diets. At the close of the war the sight of many children in Europe was preserved by its use, a remarkable example of the application of scientific results to practical problems.



One of the results of the study of vitamins was a clear conception in Osborne's mind of the importance of an investigation of the constituents of living cells. This led to a vast amount of labour upon the composition of green leaves, much of which did not reach the stage of publication. He enthusiastically coöperated in the labours of his assistants in this field and the work strikingly demonstrated the complexity of the chemical environment in which the life process takes place. Osborne's investigations in the field of protein chemistry were summarized in his well-known monograph "The Vegetable Proteins," first published in 1909, and extensively revised in 1924. His monograph on "The Proteins of the Wheat Kernel" (1907) is a standard work of reference among chemists who are occupied with the problems of cereal foods. His published work includes nearly 250 journal reports as well as public addresses and more popular articles. Shortly before his death Osborne published jointly with his colleague and successor, H. B. Vickery, a monograph in *Physiological Reviews* entitled "A Review of Hypotheses of the Structure of Proteins," which must be regarded not only as a confession of faith but as one of the sanest and most wisely critical essays on a most difficult subject. His last paper on "The Chemistry of the Cell" concludes with the following sentence, which is so typical of Osborne's scientific caution and dislike for premature speculations that it may be quoted: "I fear that for a long time to come much will still remain to be learned about the chemistry of the cell, but if, in the meantime, we can extend our knowledge of this subject it may save us from many erroneous conclusions based on incorrect results obtained without sufficient appreciation of the real nature and complexity of the problem."

Osborne was singularly fortunate in his conditions of work and enjoyed happy associations with many colleagues of distinction, notably Gideon Wells, Mendel, Vickery, and Wakeman. His extensive investigations would have been impossible without generous financial support and encouragement. Throughout the early years, when results came slowly and their application was by no means apparent, the directors of the Connecticut Agricultural Experiment Station allowed no interference or distraction to hinder the progress of the work. Since 1904 a large proportion of financial burden has been borne by the Carnegie Institution of Washington, D. C., of which he was a research associate. Osborne's connexions with both the experiment station and the Carnegie Institution of Washington furnish a striking example of the value to science of a policy of non-interference on the part of those in control of the distribution of funds for research. Except for routine annual reports, he was never asked for statements of progress or for outlines of projects. The relationship was always one of the utmost mutual confidence and esteem.

To those who were privileged to be associated with Osborne in his work he was a rare stimulus, a formidable opponent in argument, and an ever-genial but just critic. He frequently closed a discussion with the remark that facts were to be found in the laboratory, not in books. He was naturally shy and retiring, but among a small group of friends he showed himself as a gifted conversationalist, who was equally able to discuss the latest achievements of science, the current political situation, the intricacies of the world of finance, or the faults of the modern educational system. Few men have been more free from what Bacon has termed "the first distemper of learning, the studying of words and not matter."

H. D. D.[1]

### THE YALE ALUMNI WEEKLY[2]

Thomas Burr Osborne died at his home in New Haven on January 29. He had suffered an acute attack of heart disease a few days before. Osborne received his preparation for college at the Hopkins Grammar School. At Yale he was given a first colloquy appointment in both junior and senior years, served as president of the Yale Natural History Society for three years, and belonged to Psi Upsilon and Skull and Bones. He specialized in chemistry in the Yale Graduate School from 1882 to 1885, when he received the degree of Ph.D., and was an assistant in analytical chemistry from 1883 to 1886. Osborne was connected with the Connecticut Agricultural Experiment Station in New Haven as chief in protein research from 1886 until his retirement from active direction of the work of the laboratory last summer and had since held the position of advisory biochemist. He was a research associate of the Carnegie Institution in Washington, and he had been connected with the Yale faculty as a research associate in biochemistry, with the rank of professor, since 1923. Osborne had won preëminent recognition as an authority in the field of vegetable proteins and had served as president of the American Society of Biological Chemists and as an associate editor of the *Journal of Biological Chemistry*. He was the author of *Proteins of the Wheat Kernel* and *The Vegetable Proteins* and had contributed numerous papers to various scientific journals. Yale conferred the honorary degree of Sc.D. upon him in 1910, and he was elected to membership in Sigma Xi in March, 1928. He was awarded the Paris Gold Medal in 1900 and the John Scott

[1] The writer gratefully acknowledges his indebtedness to Dr. Vickery's article on Dr. Osborne's work published in the *Yale Journal of Biology and Medicine,* March ,1929.

[2] Reprinted from page 576 (Feb. 8, 1929) by permission of the editor.



Medal in 1922, and in 1928 he was the first recipient of the Thomas Burr Osborne Gold Medal, which was established in his honor by the American Association of Cereal Chemists in 1926. Osborne was an honorary member of the London Chemical Society, an associate member of the Société Royale des Sciences Médicales et Naturelles de Bruxelles, and a fellow of the American Academy of Arts and Sciences. He was married in 1886 to Elizabeth Annah Johnson, of New Haven, who survives him with one of their two sons, Arthur D. Osborne, '08. The younger son died in childhood. Osborne was the son of Arthur D. Osborne, '48, a brother of Arthur S. Osborne, '82, a grandson of Eli W. Blake (B.A. 1816) and Thomas B. Osborne (B.A 1817), a great-grandson of Ebenezer Dimon (B.A. 1783), and a great-great-grandson of Ebenezer Dimon (B.A. 1728). Other Yale relatives are: Eli Whitney (B.A. 1792), David Dimon, a non-graduate member of the Class of 1828, Theodore Dimon (B.A. 1835), E. Whitney Blake (B.A. 1839), Charles T. Blake, '47, Henry T. Blake, '48, William P. Blake, '52 S., George A. Blake, ex-'54, Eli W. Blake, '57, Edward F. Blake, '58, John M. Blake, '58 S., James P. Blake, '62, Frank W. Blake, '72, George A. Bushnell, '76, Francis H. Blake, '82 S., Edward Blake, '84 S., Joseph A. Blake, '85, Henry W. Blake, '86 S., Donald M. Barstow, '89, T. Whitney Blake, '90 S., James K. Blake, '91, Robbins B. Anderson and Howard C. Robbins, both '99, and H. Kingsley Blake and Joseph A. Blake, Jr., both '16.

### NATURE[1]

Thomas Burr Osborne, who died on January 29, was the last of the small band of pioneers who laid the foundation-stones of modern protein chemistry. Born in New Haven, Connecticut, on August 5, 1859, of old New England stock, he graduated after the usual course in arts at Yale College in 1881. Turning his attention to analytical chemistry, he took the degree of Ph.D. in 1885, and a year later joined the staff of the Connecticut Agricultural Experiment Station in New Haven. Professor S. W. Johnson, director of the station and professor of agricultural chemistry at Yale, suggested that Osborne should extend Ritthausen's early work on vegetable proteins, and in 1888 he started investigations which continued without interruption until his retirement in 1928.

From 1890 until 1901 Osborne's chief interest was in the preparation of pure specimens of the seed proteins, and his initial investigation of the oat kernel, published in 1891, was the forerunner of a series of papers in which the proteins of thirty-two different

[1] Reprinted from **123,** 613 (1929) by permission of the editor.

seeds were described. These researches demonstrated that proteins could be regarded as definite chemical individuals, and that many substances formerly grouped together under such terms as "legumin," "conglutin," and "vitellin" differed in chemical composition as well as in physical properties. His conception of the protein molecule as a definite chemical entity was strengthened by his work on the acid-binding power of edestin, published in 1899, and by later papers in which it was shown that proteins in general could form salts with both acids and bases, and that they were capable of electrolytic dissociation.

Working as he did in close contact with agriculture, Osborne early realized the need of a chemical characterization of proteins which would give some index of nutritive value, but characteristically deferred any such research until he was convinced that he could first obtain proteins in the highest state of purity. Taking full advantage of the developments in analysis due to Kossel and Fischer, he commenced in 1906 a series of protein analyses which demonstrated that wide differences existed in the amino-acid composition of many proteins of economic importance. These analyses were made with Osborne's usual extreme care and were the basis of his future work on the nutritive value of the proteins, begun in collaboration with Professor Lafayette B. Mendel of Yale, in 1909, and continued with the generous support of the Carnegie Institution of Washington until the time of his death.

The results of Osborne's protein investigations were summarized in a monograph, "The Vegetable Proteins," which was published in 1909, and extensively revised in 1924. His life was devoted almost entirely to his research, and, unlike most investigations, increasing years and fame brought no increase in administrative responsibility, consequently until the last his working hours were spent in the laboratory, and those who were privileged to work with him and gain his confidence found in him not only a genial friend and stimulating critic, but also a man with an unsurpassed wealth of practical experience in his own particular field of science.

Osborne was a member of the National Academy of Sciences, an honorary Sc.D. of Yale, and an honorary fellow of the London Chemical Society. Last year the American Association of Cereal Chemists instituted the periodic award of the Thomas Burr Osborne medal for distinguished research in cereal chemistry, and he was himself the first recipient.

A. C. C.

Obituary notices were also published in the *Bulletin de la société scientifique d'hygiène alimentaire,* **17**, 401-404 (1929) and the *Ware-ra no Kwa-gaku,* a scientific journal edited by Prof. R. Nakaseko of the Imperial University of Kyoto, **2**, 283-284 (1929).

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[1] The greater part of this paper was translated and reprinted by V. Griessmayer in "Die Proteide der Getreidearten, Hülsenfrüchte und Ölsamen sowie einiger Steinfrüchte," Heidelberg, 1897.

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*Rept. Conn. Agr. Expt. Sta.* for 1895, 239-254 (1896).
Also *J. Am. Chem. Soc.*, **18**, 542-558 (1896.).[1]

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Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1895, 255-261 (1896).
Also *J. Am. Chem. Soc.*, **18**, 575-582 (1896).[1]

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Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1895, 262-287 (1896).
Also *J. Am. Chem. Soc.*, **18**, 583-609 (1896).[1]

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*Rept. Conn. Agr. Expt. Sta.* for 1895, 288-301 (1896).
Also *J. Am. Chem. Soc.*, **18**, 609-623 (1896).[1]

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*Am. Chem. J.*, **19**, 236-237 (1897).

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Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1896, 342-368 (1897).
Also *J. Am. Chem. Soc.*, **19**, 454-482 (1897).
Translation: Die Proteide der Lupinesamen.
*Z. landw. Versuchsw.*, **2**, 357-384 (1899).

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Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1896, 369-373 (1897).
Also *J. Am. Chem. Soc.*, **19**, 482-487 (1897).
Translation: Wirkung winziger Säuremengen auf die Löslichkeit des Globulins in Salzlösungen.
*Z. landw. Versuchsw.*, **2**, 65-70 (1899).

The Proteids of the Sunflower Seed.
Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1896, 374-379 (1897).
Also *J. Am. Chem. Soc.*, **19**, 487-494 (1897).
Translation: Die Proteide des Sonnenblumensamens.
*Z. landw. Versuchsw.*, **2**, 57-64 (1899).

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Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1896, 380-386 (1897).
Also *J. Am. Chem. Soc.*, **19**, 494-500 (1897).
Translation: Die Proteide der Kuherbse (Vigna catjang).
*Z. landw. Versuchsw.*, **1**, 450-456 (1898).

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*Rept. Conn. Agr. Expt. Sta.* for 1896, 387-390 (1897).
Also *J. Am. Chem. Soc.*, **19**, 509-513 (1897).
Translation: Das Proteid der weissschaligen Adzukibohne (Phaseolus radiatus).
*Z. landw. Versuchsw.*, **1**, 457-461 (1898).

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*Rept. Conn. Agr. Expt. Sta.* for 1896, 391-397 (1897).
Also *J. Am. Chem. Soc.*, **19**, 525-532 (1897).
Translation: Eigenschaften und Zusammensetzung der Proteide des Maiskornes.
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*Ber.*, **31**, 254-259 (1898).

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*Rept. Conn. Agr. Expt. Sta.* for 1897, 324-337 (1898).
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Translation: Die Proteide der Erbse.
*Z. landw. Versuchsw.*, **2**, 160-173 (1899).

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Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1897, 337-349 (1898).
Also *J. Am. Chem. Soc.*, **20**, 362-375 (1898).
Translation: Die Proteide der Linse.
*Z. landw. Versuchsw.*, **2**, 450-461 (1899).

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Thomas B. Osborne and George F. Campbell
*Rept. Conn. Agr. Expt. Sta.* for 1897, 349-361 (1898).
Also *J. Am. Chem. Soc.*, **20**, 393-405 (1898).
Translation: Die Proteide der Saubohne (Vicia faba).
*Z. landw. Versuchsw.*, **2**, 584-596 (1899).

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*Rept. Conn. Agr. Expt. Sta.* for 1897, 361-365 (1898).
Also *J. Am. Chem. Soc.*, **20**, 406-410 (1898).
Translation: Die Proteide der Wicke.
*Z. landw. Versuchsw.*, **3**, 63-67 (1900).

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*Rept. Conn. Agr. Expt. Sta.* for 1897, 365-373 (1898).
Also *J. Am. Chem. Soc.*, **20**, 410-419 (1898).
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*Z. landw. Versuchsw.*, **3**, 68-76 (1900).

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Also *J. Am. Chem. Soc.*, **20**, 419-428 (1898).
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*Z. landw. Versuchsw.*, **2**, 597-605 (1899).

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*Rept. Conn. Agr. Expt. Sta.* for 1900, 443-471 (1901).
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*Z. anal. Chem.*, **41**, 25-35 (1902).

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Translation: Die Nucleinsäure des Weizenembryos.
*Z. physiol. Chem.*, **36**, 85-133 (1902).

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Translation: Über die Grenzen der Fällung mit Ammonsulfat bei einigen vegetabilischen Proteinen.
*Z. anal. Chem.*, **43**, 378-382 (1904).

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Translation: Spezifische Drehung einiger vegetabilischen Proteine.
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*Am. Med.*, **9**, 1028 (1905).

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Translation: Über die Löslichkeit des Globulins in Salzlösungen.
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Translation: Die Chemie der Proteinkörper des Weizenkornes. II. Darstellung der Proteine in genügender Menge für die Hydrolyse.
*Z. anal. Chem.*, **46**, 749-756 (1907).

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Translation: Die Chemie der Proteinkörper des Weizenkornes. III. Hydrolyze der Weizen-Proteine.
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*Am. J. Physiol.*, **18**, 123-128 (1907).
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Translation: Hydrolyse des Phaseolins.
*Z. anal. Chem.*, **48**, 98-108 (1909).

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*J. Biol. Chem.*, **3**, 119-133 (1907).
Translation: Die Verbrennungswärme der vegetabilischen Proteine.
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*Am. J. Physiol.*, **19**, 53-60 (1907).
Translation: Hydrolyse des Exzelsins.
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Translation: Hydrolyse des Hordeins.
*Z. anal. Chem.*, **47**, 590-597 (1908).

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Translation: Die Proteine der Erbse.
*Z. anal. Chem.*, **49**, 142-146 (1910).

Hydrolysis of Legumin from the Pea.
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Translation: Hydrolyse des Erbsenlegumins.
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*Am. J. Physiol.*, **19**, 468-474 (1907).
Translation: Hydrolyse des Glyzinins aus der Sojabohne.
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# THE ORIENTAL PEACH MOTH IN CONNECTICUT

PHILIP GARMAN

**Connecticut Agricultural Experiment Station**
**New Haven**

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## SUMMARY

1. *Damage from the Oriental peach moth* in Connecticut peach orchards annually amounts to more than $100,000.

2. *Its chief means of spread* lie in shipments of infested fruit; less important means in nursery stock movements and local flights of moths. Quinces and peaches are most seriously infested and few peach moth larvae have been found in other Connecticut fruits.

3. *The mature peach moth larva* is pink. Young ones are black-headed. Curculio larvae are curved and have yellow heads. Codling moth larvae and lesser apple worm larvae are more difficult to distinguish. (Page 407.)

4. *The peach moth's habits* are baffling and its defense almost perfect. Continuous generations in midsummer, the larval habit of digging in without eating materials placed on the surface and the ease with which peach trees are burned by insecticides, preclude use of extended spray schedules. (Page 409.)

5. *The life cycle* in peaches requires 32 days in midsummer and is divided among the various stages. Moths appear in early May and continue to emerge until mid-June. Three and sometimes a partial fourth generation of larvae occur, the first infesting twigs, the second twigs and fruit, and the third fruit.

6. *Field experiments* with bait pans, lime, and talc have given little or no control of the larvae in fruit. (Page 428.) Nicotine sulfate and white oil emulsions have afforded more control, but not enough to warrant recommending them. (Page 428.) The cost of the last two is also prohibitive. Cultivation seemed to give good results when it was first used at Wallingford, but it was not effective at Southington. (Page 435.) Paradichlorobenzene, heretofore recommended for wintering peach moth larvae, is usually applied before the majority spin. (Page 435.)

7. *A number of laboratory* control experiments have been conducted. (Page 413.)

8. *Attempts at colonization of the parasites Trichogramma minuta* and *Macrocentrus ancylivora* were made in 1929. (Pages 440 and 443.)

9. *At the request of orchard owners* artificial propagation of parasites has been started, using funds contributed in part by the growers themselves.

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# THE ORIENTAL PEACH MOTH IN CONNECTICUT

Philip Garman

The Oriental peach moth[1] is probably the worst enemy with which peach growers in Connecticut have to deal today. Because of the great difficulty of controlling it by any known sprays or other practices, it has attracted more and more attention on the part of growers, while the monetary loss has continued to mount into thousands of dollars annually. The insect was found in Connecticut about 1917, but it was not until 1924 that growers felt commercial damage. Between 1924 and 1929 it gained in destructiveness, infesting more and more orchards, in many of which it has been difficult to obtain sound fruit.

Considering the insect to have been in Connecticut since 1917 and our present infestation to be now at its height, it will be seen to have required 10 to 12 years to reach destructive numbers. Reports from available sources during 1925-1929 showed distinct advances in Connecticut on the part of the peach moth, although it was slow in establishing itself in many orchards and in a few seemed to decrease. Figures 26 to 28.

Much of the information contained herein has already been published, but the demand for literature about the insect has increased so much that it seems desirable to assemble it in one publication.

## HISTORY IN THE UNITED STATES

Briefly, the history of the peach moth in the United States is as follows: The United States Department of Agriculture discovered it about 1916 near Washington, where it became destructive in the years 1917 to 1919. From this point it has seemed to spread almost in the form of a circle increasing in diameter from year to year, until at present practically all peach-growing states east of the Mississippi and portions of Canada are infested. The damage probably runs into millions of dollars every year.

### Origin

The true origin of the peach moth is probably not known. It came to this country from Japan in flowering cherries, but Japanese authorities maintain that it was not there before 1899. It is

[1] *Grapholitha* (*Laspeyresia*) *molesta* (Busck); *Cydia molesta* (Busck) in British literature; order Lepidoptera, family Tortricidæ. Known also as the Oriental fruit moth, Oriental peach worm and Oriental fruit worm; in Japan as the smaller pear borer. It has been called the peach tip moth in Australia.

present now in Australia, Japan, China (Manchuria), Korea, Italy, France, Canada, United States, and probably in other countries. It has been reported as doing considerable damage in most of the regions where it is found, but appears to be less important in Australia and Italy than in others.

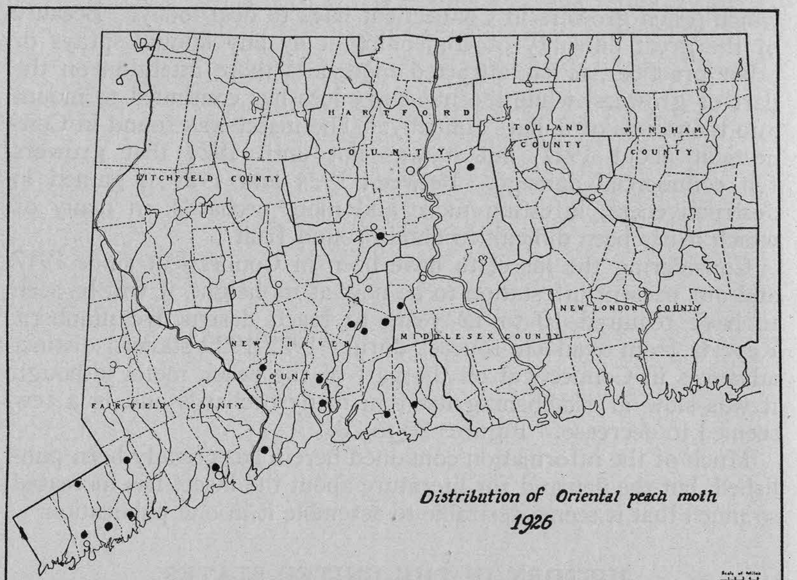


FIGURE 26. Map of Connecticut showing recorded distribution of the Oriental peach moth in 1926.

## Methods of Spread

The Oriental peach moth flies readily in the adult stage and can therefore travel from orchard to orchard in any given locality. It is known to infest nursery stock and some are doubtless carried on young trees, since the over-wintering cocoons on the trunks or branches are very difficult to detect. The most important means of spread, however, lie in the shipment of wormy fruit, which sometimes comes into Connecticut in considerable quantities, and in the local distribution of fruit from town to town or district to district, which results in a steady increase of the general infestation. Containers of various kinds, such as barrels, peach baskets or bushels, in which fruit has been stored and in which the larvae frequently spin for hibernation are also important sources of danger and spread.



## Injury

The amount of injury in different orchards varies considerably. As a rule, in orchards carrying 10 per cent or less of wormy fruit, the damage is not noticed, but when it averages much higher, it causes trouble in sorting, increase in brown rot and reduced sale value. Such fruit requires careful sorting because of the disagreeable gummy appearance, while much that remains, even after the greatest care has been taken, may contain larvae which have entered without leaving a trace. If there is much worminess

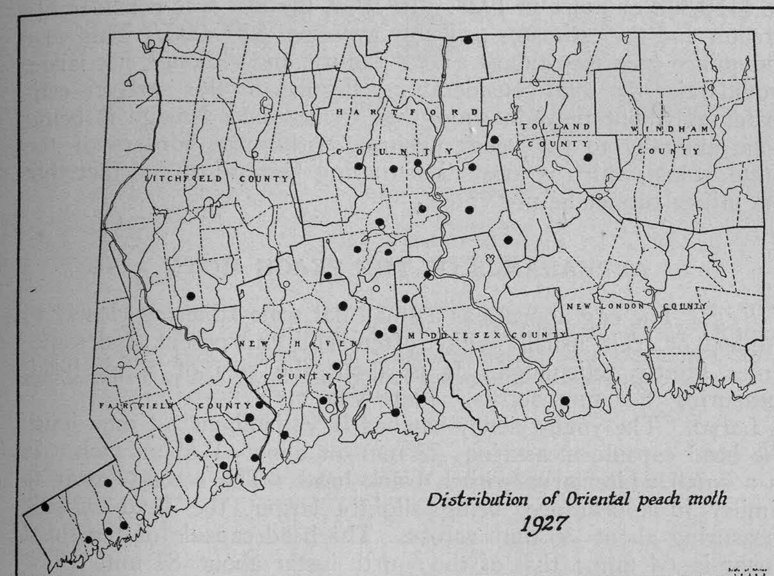


FIGURE 27. Map of Connecticut showing recorded distribution of the Oriental peach moth in 1927.

invisible from the outside, the peach finds its way into the hands of the consumer, sometimes with undesirable results. Dropped fruits resulting from an infestation are shown on Plate XI, b.

We have seen orchards in the central part of the State carry 50 to 100 per cent of infested fruit, and in some instances, the fruit may contain more than a single larva per peach. In quinces, the infestation is often more severe than in peaches, so that where the quinces are heavily infested, each fruit may contain several larvae. We have counted as many as five larvae in a single quince and under some conditions even more than this may be found. The damage to apple and pear fruits has been slight so far in Connecticut. Reports of injury to apples amounting to 50 per cent of the crop is reported from states to the south, but no cases of this sort have come to our attention. Most injury reported as peach moth injury, thus far investigated, has proved to be codling moth or lesser apple worm and not the Oriental peach moth.

The peach moth infests occasionally other fruits, such as cherry, Japanese quince, apricots and nectarines, but it has not yet been seen to do extensive damage to these plants in Connecticut. Pears are said to be heavily infested in Japan.

The amount of damage to peaches was estimated by Mr. Harold M. Rogers, president of the Connecticut Pomological Society, to be $150,000 or more in 1928. In 1929, the loss was considerably greater and the estimates probably averaged $200,000. This year the quince crop was almost a total failure, and although not large, would raise the total considerably. Figures of this sort are estimates only, but they do show that tremendous damage is being done annually to the peach business within the borders of the State, a loss which is most discouraging because of the fact that the injury cannot be prevented.

## APPEARANCE OF THE PEACH MOTH

*Egg.* The egg appears as a small flat scale adhering closely to the leaf or fruit, usually white, often semi-transparent, and sometimes faintly reticulated. It is about the size of a pin-head, measuring .5-.7 mm. across. Plate VIa, c.

*Larva.* The young newly-hatched larva is about 1.4 mm. long, the head capsule measuring .22 mm. or about .1 of an inch. It is a small white larva with a black head. The second instar is similar in appearance, being slightly larger, the head capsule measuring about .36 mm. across. The head capsule of the third instar is .64 mm.; that of the fourth instar about .81 mm. The fifth or last instar measures 12 mm. or about .5 inch in length, while the head capsule measures on an average 1.0 mm. In this instar, the head turns brownish in color, and the body becomes pinkish. The over-wintering larva tends to become shorter and thicker than mature summer larvae. Plate V, a; VII, b.

*Pupa.* The pupa is brownish in color, turning nearly black just before the adult emerges. It is 6-7 mm. in length.

*Moth.* The adults (Plate VI, a, b) are small grayish-brown moths, with wings silvery on the under surface and figured with light wavy lines above. They are inconspicuous when the wings are folded. The male and female are similar, but the male abdomen is more slender than the female's. The appendages of the two sexes are shown in Figure 32, A and B; wing spread 12.5 mm. (.5 inch); body length 4-5 mm. (about .2 inch). Wing venation of the female is shown in Figure 31.



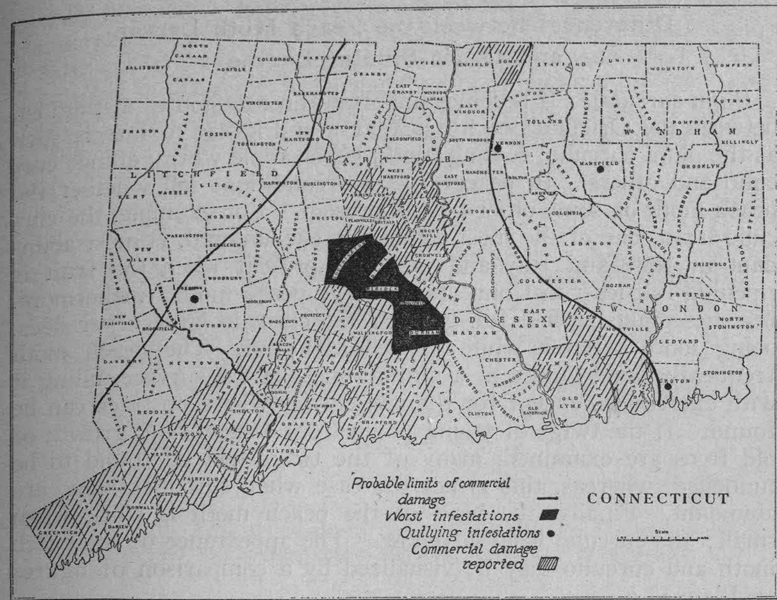


FIGURE 28. Map of Connecticut showing distribution of the Oriental peach moth in 1928. In 1929 the black area spread over Hartford County and northeast to and beyond the line of commercial damage in 1928.

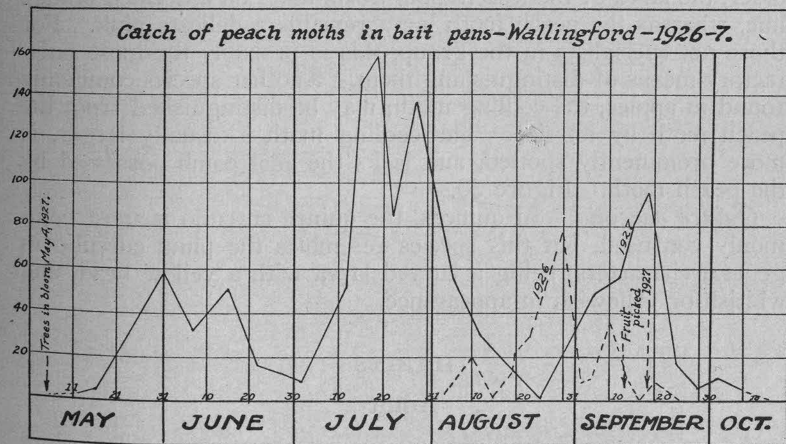


FIGURE 29. Periods of adult Oriental peach moth activity in 1926 and 1927. This shows the relative abundance at different periods during the summer, in an Elberta orchard. It also shows that the peak of the third generation varies from year to year in the same orchard.

## Differences between the Peach Moth Larvae and Other Similar Larvae

*Plum curculio.* It becomes important on occasion to distinguish between the Oriental peach moth larva and larvae of insects such as the plum curculio, codling moth, lesser apple worm, quince curculio and others. In peaches certain conditions tell whether the peach moth or some other pest is present. For example, the curculio larva, one of the most commonly encountered, is most abundant in June and July and is rarely present when the fruit is ripening—at least in Connecticut. The peach moth, furthermore, becomes pinkish when full grown; the curculio larva never does, being more often a white or yellowish tint. The peach moth frequently makes more of a gummy mess at the surface, filling it with excrement, except for the late entries where no trace can be found. If the twigs of young peach trees or new rank growth of old trees are examined, many of the twigs will be found to be tunnelled, whereas, this is not the case when curculios alone are abundant. Finally, the head of the peach moth is black when small; the curculio head is yellow. The appearance of the peach moth and curculio may be visualized by a comparison of figures on Plate V, a.

*Apple worms.* There is greater difficulty distinguishing the Oriental peach moth larva from that of the lesser apple worm, especially in the younger stages, since both have nearly the same microscopical characters and general appearance. When older, the larva of the lesser apple worm takes on a decided orange hue, whereas the peach moth larva remains a delicate pink. For those not specialists in the group, this is probably the most satisfactory means of distinguishing them. Another species commonly found in apples, the codling moth, may be distinguished from the peach moth by its size. The codling moth is usually larger, is more prominently spotted, and lacks the anal comb possessed by the peach moth. Figure 30.

*Quince curculio.* In quinces, the quince curculio is most commonly confused, but this species resembles the plum curculio in general characters, being a curved larva with a yellow head, and whitish or yellowish in appearance.

## HABITS

### Adult

Adults emerge during the day, usually resting awhile before becoming active. They fly most actively towards sundown, but have also been observed (25) in the middle of the day. Eggs are laid for an hour or two before and after sundown and some in



early morning. Mating takes place usually within two days after emergence from the cocoon and egg laying commences shortly afterwards. The moth requires some water and food (sugars) since it is attracted to fermenting baits and seeks such food in cages. In general, the flight is very irregular, most of the moths apparently remaining near the tops of the trees when in flight,

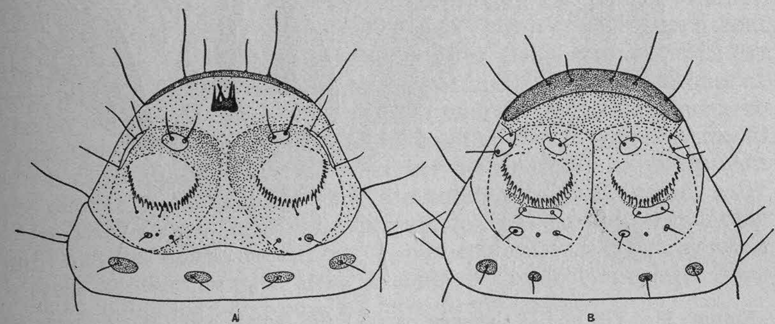


FIGURE 30. Anal segments of larva of (A) Oriental peach moth and (B) the codling moth, showing difference in structure.

and progressively fewer being found on approaching the ground. As already mentioned, they are attracted to baits and to some

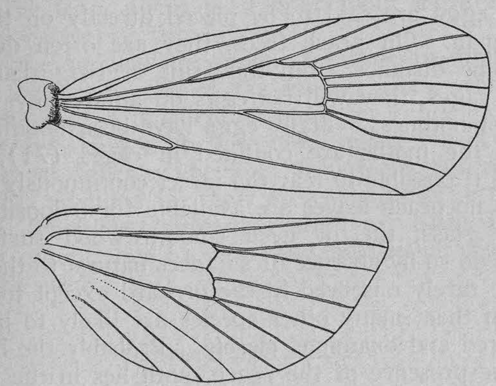

FIGURE 31. Wings of the Oriental peach moth with scales removed, showing veins.

extent to lights. Peterson has shown that ultraviolet rays are most effective (46).

In captivity, warmth and humidity are required before many eggs are deposited and crowded conditions are conducive to high egg yields. Moths lay best, in our experience, when kept in a warm tent with added heat about sundown, particularly if the weather is cool. If not cool, no additional heat is necessary. If very hot, 90-100°, the moths suffer and many die without laying. Humidity above the average is desirable. A cage used for confining the moths is shown on Plate XI, a.

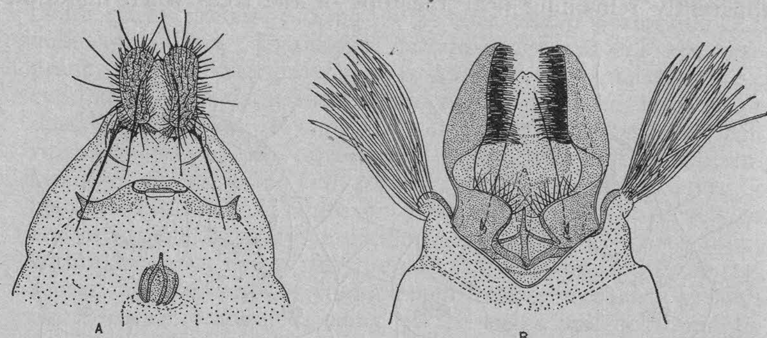


FIGURE 32. Tip of the abdomen of (A) the female and (B) the male peach moths, showing details of structure.

Eggs are laid on peach leaves usually on the under side, sometimes on the upper side and on the stems, but never on the fruit itself. On quinces, they may be deposited on upper or under surfaces of the leaves, on the sepals of the fruit, or on the fruit itself. The eggs are said to be placed directly on the fruit of pears, in Japan. On peach trees, they are often deposited on leaves at some distance from the fruit or twig that the larva infests. In cages, they will lay eggs on almost any material of the desired smoothness. Many eggs have been obtained on wax paper when the moths are confined in cages (71), a scheme which makes it possible to rear the insect continuously during the winter when no peach leaves are available for oviposition. They will lay on glass, tin, or even smooth wood surfaces when compelled to do so by absence of surfaces natural to them.

Moths are rarely observed in the orchard except towards sundown. Even then, many other species are likely to be confused unless captured and examined closely. Probably the best way to determine the presence of the peach moth lies in the use of bait pans, which are discussed on page 428. The moths are easily recognized in such pans, especially during midsummer, when many may be seen floating on the surface of the bait.

## Larva

On hatching, the minute larva slips out from the side of the egg, and being very active, soon finds a suitable twig or fruit



where it starts immediately to work. It usually enters peach twigs near, but a little below, the actively growing tip sometimes through the base of the leaf. Plate I, a, b, shows typical twig injury. Peaches are entered near the stem, or through the stem itself (Plate II, a), leaving little or no trace at the point of entry. Sometimes the fruit is entered through the side, especially if two fruits or a fruit and a leaf are in contact. Plate II, b; III, a. Quinces are usually entered through the calyx end, though occasionally at other points. Plate IV. It is well known that the larva, on burrowing into the fruit or twig, throws aside the first mouthfuls until well below the surface. This is also true of the larvae that transfer from twig to twig when partly grown, or from twig to fruit. The habit makes the insect very difficult to kill because of the fact that whatever poisons may be present on the outside of the fruit or twig are automatically discarded.

In peach twigs, the larva continues to feed on the central core until mature, unless forced out by an accumulation of gum, when it seeks another twig or fruit to continue its development. Two to three twigs may be tunnelled by a single larva.

In peaches the larva, for the most part, continues to eat next to the pit (Plate III, b), excavating a hole of considerable size and filling it with excrement. When fully grown, it bores through the side of the fruit and seeks quarters for cocooning. Only one fruit is usually infested by a larva.

The behavior in quinces is essentially the same as for peaches, except that the larva seems to wander about more in the flesh, making tortuous tunnels throughout.

In apples, the tunnels are similar to those in quinces. They differ from the usual work of the codling moth, which burrows directly to the core if it enters through the calyx or if through the side, after making a shallow mine under the skin. Young larvae have great difficulty entering through the skin of the apple, which probably accounts for their present scarcity in this fruit in Connecticut. They are, however, reared very easily in this fruit when points of entrance are provided and either ripe or green apples may be used.

## Cocoon and Pupa

After leaving the fruit the larvae spin or crawl down seeking quarters to transform either on the ground or on the trunk of the tree. A small percentage spins on the branches of the tree itself. They will seek hollow stems and will spin on the soil itself, boards, or even dried peach mummies lying on the ground. On the trunk, they most frequently crawl under a flap of bark, sometimes abandoning a cocoon after construction, evidently because of an unsuitable location. The cocoon itself is constructed of fine silk, and is covered with bits of bark or other material taken from the material on which the cocoon is constructed. If the soil is well cultivated at the time of spinning, many are naturally forced to the trunk and spin within a few feet of the ground. During the winter, a majority of the larvae on the trunks will be found on the north side, but there are many that also spin in other locations. The general tendency, however, seems to be to spin away from the sun.

The cause of hibernation may naturally be attributed to cold, either its effect upon eggs, larvae or adults. However, in 1929 there was considerable hibernation (34 per cent) of larvae obtained from eggs placed July 19 immediately after oviposition in an incubator kept constantly at 70° F. From this, it would seem that whatever conditions affected hibernation were *present when the eggs were laid,* and they may be enzymatic in nature as suggested by Shelford,[1] rather than due to effects of temperature.

## SEASONAL LIFE HISTORY

Moths emerge from hibernation in Connecticut during the middle or fore part of May and continue to emerge for probably a month under normal conditions. There is a considerable difference in the time of emergence, depending on the location of the cocoon, that is, whether protected from the sun or not. Under normal conditions shade is provided by the foliage shortly after warm weather begins, so that delayed emergence takes place. Bait pan records indicate that moths are most abundant about the first of June, and this corresponds in general with our insectary records. When placed in warm tents such as were provided in 1929, or exposed to direct sunlight, appearance of the moths is much earlier, but in Connecticut we have seen no evidence of advance emergence in the field. In packing houses or cold storage plants, however, emergence is much later and where these are near bearing orchards it will doubtless effect the sequence of the broods appearing in the orchards nearby.

The various flight periods of the adult are essentially as shown in Figure 29, but it has been observed in two years in two different orchards that the greatest number of moths were caught in bait pans during the middle of July or at the height of the second brood. In 1929 the number exceeded 1,000 a week in 20 bait pans during this period, whereas it dropped considerably below that figure in both June and August. In 1926, however, there were more moths caught in June than in July or August, although during that year all three broods were about equal. The reason for these conditions can only be surmised but may be connected in some way with the hibernation of certain individuals or in parasitic action.

[1] Laboratory and Field Ecology, 169. 1929.



The eggs of the first brood are laid beginning in May and continuing until the latter part of June and those of the second and third generations from July to late September.

Larvae are found in the fruit or twigs following the course of egg-laying activity, as shown in Figure 33. Larvae of the second generation may enter peaches in small numbers, but the number

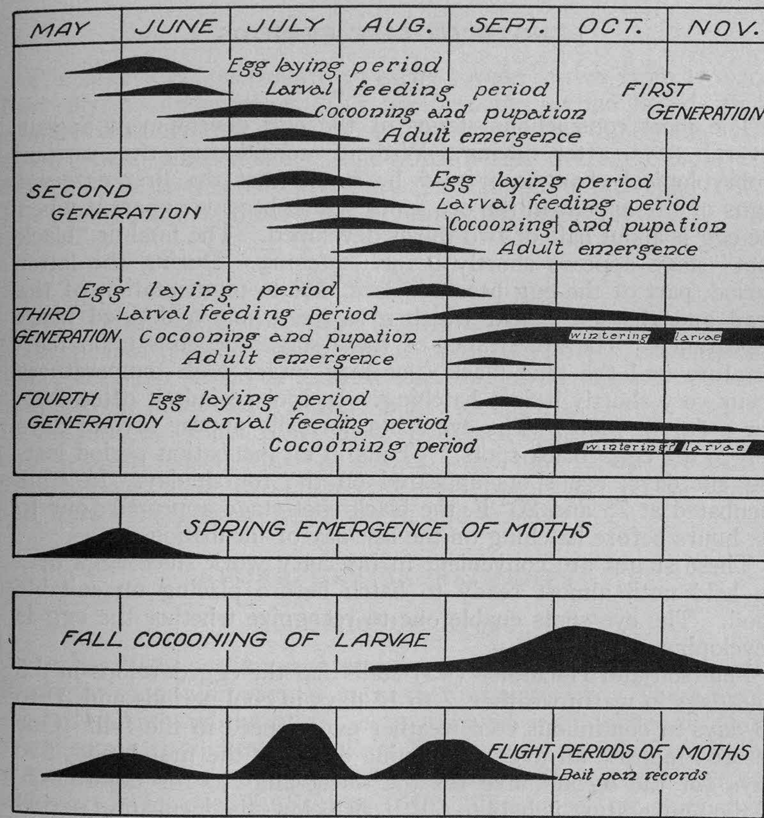


FIGURE 33. Life history chart of the Oriental peach moth.

increases rapidly with the appearance of the third brood and the ripening of the fruit. Hibernation tendencies begin to be apparent shortly after the first of August.

Emergence from fruit takes place during August, September and October and may continue until December. In 1928 the majority of larvae left the quinces and peaches in October and some the first part of November, while few or none emerged from the fruit after this date. In 1929 the emergence from fruit was apparently much earlier and although it again continued during October, it probably reached its peak in September of this year. The year 1928 was a wet one; 1929 very dry.

Spinning takes place, of course, shortly after leaving the fruit.

Spring pupation of the larvae began in 1929 in the first week in April and continued until June, approximately half being transformed by the first week in April.

## LENGTH OF LIFE PERIODS

### Egg

The most conspicuous stages of the egg development appear several days after laying. Without considering the various embryological changes, it may be stated that the first external signs of life appear in the eye spots, which become apparent when the egg is about half or two-thirds developed. The final or "black spot" stage appears shortly before hatching. During the latter period, part of the egg becomes dark, due to pigmentation of the head and thoracic shield which give the whole a decided black appearance. The appearance of these stages depends upon temperature and the true black spot may under high temperatures occur very shortly before hatching. In cool periods it often lasts for a day or more. The eye spots normally appear several days before the egg "black-spots." Thus in an incubation period lasting six days, eye spots appeared on the fourth day. In eggs incubated at 75 and 80° F. the black spot stage appeared four to six hours before hatching on the last day of incubation.

These stages are convenient in insectary work since eggs may be held until almost ready to hatch before placing on suitable food. The eye spots enable one to recognize whether the egg is developing normally.

Peterson and Haeussler (45) state that the egg develops in 3.5 to 6 days in warm weather, 7 to 14 days in cool periods and 20 to 43 days in continuous cool weather experienced in the fall. Our records indicate an average of nine days for the first brood, five days for the second, five for the third, and 7.6 for the fourth. If the temperature is held to 60° F. or below, the incubation period increases accordingly and it is very likely that eggs laid in September would in all probability remain two weeks or more before hatching and the larval development would likewise be slow afterwards. Our experience indicates that eggs will hatch in 3.5 to 4 days at 90° F., but require 12 to 15 days when the thermometer remains at about 60.°

### Larva

The length of the larval feeding period averaged in 1925-26 15.6 days for the first brood, 12.8 days for the second and 18.1 days for the third. Quality of the food makes considerable difference in the length of the stage, it being noted that a single instar reared on some of the prepared foods experimented with, required as much time as the entire larval period on normal foods. We know also that larvae fed on apples require a longer period to mature than those fed on peaches. The life cycle in quinces has, however, not been studied carefully.



### Cocoon and Pupa

The time spent in constructing the cocoon varies from two to four days in midsummer. For the first and second broods this is approximately two days. For generations that hibernate, this is, of course, much longer. The pupal period averaged about 11 days for the first, second and third generations in 1925 and 1926. The period in spring, however, is somewhat longer.

### Adult Moth

The female begins to lay eggs two to four days after emergence. Mating usually takes place within two days after emergence. There is then a period of about a week[1] when the eggs are deposited, and the adult may continue to live as much as a week longer. In field cages (Plate X, a) they have been observed to live for two to three weeks, while in smaller cages they rarely live more than 10 days. The maximum egg deposition occurs on the third and fourth days after emergence in midsummer.

## LABORATORY EXPERIMENTS

### Control of the Eggs

During 1928, preliminary tests were carried out with white oil emulsions containing various impregnating materials. These tests showed a high mortality for eggs sprayed with white oil plus pyrethrum soap, indicating at least 15 per cent better kill for such a combination than was formerly obtained with nicotine sulfate and soap as reported by Stearns (61). The work was continued in 1929 and the results are shown in Tables 2 to 11. The figures indicate that some of the commercial white oils on the market give a very good kill without additions, but that in general they average slightly higher when combined with the materials mentioned. It will be noted that these tests were made from June to August during the usual spray range for Elberta peaches and include eggs of many stages of development. In all about 7,000 eggs were used together with a total of more than 400 for 1928. No checks are shown in the tables, although some were used with

[1] Longer under some conditions.

TABLE 1. LIFE HISTORY DATA ON THE ORIENTAL PEACH MOTH, 1925-1926

Incubation of the Egg—Days

| Date | First Brood No. observed | First Brood Average | First Brood Range | Second Brood No. observed | Second Brood Average | Second Brood Range | Third Brood No. observed | Third Brood Average | Third Brood Range | Fourth Brood No. observed | Fourth Brood Average | Fourth Brood Range | Total observations |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1925 .......... | 276 | 9.0 | 3–13 | 155 | 4.8 | 4–6 | 39 | 4.9 | 4–6 | 34 | 7.6 | 6–11 | |
| 1926 .......... | 268 | 9.3 | 6–16 | 125 | 4.9 | 2–6 | 142 | 5.3 | 3–7 | | | | |
| Aver. for 1925-6.. | 544 | 9.1 | 3–16 | 280 | 4.8 | 2–6 | 181 | 5.1 | 3–7 | 34 | 7.6 | 6–11 | 839 |

Larval Feeding Period—Days

| Date | First Brood No. observed | First Brood Average | First Brood Range | Second Brood No. observed | Second Brood Average | Second Brood Range | Third Brood No. observed | Third Brood Average | Third Brood Range | Total observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 1925 .......... | 26 | 15.4 | 13–20 | 42 | 13.2 | 10–17 | 16 | 16.5 | 12–28 | |
| 1926 .......... | 63 | 15.8 | 12–27 | 64 | 12.4 | 10–21 | 92 | 19.8 | 14–34 | |
| Aver. for 1925-6.. | 89 | 15.6 | 12–27 | 106 | 12.8 | 10–21 | 108 | 18.1 | 12–34 | 403 |

Cocooning and Pupal Period—Days

| Date | First Brood No. observed | First Brood Average | First Brood Range | Second Brood No. observed | Second Brood Average | Second Brood Range | Third Brood No. observed[1] | Third Brood Average | Third Brood Range | Total observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 1925 .......... | 17 | 13.4 | 9–17 | 36 | 13.3 | 9–16 | 11 | 13.2 | 12–16 | |
| 1926 .......... | 78 | 12.8 | 8–15 | 72 | 12.5 | 8–18 | | | | |
| Aver. for 1925-6.. | 95 | 13.1 | | 108 | 12.9 | 8–18 | 11 | 13.2 | 12–16 | |
| Egg to Adult.... | Sum | 37.8 | 23–60 | | 30.5 | 20–45 | 11 | 36.4 | | 214 |

Total Period[2]—Egg to Adult—Days

| Date | First Brood No. observed | First Brood Average | First Brood Range | Second Brood No. observed | Second Brood Average | Second Brood Range | Third Brood No. observed | Third Brood Average | Third Brood Range | Total observations |
|---|---|---|---|---|---|---|---|---|---|---|
| 1925 .......... | 30 | 35.2 | 29–43 | 66 | 32.4 | 29–38 | 22 | 281.7 | 271–294 | |
| 1926 .......... | 102 | 39.0 | 31–49 | 80 | 30.3 | 26–37 | 56 | 286.8 | 259–318 | |
| Aver. .......... | 132 | 37.1 | 29–49 | 146 | 31.3 | 26–38 | 78 | 284.2 | 259–318 | 356 |

[1] Only those emerging before winter are recorded.
[2] Records of continuous periods from egg to adult.



each test, because at no time did more than 10 per cent fail to hatch. The average mortality of all checks was five per cent. It should also be remarked that very favorable results were obtained with one per cent oils containing about 20 per cent of steam distilled pine oil (straw color); in fact, a higher kill was obtained with this than with any other combination. Oleoresin capsicum-soap emulsions also seemed to have some killing power, as shown in Table 10. Judging from the amount of control secured with white oil emulsions, these materials should show some control in the field and this has been substantiated in part by our 1929 results. The degree of control, however, in these tests has not been any better than was previously obtained with nicotine preparations, but owing to differences in methods of applications and time of applications ought not, perhaps, to be compared.

The laboratory tests described were conducted in an outdoor insectary with eggs produced under artificial conditions. All tests were handled the same way, the sprays being applied with a small atomizer. The same nozzle was used each time and the peach leaves containing the eggs were pinned to a rack in the open insectary that had good ventilation, but was protected from sunlight.

TABLE 2. EXPERIMENTS WITH SPRAYS TO KILL THE EGGS OF THE ORIENTAL PEACH MOTH IN 1929

Lubricating Oils

| Exp. No. | Materials | Eggs laid | Treated | Examined | No. dead | Hatched | Per cent killed |
|---|---|---|---|---|---|---|---|
| 38 | W. O. E.,[1] light 6 gm. Water to 600 cc. .... | June 17 | June 19 | June 24 | 73 | 9 | 89 |
| 24 | W. O. E., 6 gm. | | | | | | |
| 24 | Water to 600 cc. .... | May 30 | June 3 | June 10 | 108 | 6 | 94 |
| 11 | W. O. E., light 4 gm. Water to 600 cc. .... | May 27 | May 29 | June 3 | 15 | 3 | 83 |
| 35 | W. O. E., light 3 gm. Water to 600 cc. .... | June 11 | June 12 | June 18 | 47 | 26 | 64 |
| 30 | White Oil A, 6 gm. Soap 2 gm., Water to 600 cc. ............ | June 8, 9 | June 11 | June 18 | 71 | 7 | 91 |
| 44 | W. O. E., light 6 gm. Water to 600 cc. .... | July 12–14 | July 16 | July 22 | 171 | 54 | 76 |
| 48 | W. O. E., light 6 gm. Water to 600 cc. .... | July 13 | July 17 | July 22 | 88 | 23 | 79 |
| 49 | W. O. E., Conc. 6 gm. Water to 600 cc. .... | July 13 | July 17 | July 22 | 149 | 8 | 94 |
| 53 | W. O. E., Conc. 6 gm. Water to 600 cc. .... | July 24 | B. Spot | July 30 | 100 | 18 | 84 |
| 54 | W. O. E., light 12 gm. Water to 600 cc. .... | July 24 | B. Spot | July 30 | 90 | 5 | 94 |
| 56 | W. O. E., Conc. 6 gm. | July 23 | July 24 | July 30 | 67 | 15 | 81 |
| | W. O. E., Conc. 6 gm. | B. Spots | Aug. 27 | Aug. 29 | 35 | 12 | 74 |
| | W. O. E., Conc. 6 gm. | Aug. 22 | Aug. 24 | Aug. 29 | 77 | 13 | 85 |

[1] W. O. E.—A commercial white oil emulsion; light—viscosity of oil 50 sec.; concentrate, 108 sec. White oil A—a white lubricating oil of 90 sec. viscosity with 96 per cent. unsulfonatable.

TABLE 3. Lubricating Oils, Laboratory Made Emulsions

| Exp. No. | Material | Total oil content | Date eggs laid | Treated | Eggs examined | No. dead | No. hatched | Per cent dead |
|---|---|---|---|---|---|---|---|---|
| 131 | 20% pine oil, 80% white oil A Mineral oil soap | .5% | May 24–25 | May 28 | June 4 | 30 | 4 | 88 |
| 135 | Same | .5% | May 28–29 | May 31 | June 4 | 158 | 21 | 88 |
| 138 | 20% pine oil, 80% white oil A Milk | .5% | May 31 | June 4 | June 11 | 38 | 4 | 90 |
| 161 | 20% water white pine oil, 80% white oil A Milk | .5% | June 19 | June 20 | June 25 | 63 | 8 | 88 |
| 163 | Same | .5% | June 22 | June 25 | June 29 | 57 | 0 | 100 |
| 179 | Same | .5% | July 9 | July 10 | July 15 | 27 | 0 | 100 |
| 194 | Same | .5% | July 16 | July 17 | July 24 | 96 | 17 | 85 |
| 202 | Same | .5% | July 20 | July 22 | July 27 | 184 | 35 | 84 |
| 225 | Same | .5% | July 25 | July 27 | July 31 | 74 | 18 | 80 |
| 189 | Same | 1.0% | July 12–14 | July 16 | July 22 | 76 | 3 | 96 |
| | **Pure Oils** | | | | | | | |
| 150 | Pine oil-milk | 1.0% | June 8–9 | June 11 | June 17 | 68 | 27 | 71 |
| 151 | Water white kerosene-milk | 1.0% | June 10 | June 11 | June 17 | 68 | 11 | 86 |
| 146 | Oil A-milk | 1.0% | June 5 | June 7 | June 13 | 92 | 3 | 96 |
| 166 | Same | 1.0% | June 22 | June 25 | June 29 | 46 | 20 | 69 |
| 191 | Same | 1.0% | July 13–14 | July 17 | July 22 | 92 | 6 | 94 |
| 198 | Same | 1.0% | July 16 | July 19 | July 24 | 82 | 8 | 91 |
| 211 | Same | 1.0% | July 24 | July 25 | July 30 | 59 | 20 | 74 |
| 241 | Oil A-milk | 1.0% | July 31 | Aug. 2 | Aug. 7 | 155 | 0 | 100 |
| 264 | Oil B-milk | 1.0% | Aug. 19 | Aug. 20 | Aug. 26 | 90 | 4 | 95 |
| 279 | Same | 1.0% | Aug. 23 | Aug. 26 | Aug. 30 | 175 | 9 | 95 |
| 153 | Oil B-milk | 1.0% | June 12 | June 13 | June 18 | 91 | 3 | 96 |
| 167 | Same | 1.0% | June 22 | June 25 | June 29 | 45 | 7 | 86 |
| 192 | Same | 1.0% | July 13–14 | July 17 | July 22 | 120 | 0 | 100 |



TABLE 3. Lubricating Oils, Laboratory Made Emulsions (Continued)

| Exp. No. | Material | Total oil content | Date eggs laid | Treated | Eggs examined | No. dead | No. hatched | Per cent dead |
|---|---|---|---|---|---|---|---|---|
| 199 | Same | 1.0% | July 16 | July 19 | July 24 | 76 | 19 | 80 |
| 210 | Same | 1.0% | July 24 | July 25 | July 30 | 85 | 13 | 86 |
| 242 | Same | 1.0% | July 31 | Aug. 2 | Aug. 7 | 252 | 3 | 98 |
| 265 | Same | 1.0% | Aug. 19 | Aug. 20 | Aug. 26 | 87 | 5 | 94 |
| 209 | 56-oil-milk | 1.0% | July 24 | July 25 | July 30 | 68 | 22 | 75 |
| 240 | Same | 1.0% | July 31 | Aug. 2 | Aug. 7 | 125 | 7 | 94 |
| 262 | Same | 1.0% | Aug. 19 | Aug. 20 | Aug. 26 | 103 | 1 | 99 |
| 280 | Same | 1.0% | Aug. 23 | Aug. 26 | Aug. 30 | 101 | 4 | 96 |
| 291 | Same | 1.0% | Aug. 28 | Aug. 30 | Sept. 9 | 216 | 16 | 93 |

Notes

| Oils used | Per cent unsulfonatable | Viscosity Saybolt |
|---|---|---|
| 56 oil | 97 | 58 |
| White oil A | 96 | 90 |
| White oil B | 98 | 160 |

Pine oils in Nos. 131, 135, 138 and 150 straw-colored; in all others, water white.

TABLE 4. EXPERIMENTS WITH SPRAYS TO KILL THE EGGS OF THE ORIENTAL PEACH MOTH, 1929

Lubricating Oils with Additional Contact Insecticides

1. Pyrethrum products

| Exp. No. | Materials | Eggs laid | Eggs treated | Eggs examined | No. dead | No. hatched | Per cent killed | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | W. O. E.,[1] 1.6 gm., Pyrethrum soap, 1 gm., Water to 600 cc. .... | May 23 | May 24 | May 29 | 24 | 3 | 89 | |
| 16 | Same as 1 ......... | May 28 | May 30 | June 10 | 85 | 13 | 86 | |
| 50 | W. O. E., conc. 6 gm., Pyrethrum soap, 1 gm., Water to 600 cc. .... | July 13 | July 17 | July 22 | 93 | 4 | 96 | Actual kill, including dead larvae, 98% |
| 51 | W. O. E., light 6 gm., Pyrethrum soap, 1 gm., Water to 600 cc. .... | July 13 | July 17 | July 22 | 109 | 9 | 92 | |
| 52 | W. O. E., conc., 6 gm., Pyrethrum soap, 1 gm., Water to 600 cc. .... | B. spot | July 24 | July 30 | 187 | 11 | 94 | |
| 55 | W. O. E., conc., 6 gm., Pyrethrum soap, 1 gm., Water to 600 cc. .... | July 23 | July 24 | July 30 | 152 | 10 | 94 | |
| | W. O. E., conc., 6 gm., Pyrethrum soap, 1 gm., Water to 600 cc. .... | Black spots | Aug. 27 | Aug. 29 | 61 | 9 | 87 | |
| | W. O. E., conc., 6 gm., Pyrethrum soap, 1 gm., Water to 600 cc. .... | Aug. 22 | Aug. 24 | Aug. 29 | 103 | 12 | 89 | 2 dead on leaves after hatching. Actual kill 90% |

[1] White oil emulsions.

TABLE 5. Lubricating Oils with Additional Contact Insecticides

2. Derris and similar materials

| Exp. No. | Materials | Eggs laid | Eggs treated | Eggs examined | No. dead | No. hatched | Per cent killed |
|---|---|---|---|---|---|---|---|
| 34 | W. O. E.,[1] 1.3 gm., Derris preparation, 1 gm., Water to 600 cc. .................... | June 11 | June 11 | June 18 | 27 | 18 | 60 |
| 18 | W. O. E., 1.6 gm., Derris preparation, 1 gm., Water to 600 cc. .................... | May 28 | May 31 | June 10 | 33 | 15 | 68 |
| 33 | W. O. E., 1.3 gm., Rotenone (10%), .5 cc., Water to 600 cc. .................... | June 11 | June 12 | June 18 | 63 | 23 | 73 |

[1] White oil emulsion.

TABLE 6. Lubricating Oils with Additional Contact Insecticides

3. Nicotine products and substitutes

| Exp. No. | Materials | Eggs laid | Eggs treated | Examined | No. dead | No. hatched | Per cent killed | Notes |
|---|---|---|---|---|---|---|---|---|
| 12 | W. O. E.,[1] 1.6 gm., Free nicotine, 1 cc., Water to 600 cc. .... | May 22 | May 25 | May 29 | 13 | 4 | 76 | Av. 86% |
| | " .... | June 17 | June 19 | June 24 | 92 | 11 | 89 | |
| 4 | W. O. E., 1.6 gm., Nic. sulf., 1 cc., Water to 600 cc. .... | May 22 | May 25 | May 29 | 15 | 3 | 83 | Av. 85% |
| 17 | Same ............ | May 28 | May 30 | June 10 | 110 | 2 | 98 | |
| 45 | W. O. E., 1.6 gm., Nic. sulf., 1 cc., Water to 600 cc. .... | July 12, 14 | July 16 | July 22 | 105 | 32 | 76 | |

[1] White oil emulsion, commercial.

TABLE 7. Lubricating Oils with Additional Contact Insecticides

4. Pine oils and miscible pine oils

| Exp. No. | Materials | Eggs laid | Eggs treated | Eggs examined | No. dead | No. hatched | Per cent killed |
|---|---|---|---|---|---|---|---|
| 23 | White oil emulsion, 1.3 gm., Miscible pine oil, 1 cc., Water to 600 cc. .................... | May 30 | June 3 | June 10 | 81 | 29 | 73 |
| 25 | White oil, 5 cc., Pine oil, 1 cc., Soap, 2 gm., Water to 600 cc. .................... | May 30 | June 3 | June 10 | 87 | 1 | 98 |
| 31 | " .................... | June 8, 9 | June 11 | June 18 | 52 | 1 | 98 |
| 189 | White oil, 3 gm., Pine oil, 2 gm., Milk emulsifier, Diluted to 1% oil .................... | July 12, 14 | July 16 | July 22 | 76 | 3 | 95 |

NOTES: White oil used had viscosity of 90 sec. No. 23, a commercial emulsion; Nos. 25, 31, and 189, laboratory made emulsions. Pine oil—steam distilled, straw color.

TABLE 8. Lubricating Oils with Additional Contact Insecticides

5. Oleoresin capsicum

| Exp. No. | Materials | Eggs laid | Eggs treated | Eggs examined | No. dead | No. hatched | Per cent killed |
|---|---|---|---|---|---|---|---|
| 32 | 90 visc. white oil, 5 gm., Ol. cap., 1 gm., Water to 600 cc., Soap, 2 gm. .......................... | June 8–9 | June 11 | June 18 | 32 | 3 | 91 |
| 37a 37b | 90 visc. white oil, 3 gm., Ol. cap., 5 cc., Soap, 2 gm., Water to 600 cc. .................... | June 15–16 | June 17 | June 24 | 197 | 19 | 91 |



TABLE 9. MISCELLANEOUS MATERIALS

| Exp. No. | Materials | Eggs laid | Eggs treated | Eggs examined | No. dead | No. hatched | Per cent killed |
|---|---|---|---|---|---|---|---|
| 6 | Free nic., .2 cc., Soap, 2.0 gm., Water to 200 cc. .................... | May 25 | May 28 | May 31 | 6 | 10 | 37 |
| 8 | Penetrol, 1 cc., Water to 200 cc. .................... | May 26 | May 28 | May 31 | 2 | 20 | 9 |
| 12 | Dipyridils, .5 cc., Soap, 1.0 gm., Water to 200 cc. .................... | May 27 | May 29 | June 3 | 1 | 13 | 7 |
| 14 | Miscible pine oil, 1 cc., Water to 100 cc. .................... | May 27 | May 29 | June 3 | 1 | 12 | 7 |
| 15 | Miscible pine oil, 1 cc., Water to 100 cc. .................... | May 26 | May 29 | June 3 | 1 | 12 | 7 |

TABLE 10. OLEORESIN CAPSICUM EMULSION

| Exp. No. | Materials | Eggs laid | Eggs treated | Eggs examined | No. dead | No. hatched | Per cent killed |
|---|---|---|---|---|---|---|---|
| 26 | Ol. cap., 1 cc., Soap, 1 gm., Water to 100 cc. .................... | June 1, 2 | June 3 | June 12 | 44 | 11 | 80 |
| 28 | Ol. cap., 1 cc., Soap, 2 gm., Water to 500 cc. .................... | May 31 June 3, 4 | June 5 | June 14 | 21 | 34 | 38 |
| 29 | Ol. cap., 1 cc., Soap, 1 gm., Water to 100 cc. .................... | June 7 | June 11 | June 15 | 77 | 20 | 79 |

TABLE 11. ROTENONE

| Exp. No. | Materials | Eggs laid | Eggs treated | Examined | No. dead | No. hatched | Per cent killed | Notes |
|---|---|---|---|---|---|---|---|---|
| 40 | Rotenone (10%), 1 cc., Syrup, 2 gm., Water to 100 cc. .... | June 16, 17 | June 20 | June 26 | 24 | 7 | 77 | Probable efficiency about 93% on account of larval mortality after hatching |
| 41 | Rotenone (5%), 1 cc., Syrup, 2 gm., Water to 100 cc. .... | | June 28 | June 29 | 90 | 75 | 54 | 13 larvae found dead on leaves, bringing actual kill to about 61% |



## Control of Larvae

Except in the earlier instars, the larva of the Oriental peach moth is very difficult to kill. Older larvae will pass through almost any poison barrier short of metallic arsenic or arsenic pentoxide, so that from a practical standpoint the older larvae are invulnerable. The newly-hatched larvae are, on the other hand, more susceptible and should be, in theory at least, easily checked. The use of mechanical barriers such as lime and talcum powder depend on the fact that particles of these materials adhere to the surface of the newly-hatched larva and cause it to drop from the tree. Experiments with very young larvae placed on peaches dusted with different materials show that 90-10 arsenate sulfur dust, various fluosilicates and fluorides and impregnated dusts containing pyrethrum and eight per cent dipyridyl sulfate have considerable effect in preventing entrance. One of the most striking results was obtained with a special pyrethrum dust which apparently killed all larvae coming in contact with it. Not much is known of the costs of some of these materials and they have not as yet been used in field experiments. The results are shown in Table 12.

Control of hibernating larvae after spinning would be desirable if such could be accomplished economically without harm to the tree. During 1929, preliminary tests were made with hibernating larvae in paper cells that were treated with a number of materials. These tests show good killing power for certain emulsions containing 20-30 per cent pine oil in emulsified form, but this is probably too much oil for the ordinary peach tree to withstand. These results are shown in Table 13. In this connection several of the constituents of pine oil were tried and showed considerable action for limonene and terpineol, but very little for dipentene and pinene. See Table 15. Following this clue, sweet orange oil containing considerable limonene was tried and showed again considerable killing power. Our tests also demonstrate that pure gasoline or kerosene are highly destructive to larvae spun in paper cells. In addition to these, several tar acid oils were used upon larvae spun on pear branches, with fair results at 3 per cent. Experiments by Ross (55) indicate that 10 to 15 per cent tar acid oils are necessary to kill the over-wintering larvae, and the above results seem to substantiate this. Doubtless a higher percentage of crescylic acid would increase the kill to the figures he obtained.

TABLE 12. TESTS OF VARIOUS INSECTICIDES TO POISON OR PREVENT ENTRANCE OF THE NEWLY HATCHED LARVAE OF THE PEACH MOTH

| No. larvae or eggs | Number of tests | Average per cent entered | Materials used and formulae |
|---|---|---|---|
| | | | **Arsenicals** |
| 70 | 4 | 4.2 | 90–10 sulphur-arsenate dust |
| | | | **Fluosilicates and Fluorides** |
| 31 | 2 | 6 | Cal. fluosilicate 1926 product |
| 45 | 3 | 6 | Magnesium fluoride pure |
| 10 | 1 | 10 | Sodium fluosilicate—lime dust, 1 part—4 parts lime |
| 93 | 1 | 25 (10–18%)[1] | Sodium fluosilicate—lime dust, 1 part—10 parts lime |
| | | | **Hydrated Lime** |
| 42 | 1 | 73 | Pure hydrated lime dust |
| 32 | 2 | 36 | Pure hydrated lime dust |
| | | | **Talc Dust, Fibrous** |
| 41 | 1 | 51 (41)[1] | Pure talc dust |
| 64 | 1 | 62 | Pure talc dust |
| | | | **Dipyridyl Sulphate Dusts** |
| 43 | 1 | 16 (6)[1] | 8% dipyridyl sulfate in an inert carrier |
| 47 | 1 | 23 (0)[1] | 8% dipyridyl sulfate in an inert carrier |
| 22 | 1 | 0 | 8% dipyridyl sulfate in an inert carrier |
| 23 | 1 | 69 | 1 gm. dipyridyl sulfate, 30 gms. lime, 600 cc. water—sprayed |
| | | | **Pyrethrum Dust** |
| 23 | 1 | 0 | 50% pyrethrum extract, 20 dead larvae found in stem ends |
| 23 | 1 | 0 | 23–30% pyrethrum extract, 16 dead in stem ends |
| 35 | 3 | 54.2 | None |
| 12 | 1 | 100 | " |
| 10 | 1 | 90 | " |
| 5 | 1 | 80 | " |
| 41 | 1 | 90 | " |
| 11 | 1 | 57 | " |
| 32 | 1 | 59 | " |
| 18 | 1 | 50 | " |
| 199 | 10 | 56 | |

[1] Actual percentage entered after deducting the infestation in the peaches in the beginning. Ripe or nearly ripe peaches were used and it was impossible to obtain fruit entirely free of worms. Percentage deducted represents infestation of a representative sample. Experiments all conducted by placing eggs cut from leaves in the stem ends of dusted or sprayed fruit.



TABLE 13. EXPERIMENTS IN KILLING THE OVERWINTERING LARVAE OF THE ORIENTAL PEACH MOTH, 1929

Miscible Pine Oils and Pine Oil Emulsions

| Exp. No. | Material | Dates | Per cent killed | Notes |
|---|---|---|---|---|
| 1 | Miscible[1] pine oil, 50% emulsion | April 10–15 | 100 | |
| 2 | Miscible[1] pine oil, 33% emulsion | April 10–15 | 100 | |
| 3 | Miscible[1] pine oil, 20% emulsion | April 10–15 | 88 | |
| 4 | Miscible[1] pine oil, 15% emulsion | April 17–22 | 66 | |
| 5 | Miscible[1] pine oil, 10% emulsion | April 10–June 21 | 66 | |
| 6 | Miscible[1] pine oil, 10% emulsion | May 20–May 25 | 92 | Different stock |
| 7 | Sol. pine oil, 20% emulsion | April 24–29 | 86 | |
| 8 | Form. 87, 20% pine oil | April 22–26 | 88 | |
| 9 | Form. 87, 20% pine oil | April 27–May 3 | 100 | |
| 10 | Form. 88, 10% pine oil | April 22–26 | 00 | |
| 11 | Form. 74, 3% pine oil | Feb. 25–June 21 | 50 | |
| 12 | Check, no treatment | Feb. 25–June 25 | 00 | |
| 13 | Form. 93, 2.5% pine oil plus pyrethrum 10% | May 6–June 21 | 100 | 9 pupae in this lot; 4 dead; 4 larvae—all dead |
| 14 | Form. 93, 10% | May 17–June 25 | 100 | |
| 15 | Form. 93, 5% | May 17–June 24 | 97 | |
| 15a | Form. 93, 5% | May 17–June 25 | 100 | |

[1] NOTES: Miscible pine oil at 20 per cent sprayed on two peach trees at the Mount Carmel farm on April 23 after buds had reached pink. Many buds were killed but new growths started nicely on May 3.

The method used consisted of dipping the larvæ, spun in paper cells, in each material, blotting off the excess liquid and removing to the insectary where they were kept in open containers.

TABLE 14. MISCIBLE KEROSENE AND COMBINATIONS

| Exp. No. | Material | Dates | Per cent killed | Notes |
|---|---|---|---|---|
| 16 | Miscible kerosene 5%, naphthalene .1% | April 12–22 | 9 | Pupae |
| 17 | Miscible kerosene 10% | April 12–June 21 | 00 | |
| 18 | Miscible kerosene 15% | April 17–June 24 | 44 | 2 pupae |
| 19 | Miscible kerosene 10%, naphthalene .2% | April 12–June 21 | 50 | No pupae |
| 20 | Miscible kerosene 10%, ethyl acetate .1% | April 17–June 24 | 9 | |
| 21 | Miscible kerosene 10%, carbon disulfide .1% | April 17–June 24 | 0 | |
| 22 | Miscible kerosene 10%, beta-naphthol .1% | April 10–June 15 | 0 | No pupae |
| 23 | Miscible kerosene 10%, naphthalene 1.0% | April 29–June 24 | 22 | Pupae |

TABLE 15. EXPERIMENTS IN KILLING THE OVERWINTERING LARVAE OF THE ORIENTAL PEACH MOTH WITH VARIOUS SUBSTANCES, 1929

Mineral Oils and Combinations

| Exp. No. | Material | Dates | Per cent killed | Notes |
|---|---|---|---|---|
| 24 | Gasoline 80%, pine oil 20% | Feb. 25–June 21 | 100 | |
| 25 | Gasoline 50%, pine oil 50% | Feb. 13–April 10 | 100 | |
| | | Feb. 25–April 10 | | |
| 26 | Gasoline, pure | Feb. 25–April 10 | 91 | |
| 27 | Kerosene (best grade), pure | May 5–June 24 | 100 | 8 pupae in this lot |
| 28 | Fuel oil | Feb. 25–April 10 | 50 | |
| 29 | Kerosene | Feb. 25–April 10 | 100 | |
| 30 | Kerosene 50%, fish oil 50% | Feb. 11–June 24 | 70 | |
| 31 | Same, emulsified and diluted to 41% oil | Feb. 11–June 24 | 62 | |
| 32 | Check, no treatment | | 00 | |



TABLE 16. EFFECT OF SWEET ORANGE OIL AND VARIOUS PINE OIL CONSTITUENTS ON THE OVERWINTERING LARVAE, 1929-1930

| Materials | Per cent oil in diluted emulsion | Date | No. larvae or pupae | Per cent dead |
|---|---|---|---|---|
| Check, no treatment | .. | 1929 | 5 larvae | 0 |
| | | 1930 | 18 larvae | 5 |
| Soap 2% | .. | 1929 | 21 pupae | 21 |
| | | 1930 | 10 larvae | 20 |
| Dipentene | 10 | 1929 | 86 pupae | 1 |
| Soap 2% | 9 | 1930 | 29 larvae | 17 |
| Pinene | 10 | 1929 | 23 pupae | 27 |
| Soap 2% | 9 | 1930 | 28 larvae | 42 |
| Sweet orange oil | 10 | 1929 | 4 larvae | 100 |
| Soap 2% | 9 | 1930 | 26 larvae | 88 |
| | 10 | 1929 | 16 pupae | 100 |
| Terpineol | 10 | 1929 | 105 larvae | 97 |
| Soap 2% | 9 | 1930 | 32 larvae | 90 |
| d—Limonene | 10 | 1929 | 14 larvae | 100 |
| Soap 2% | 10 | 1929 | 66 pupae | 98 |
| | 9 | 1930 | 32 larvae | 100 |

NOTES: All tests were made with larvæ or pupæ in paper cells; 1929 treated May 20-29, examined June 21; 1930 treated Feb. 12, examined Feb. 20. Terpineol used at 10 per cent strength on peach foilage burned severely, limonene and pinene burned slightly, and orange oil and dipentene even less.

## Control of the Moth

Two methods are available for control of the moth, namely, poisoning and repellent action to prevent egg laying. An attempt to poison adult moths was made in 1929 by adding rotenone to syrup and spraying it on leaves within oviposition cages. The results obtained are shown in Table 17 and indicate a decided reduction in number of eggs. In only one of the tests was it apparent that any poison was taken by the moths themselves. Our repellent tests have been confined to cage and small field tests; the field tests of 1928 with alpha-naphthylamine reversed results obtained in cage tests. Field technique with these materials has not yet been perfected, so that further discussion of results is not advisable at this time. The main difficulty with most repellents lies in their volatility, which causes them to disappear from the tree within a short period. Doctor Lipp, of the United States Department of Agriculture, has done much work with repellents and has devised a means for testing materials of this sort. In laboratory tests he found bone oil and alpha-naphthylamine very efficient (34).

TABLE 17. TESTS IN PREVENTION OF EGG-LAYING BY APPLICATIONS OF ROTENONE AND SYRUP

| Dates | Notes on experiments | No. eggs obtained on— Treated | Untreated |
|---|---|---|---|
| July 19–24 | Large number of moths in cage about 6" square, two shoots sprayed with rotenone (1.5 cc. 10% in acetone) in 200 cc. water, 2 gm. refiners' syrup added, two shoots untreated in opposite corners of cage. Moths crowded probably accounting for the fairly large number on treated shoots. | 763 | 1719 |
| June 13 | 50 moths in two different cages of same size, one with peach shoots treated with 1 cc. 10% acetone solution plus 1 gm. honey in 100 cc. water. June 17, three moths or 6% were alive in cage with treated shoots; 19, or approximately 50%, were alive in untreated ............... | 76 | 288 |
| June 18 | Same as on June 13. June 24, 6 moths were alive in treated cage, 12 in check ... | 15 | 203 |
| June 24 | Same as June 18 and 13, using syrup instead of honey, about 25 moths in each cage. June 29, three alive in both cages.. | 0 | 7 |
| | Total ............................ | 854 | 2217 |

## FIELD CONTROLS

### History

Shortly after the discovery of the moth in 1917, an investigation of controls in the District of Columbia, Maryland and Virginia disclosed the fact that the ordinary arsenical lime sulfur sprays (self-boiled) were not adequate, because of injury to the tree and the several brooded nature of the pest. Nicotine sulfate was next advocated by Virginia (61) and taken up in New Jersey. By this means about 10 per cent reduction in injury may be obtained, but this is not sufficient and it is considered too expensive by orchardists for the results obtained. Turning now to other means, Ohio (69) studied the use of hydrated lime in large quantities, but this material has not been entirely successful and has not worked well in our field experiments. Likewise, talc dust has been used in New Jersey (10) with considerable promise, but has not yet given satisfactory results in Connecticut. Both this and lime sprays should, however, be considered as still in the experimental stage.

It was found also that pans containing fermented molasses attracted many moths, so this too was used as a control, with little or no success to date. The reason for this failure lies probably in the fact that only a small percentage of the moths in an orchard are captured by this method. For example, bait pans hung in a cage provided with moths caught very few and eggs were deposited within a few feet of the baits. Stear (58) reports 4-30 per cent catch of marked moths liberated in an orchard where pans were maintained. Much work has been done towards perfecting baits and containers by Frost (18, 19) and Peterson (42, 43) and it has been shown by these workers that enamel or protected pans containing one-half gallon or more give the best results. The best bait appears to be a cheap grade of molasses or refiners' syrup diluted one part in 20 parts of water. For our conditions a refiners' syrup has given good results. Bait pans, in spite of their failure to date in giving satisfactory control, are useful in indicating the extent of the different broods and in telling the orchardist whether moths are abundant in his orchard.



### Control Experiments in Connecticut

Our first experiments in control of the Oriental peach moth in Connecticut consisted of various nicotine and arsenical applications, which gave the results shown in Table 18. These were conducted in a large orchard near Greenwich in southwestern Connecticut. The spraying equipment is seen in Plate XII. The fruit was graded from exterior examination, but a representative number from each plot was cut open, and the number missed on the first examination was then estimated. The percentages appear in the last column.

TABLE 18. RESULTS OF SPRAY EXPERIMENTS TO CONTROL THE ORIENTAL PEACH MOTH AT CONYERS FARM, 1924. VARIETY, BELLE OF GEORGIA

| Block | Treatment | Good | Infested | Per cent | Per cent infested based on cut fruit |
|---|---|---|---|---|---|
| 1 | Fungicide only, 2 sprays .. | 3237 | 393 | 10.8 | 23 |
| 2 | Five sprays with nicotine sulfate. Two of these with arsenate .......... | 2528 | 190 | 6.9 | 14 |
| 3 | Fungicide plus lead arsenate ................. | 3539 | 408 | 10.3 | .. |
| 4 | Five dusts containing nicotine, 2 with arsenate .... | 1847 | 63 | 3.2 | 11 |

This work was continued in 1925 in two different orchards and complete records were kept of the fruit examined, all being cut open. These figures show that that old or second brood injury is about one-third or one-fourth the total injuries, but that none of the scheduled applications were especially successful. Table 19 shows results obtained in the Barnes orchard at Wallingford, and Table 20 those at Conyers Farm in Greenwich.

TABLE 19. RESULTS OF SPRAY EXPERIMENTS TO CONTROL THE ORIENTAL PEACH MOTH, BARNES ORCHARD, 1925. VARIETY, ELBERTA

| Block No. | Treatment | Total fruits | Per cent infested |
|---|---|---|---|
| 1 | 90–10 dust, July 15, Aug. 14 | 824 | 37.8 |
| 2 | Nicotine dust, July 15, July 30, Aug. 14 | 755 | 27.9 |
| 3 | Check | 439 | 46.7 |

Table 19 shows a considerable reduction for nicotine dust. The results obtained at Conyers Farm contradict this, although in the previous season they were more favorable. Thus in 1924 we obtained a reduction of 12 per cent by this means, whereas in 1925, after shifting the block to a more unfavorable location, no reduction was obtained. Here the most favorable treatment was found to be nicotine sprays, which netted a reduction of 12 per cent. It becomes apparent, therefore, that nicotine sulfate, either in the form of a spray or dust, will reduce injury from the peach moth, for in spite of one failure, there are three successes in our field experiments. The amount of injury reduction varied from 12 per cent with a 23 per cent infestation to about 18 per cent with a total check infestation of 46.7 per cent. In the Barnes orchard, however, this left 27.9 per cent infested fruit in the nicotine dusted plot, which is too much from a commercial standpoint.

TABLE 20. RESULTS OF SPRAY EXPERIMENTS TO CONTROL THE ORIENTAL PEACH MOTH AT CONYERS FARM, 1925. VARIETY, BELLE OF GEORGIA

| Block No. | Treatment | Total fruits | Per cent injured |
|---|---|---|---|
| 1 | Nicotine dust (2.7%) July 13, July 29, Aug. 10 | 1964 | 22.9 |
| 2 | 90-10 sulfur arsenate dust, July 13, Aug. 10 | 1932 | 15.5 |
| 3 | Check | 1924 | 21.5 |
| 4 | Nicotine sulfate spray, July 13, July 29, Aug. 10, Aug. 20 | 1883 | 10.5 |

In 1927, a block of about 50 trees at Wallingford was sprayed twice in July with sodium fluosilicate, glue, lime and water, followed by two applications of white oil emulsion, to which was added nicotine sulfate half strength and oil of citronella. The following results were obtained:

TABLE 21. RESULTS OF SPRAYING TO CONTROL THE ORIENTAL PEACH MOTH AT WALLINGFORD, 1927. VARIETY, ELBERTA

| Treatment | Total fruits | Per cent old injury | Per cent new injury | Total per cent injured |
|---|---|---|---|---|
| Sprayed | 702 | 3.9 | 5.3 | 9.2 |
| Check—Sulfur dust only | 747 | 8.3 | 6.2 | 14.5 |



It may be added that the sprayed plot here was in an unfavorable location, indicating that the reduction in old and new injury does not necessarily show the value of the treatments. There is some reduction both in old and new injury, however. In 1929, after a lapse of one year, field work was again undertaken, due to the development of talc dusts and heavy lime sprays in the meantime. Also it was thought advisable to test oils with additional materials as controls. An orchard of about four acres was leased at Mount Carmel and work conducted throughout the season. The following results were obtained after cutting all fruit from five selected trees.

TABLE 22. RESULTS OF SPRAYING TO CONTROL THE ORIENTAL PEACH MOTH AT MOUNT CARMEL, 1929. VARIETY, ELBERTA

| Block No. | Treatment | Total fruits | Per cent injured fruit | Per cent fruit injury to check trees in each block |
|---|---|---|---|---|
| 1 | Talc dust, 10 applications | 1402 | 28.2 | 25.2 |
| 2 | White oil emulsion,[1] light, with nicotine sulfate, 5 sprays in August and September at weekly intervals | 768 | 16.0 | 28.0 |
| 3 | W. O. E.,[2] concentrate with pyrethrum soap, 5 sprays in August and September at weekly intervals | 535 | 19.4 | 19.5 |
| 4 | Lime, 5 applications in June and July at 10-day intervals | 1569 | 19.9 | 20.2 |
| 5 | Check, no treatment | 1420 | 22.2 | ... |

In addition to the figures given above, an experiment was carried on in a small plot of about twenty trees on the Experiment Station farm, using a commercial white oil emulsion in comparison with no treatment. This is shown in Table 23.

TABLE 23. EXPERIMENT TO CONTROL THE ORIENTAL PEACH MOTH, STATION FARM, 1929. VARIETY, ELBERTA

| Treatment | Total fruits | Per cent injured |
|---|---|---|
| W. O. E. conc. 1%, .8% oil, 4 sprays in August, 1 in September | 658 | 7 |
| Check, no treatment | 699 | 20 |

Several quince trees were also sprayed with white oil emulsion (concentrate) during August and September, 1929, at weekly intervals. These fruits were picked about October 1, and the number of exit holes counted on the sprayed and the unsprayed fruit. There were fewer such marks on the sprayed quinces, although the amount of infested fruit was about the same. In

[1] Commercial preparation, 1.5 per cent oil in diluted spray. Viscosity of oil 50 sec.
[2] Commercial preparation, .8 per cent oil in diluted spray. Viscosity of oil 108 sec.

1928 two orchardists sprayed and dusted their quinces (sulfur-arsenate 90-10 dust and lead arsenate in combination with dry mix) at 10 days intervals in August. The treatments apparently gave no control. In the case of quinces there is the whole of September when reinfestation might occur, but it seems inadvisable with poison sprays to continue applications too late, on account of harmful residue that may remain at harvest. Oil sprays might possibly be continued except for the expense which would (at present costs), after many applications easily consume whatever profit there is in the fruit and certainly would not pay unless their effectiveness is considerably increased.

In 1926 and 1927 bait pans were used in a large orchard in Wallingford and the fruit scored at harvest by cutting open a representative number. Results are given in Table 24.

TABLE 24. TESTS WITH BAIT PANS AS A CONTROL FOR THE ORIENTAL PEACH MOTH, 1926 AND 1927. VARIETY, ELBERTA

| Treatment[1] | Total fruits | Per cent injured |
|---|---|---|
| 1927 | | |
| Pail in every tree | 775 | 13.9 |
| Check, dust only | 747 | 14.5 |
| 1926 | | |
| Pail in every tree | 1024 | 12.7 |
| Pail in every other tree | 1370 | 9.7 |
| Check, dust only | 928 | 10.5 |

The theory of this means of control is that moths are attracted to fermenting baits, fly into the liquid and are unable to escape. When the moths are most numerous in the orchard, thousands may be caught in the pans. It is believed that the fermenting sugars are necessary and it has been proved that tin pails are not as satisfactory as enamel or glass containers, because of the reaction of the liquids on the metal. Suitable enamel pails may be purchased as low as 15 cents each and for practical purposes (determination of broods) cheap molasses can be used. This should preferably be renewed once a month and the pails kept filled with water frequently during dry periods. A dilution of one part molasses in 20 parts water with or without yeast is satisfactory.

## Control in Twigs

During 1919, the writer conducted some experiments on the grounds of the Maryland Agricultural Experiment Station for control of the Oriental peach moth in twigs. Twelve small trees were selected and every other tree sprayed with a formula con-

[1] All trees, including those with pails, were dusted several times with sulfur dust by the owner.



TABLE 25. CONTROL OF THE ORIENTAL PEACH MOTH IN TWIGS, COLLEGE PARK, MD., 1919

| Treatment | Exp. No. of tree | Number of injured shoots on following dates: May 29 | June 5 | July 5 | July 16 | Aug. 8-9 | Aug. 16 | Aug. 18 | Sept. 1 | Estimated shoots per tree | Total twigs injured |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sprayed ... | 2 | 0 | 0 | 17 | 10 | 26 | 5 | 9 | 5 | 100 | |
| | 4 | 0 | 0 | 18 | 17 | 28 | 1 | 3 | 3 | 200–300 | |
| | 6 | 0 | 2 | 15 | 8 | 21 | 2 | 0 | 0 | 100 | |
| | 8 | 1 | 2 | 11 | 11 | 9 | 1 | 3 | 6 | 200–300 | |
| | 10 | 0 | 4 | 13 | 21 | 32 | 3 | 0 | 2 | 200–300 | |
| | 12 | 3 | 7 | 12 | 4 | 6 | 0 | 0 | 0 | 70 | |
| Totals.. | | 4 | 15 | 86 | 77 | 152 | 11 | 15 | 16 | | 376 |
| Checks .... | 1 | 8 | 0 | 54 | 4 | 48 | 5 | 9 | 5 | 150–200 | |
| | 3 | 10 | 0 | 32 | 12 | 52 | 6 | 5 | 4 | 150–250 | |
| | 5 | 9 | 2 | 33 | 11 | 8 | 6 | 2 | 4 | 75 | |
| | 7 | 18 | 8 | 36 | 7 | 18 | 8 | 3 | 6 | 200–300 | |
| | 9 | 4 | 14 | 23 | 7 | 46 | 5 | 8 | 3 | 70 | |
| | 11 | 13 | 13 | 55 | 22 | 77 | 10 | 5 | 1 | 300–400 | |
| Totals.. | | 62 | 37 | 233 | 63 | 249 | 40 | 32 | 23 | | 739 |

NOTES: Dates of spray applications, May 9, May 12, May 31, June 21, July 11, Aug. 1 and Aug. 8. Sprays on May 9 and Aug. 1 contained arsenate of lead; others did not.

taining self-boiled lime sulfur, calcium arsenate, calcium caseinate and nicotine sulfate. The arsenate was used in two of the applications and the number of injured twigs counted regularly and tagged. The results are shown in Table 25. Since these figures have not been published, they are given here, with permission of the Maryland Experiment Station.

From the data in Table 25 it was concluded that sprays should be made more frequently to obtain satisfactory control, especially since the results vary and, considered from the mathematical standpoint, are doubtfully important. There is little doubt, however, that there is some reduction in number of injured twigs. In 1929, 12 small peach trees at New Haven were divided into two plots, one of which was dusted frequently with talcum powder and the other left without treatment. Injured twigs were frequently removed, care being taken to obtain all infested shoots. The results are shown in Table 26. Both ordinary and fibrous talc dusts were employed and the results revealed more injured twigs for the ordinary talc and slightly less for the fibrous talc. This corresponds in general with our field experiment with fruit, where there was no gain in sound fruit from the use of talc. Weather conditions were favorable for the tests, since there was very little rainfall.

TABLE 26. EFFECT OF DUSTING WITH TALC TO PREVENT ENTRY OF LARVAE IN TWIGS

| Kind of talc | Dates treated | Date injured twigs removed | Number from dusted trees | Number from check trees |
|---|---|---|---|---|
| Ordinary | June 14 | June 18 | 17 | 19 |
| | June 18 | June 20 | 29 | 20 |
| | June 26 | June 24 | 25 | 26 |
| | June 29 | June 26 | 16 | 15 |
| | | June 28 | 16 | 11 |
| | | July 1 | 16 | 9 |
| Totals | | | 119 | 100 |
| Fibrous talc | July 3 | July 3 | 5 | 4 |
| | July 6 | July 6 | 4 | 10 |
| | July 12 | July 9 | 19 | 24 |
| | July 16 | July 11 | 9 | 13 |
| | | July 13 | 25 | 15 |
| | | July 15 | 7 | 9 |
| | | July 19 | 12 | 12 |
| Totals | | | 81 | 87 |
| Totals for both kinds of talc | | | 200 | 187 |



## Cultivation

Complete thorough cultivation for the peach moth has been practiced for a number of years by Connecticut growers. The best results were obtained apparently in the Barnes Orchard at Wallingford, where all ground was broken or plowed in the fall, with frequent cultivation in spring and summer up to August. There is little doubt that some good has been done by this control measure, but from observations in other orchards, where the infestation is heavy, it is apparent that such methods do not afford complete or, in some cases, even satisfactory relief. Thus in the Rogers orchard, one of the heaviest infestations yet seen in Connecticut followed a year of intensive complete cultivation. There are orchards, too, that cannot be completely cultivated, being located on hillsides where complete cultivation would do more harm than good because of erosion. On the other hand, some cultivation of peaches appears to be essential in peach culture in Connecticut and whether it is complete or partial is determined by the nature of the land and preference of the owner.

## SUMMARY OF CONTROLS

1. Thus far it has been seen that arsenicals as controls are ineffective, as well as dangerous on peach trees, if applied repeatedly.
2. Nicotine sprays or dusts reduce the infestation considerably but not enough.
3. Lime sprays and talc dusts did not afford protection in our orchard in 1929.
4. White oil emulsions gave some reduction but not enough.
5. White oil emulsions with additional materials have not materially increased effectiveness in the field.
6. Materials applied against the overwintering larvae, while apparently effective in laboratory tests, have not yet been proved safe or effective in field practice.
7. Repellents are still in the experimental stage and have not yet been proved of value in field control.
8. Bait pans have not been effective so far, apparently because of the large number of moths in an infested orehard and the relatively small number caught by such means.
9. Cultivation recommended for the last few years has not given the desired relief in heavily infested orchards. There is no doubt, however, that it destroys many larvae and should therefore be continued in the general scheme of control.
10. Paradichlorobenzene will kill most of the larvae that are reached, but cannot be depended upon for complete control; and furthermore, is usually applied before the majority of the larvae spin.

## RECOMMENDATIONS

The present status of the peach moth in Connecticut justifies the following recommendations. It should be recognized, of course, that only partial control will result from these measures, but we believe them advisable in view of the seriousness of the situation.

1. Cultivation: complete to trunks of trees, spring cultivation to be complete by May 15, preferably May 1; depth, four inches.
2. Prompt destruction of cull fruit and screening of packing sheds to prevent escape of moths. The fruit shed should be closed until the middle of July. Care or destruction of containers where larvae have spun.

## PARASITES

In considering the damage brought about by the Oriental peach moth, it has been observed that the period of increase and decrease in certain orchards has followed a definite cycle. Beginning with a small infestation of perhaps 10 to 15 per cent, where it may remain for two or three years, it may then jump to 50 per cent or even higher, and stay there several years before it begins to decline. In some orchards the period of severe damage has persisted for three or even four years, causing great monetary loss. Connected with periods of decline there has been apparent in several different orchards a decided increase in parasites, particularly the more common *Macrocentrus ancylivora*. In other localities *Trichogramma minuta* has been observed throughout the season. *Glypta rufiscutellaris* has been abundant in some years, and in one orchard a considerable number of *Eubadizon* sp. was found. A list of about 50 parasites has been compiled by Stearns (80) and there are probably others not yet recorded. Thirty parasites are listed below from Connecticut and neighboring states.

| | Parasite | Distribution | Prevalence in Connecticut |
|---|---|---|---|
| 1. | *Macrocentrus ancylivora* Roh. | New Jersey, Pennsylvania, Connecticut, Maryland, Virginia, Ohio, New York | Present in considerable abundance in some orchards. |
| 2. | *Macrocentrus delicatus* Cr. | New Jersey, Connecticut, probably others | |
| 3. | *Glypta rufiscutellaris* Cr. | New Jersey, Connecticut, Pennsylvania, Maryland, Virginia, Georgia, Ontario | Fairly common in Connecticut. |
| 4. | *Eubadizon* sp. | Connecticut, Georgia, Ontario, Virginia | Present in one orchard in considerable numbers. |
| 5. | *Trichogramma minuta* Riley | New Jersey, Virginia, Maryland, Connecticut | Very abundant in some orchards. |

The following parasites from nearby states have not been observed in Connecticut or are rare in our orchards:



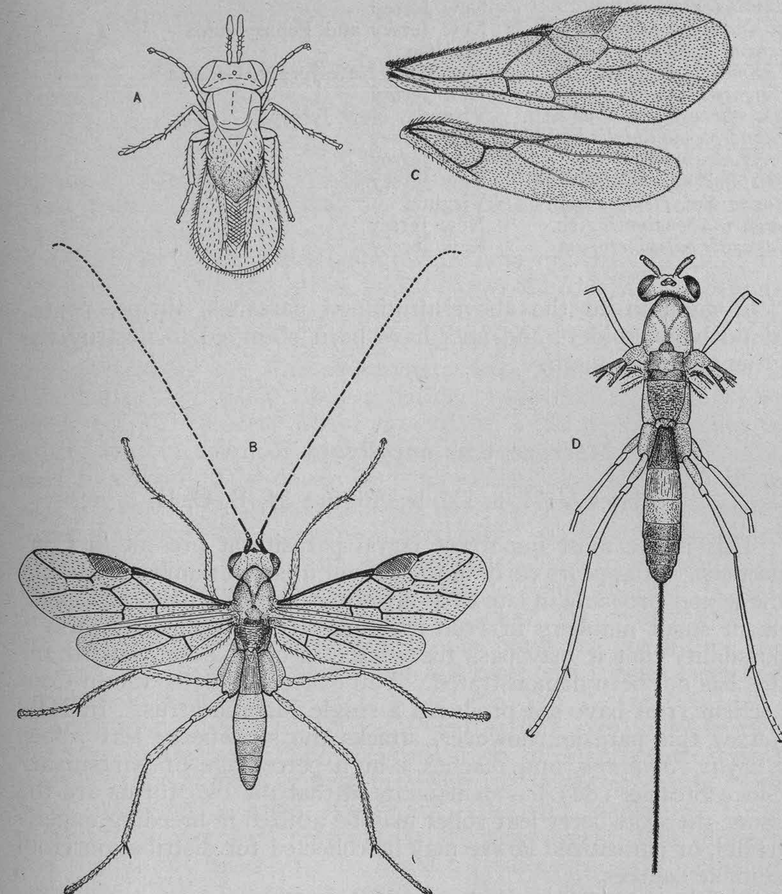


FIGURE 34. Parasites of the Oriental peach moth. A, an egg parasite, *Trichogramma minuta* Riley; B, C, D, *Macrocentrus ancylivora* Rohwer; B, male; C, wings of female; D, body of female. All much enlarged.

| | | |
|---|---|---|
| 6. | *Ascogaster carpocapsae* | Virginia, Maryland, New Jersey, Pennsylvania |
| 7. | *Cremastus minor* Cush. | New Jersey |
| 8. | *Cremastus forbesii* Weed. | New Jersey |
| 9. | *Cremastus* sp. | New Jersey |
| 10. | *Aenoplex betulaecola* Ash. | New Jersey, Pennsylvania |
| 11. | *Allocota thyridopterigis* Riley | Pennsylvania |
| 12. | *Calliephialtes grapholithae* Cresson | New Jersey, Pennsylvania |
| 13. | *Calliephialtes* sp. | New Jersey |
| 14. | *Centeterus ineptifrons* Gahan | New Jersey, Pennsylvania, Virginia (in quinces) |
| 15. | *Cryptus vinctus* Say. | New Jersey |
| 16. | *Ephialtes aequalis* Prov. | Virginia |
| 17. | *Epiurus indagator* Cress. | New Jersey |
| 18. | *Goniozus* sp. | Virginia |

19. *Hemiteles* sp. — New Jersey
20. *Itoplectis conquisitor* Say. — New Jersey and Pennsylvania
21. *Leucodesmia nigriventris* Gir. — Virginia
22. *Euzanillia variabilis* Coq. — Maryland, New Jersey, Georgia
23. *Meteorus hyphantria* Riley — New Jersey
24. *Microbracon gelechiae* Ash. — Virginia, New Jersey
25. *Phanerotoma tibialis* Hald. — New Jersey
26. *Phygadeum* sp. — New Jersey
27. *Pristomerus ocellatus* Cush. — New Jersey
28. *Rogas platypterigis* Ash. — Virginia
29. *Sagaritis consimilis* Ash. — New Jersey
30. *Sagaritis patsuiketorum* — New Jersey

In addition to the above-mentioned parasites, thrips, pentatomid bugs, spiders and ants have been observed to destroy the Oriental peach moth.

## Macrocentrus ancylivora Rohwer

Plates VIII, a, IX, b; Figure 34, B, C, D.

This is the most important larval parasite at present in Connecticut. It appears early in the season in small numbers, passing the winter probably in late twig-infesting larvae of the peach moth, or in small numbers in fruit-infesting larvae. There is also a possibility that it may pass the winter in other hosts, but so far this has not been demonstrated. Fall collections of larvae in Connecticut fruit have not produced a single Macrocentrus. In New Jersey this parasite, however, attacks the strawberry leaf roller, *Ancylis comptana,* and reaches a high percentage of parasitism.[1] Since Stearns (85) has demonstrated that the two forms are the same, the strawberry leaf roller may be utilized in breeding experiments, or parasitized larvae may be collected for distribution from suitable sources.

Briefly, the life history is as follows: The eggs of the parasite are laid in the body of the peach moth larva of all stages. "Macros" will also develop in all stages of the leaf roller. Fink (79) states that the incubation period lasts from 3-13 days and that the number of eggs found in the female ovaries varies, the minimum contained being 384 and the maximum 786. If all eggs develop and are successfully deposited, each one in a single peach moth larva, the normal increase would be from two to seven times as fast as that of the peach moth, since the period of development is essentially the same as that of its host. That is to say, development from egg to adult requires approximately the same length of time as the peach moth and the only chance for this species to

[1] It has also been reared by us from Connecticut leaf rollers.



gain on its host lies in the greater egg-laying powers of the parasite.

Under normal conditions many "Macro" larvae will emerge from hibernating larvae in October, leaving few to be carried over until the following year. Those passing the winter do so in the larval stage inside the host, spinning and pupating the following spring. Development will naturally be slower in fall and spring than in midsummer, so that the life cycle as stated will not apply at these periods.

Of all larval parasites collected in nine orchards in 1929, 65 per cent were Macrocentrus, which shows the relative importance of this species. Less extensive collecting in 1928 showed relatively few. "Macros" first began to be noticed in Connecticut in the orchard of the Barnes Orchard and Nursery Company at Wallingford in 1926, when a decided reduction in fruit injury occurred. They were again noticed in 1927 and reduction in injury attributed in part to their presence together with cultivation that was thoroughly done. Further observation at Southington in 1928 and 1929, however, led to the conclusion that cultivation had not reduced the infestation materially. At East Wallingford in the Young orchard, there was a decided drop in infested fruit for the first time in 1929 and the "Macros" were collected in considerable numbers in this orchard in June. It seems logical to attribute some beneficial action to the parasites present in the orchard, and in all probability the Macrocentrus species have had much to do with it.

According to Stearns (80), as well as our own work in two different localities in 1929, the parasitism of Macrocentrus rises sharply as the number of twig-infesting larvae decreases and more peach moth larvae enter the fruit. This will account in large measure for increased percentages of parasitism in late summer and should not necessarily be taken to indicate greatly increased parasitism. We believe an early parasitism, 40 to 50 per cent, reaching its height in the second brood occurring in July, is needed to check the peach moth and that it is highly desirable to supplement its work with another parasite or parasites which will work better on larvae in the fruit or in the egg. The following table gives results of liberations of "Macros" in 1929.

### Introduction of Macrocentrus

In 1929 about 1,000 "Macros" were placed in an orchard in Southington and approximately 300 in Farmington, where no parasites were observed. These came from the laboratory of the United States Bureau of Entomology, at Moorestown, N. J., in wooden boxes containing 100 to 400 adults. Others were brought back by the writer in strawberry leaf rollers from which the para-

TABLE 27. RESULTS OF MACROCENTRUS LIBERATIONS, 1929

| Source of twigs | Date of collection | Moths obtained | Macrocentrus obtained | Larvae (alive) | Per cent parasites to date | Notes |
|---|---|---|---|---|---|---|
| Southington, Rogers .......... | June 10 | 56 | 1 | 0 | 1.7 | General collections in vicinity of Plots 1 and 2 |
| Rogers .......................... | July 2 | 11 | 4 | 0 | 26 | General collections in vicinity of Plots 1 and 2 |
| Rogers .......................... | July 15 | 37 | 10 | 0 | 21 | General collections in vicinity of Plots 1 and 2 |
| Rogers .......................... | Aug. 13 | 0 | 23 | 4 | 85 | General collections in vicinity of Plots 1 and 2 |
| Rogers plots 1 and 2 .......... | Aug. 24 | 0 | 6 | 0 | 100 | Collected from trunks of trees |
| " plots 1 and 2 .......... | Sept. 2 | 1 | 3 | 3 | 42 | |
| " plot 3 .................. | Aug. 26 | 1 | 4 | 0 | 80 | |
| " plots 4 and 5 .......... | Sept. 2 | 0 | 3 | 0 | 100 | |
| Southington, Rogers "Barn lot" | Aug. 13 | 2 | 40 | 10 | 77 | About 2 miles from points where parasites were liberated |
| Farmington, Root .............. | July 15 | 50 | 0 | 0 | 00 | Collections in June also showed no parasitism |
| Root .............................. | Sept. 2 | 1 | 2 | 4 | 28 | Collections in June also showed no parasitism |

Record of Parasites Released, Southington, Rogers orchard

| Plot | Date | Males | Females | Total parasites | Notes |
|---|---|---|---|---|---|
| 1 .................. | Aug. 13 | 72 | 54 | 126 | Counted by us |
| 2 .................. | Aug. 15 | 88 | 81 | 169 | Counted by us |
| 3 .................. | Aug. 22 | 400 males and females | | 400 | Not counted by us |
| 4 .................. | Aug. 29 | 129 | 175 | 304 | |
| | | | | 999 | |

Farmington, Root orchard

| Plot | Date | Males | Females | Total parasites | Notes |
|---|---|---|---|---|---|
| | Aug. 15 | | | 10 | |
| | Aug. 20 | | | 112 | |
| | Aug. 26 | | | 200 | |
| | | | | 322 | |

Total parasites released 1321



sites were subsequently bred. Both methods were successful as far as the parasites themselves were concerned. "Macros" are easily handled, and we experienced no difficulty in getting them into orchards 25 to 40 miles from the laboratory. They can no doubt be transported with ease much further. The strawberry leaf rollers were collected in New Jersey the last week of July, brought to New Haven, where the folded leaves were kept for awhile in our insectary and then put in emergence cages. Plate X, b. Some 450 parasites emerged from a total of 6,000 folded leaves. They were placed in a small mating box after emergence and transported therein direct to the orchard. Release of this lot was made in several different portions of the orchard, locations being selected where there were plenty of new growth and freshly-injured twigs. Recovery of the parasite was made in the Farmington orchard towards the latter part of the season. At the Southington orchard "Macros" were present in June, averaging 1 to 2 per cent in collections made June 10 and 17. In July it increased to 20 per cent and in August there was a further increase to 80 per cent which was shortly before parasite introduction. Collections after this date varied from 80 to 100 per cent parasitized.

### **Glypta rufiscutellaris** Cresson

Plate VIII, b.

This is a second larval parasite, fairly common in some years, but decreasing to negligible numbers in others. It was observed in 1928 to constitute about 70 per cent of the parasites collected on the Station grounds in New Haven, whereas in 1929 there were no Glypta taken in this locality. Just why this variation should occur is not well understood.

Not much is known of the life history in Connecticut except that the adults appear in August and September and frequently winter in the cocoons of the peach moth. From this it would appear as if there were two generations. We have not observed mating nor have we been able to get them to oviposit in larvae that infest twigs. Glypta will no doubt prove to be useful in some orchards, but it will need to be studied carefully to determine the best methods of handling, as well as the cause of fluctuations already mentioned. We have succeeded in rearing this species also from strawberry leaf rollers obtained in Connecticut.

### **Trichogramma minuta** Riley

Plate IX, a; Figure 34, A.

Eggs of the Oriental peach moth are parasitized by this species, the small fly inserting its eggs directly in the eggs of the peach moth. The entire life cycle of the parasite from egg to adult is passed within the egg, which is completely destroyed. Parasitism of this type is highly desirable, especially since there is no chance on the part of the peach moth to do damage before being killed. Investigations in Connecticut have revealed the presence of Trichogramma in considerable numbers in four different orchards and it doubtless occurs in others. It was found at New Haven in 1929, parasitizing eggs placed in the trees as well as eggs normally present. Table 28 gives the results of these counts:

TABLE 28. PARASITISM OF THE ORIENTAL PEACH MOTH BY TRICHOGRAMMA MINUTA

| Date | Number of eggs | Per cent of parasitism | Notes |
|---|---|---|---|
| June 21 ........... | 39 | 20 | In eggs normally present |
| June 22–25 ........ | 89 | 51 | Placed in the field in several different locations |
| June 26–28 ........ | 63 | 49 | Placed in the field in several different locations |
| July 5–8 .......... | 39 | 66 | Placed in the field in several different locations |
| July 16–18 ........ | 278 | 20 | Placed in the field in several different locations |
| Aug. 17–20 ........ | 216 | 68.9 | Placed in the field in several different locations |
| Sept. 5 ........... | 192 | 80 | Eggs normally present, collected from leaves on trees |

Parasitism of this magnitude must result in some good; it should be noted that parasitism began early and continued until harvest. At Mount Carmel parasitism was not followed throughout the season, but was observed in June to be about 15 per cent and again in September, when more than 80 per cent of the eggs were affected. An attempt was made at Southington to colonize the species with material obtained from the laboratory of the United States Bureau of Entomology, at Arlington, Mass. The parasites were obtained in grain moth eggs fastened to small pasteboard cards. These were hung in trees, using about 4,000 per tree, and the degree of parasitism was determined before and after from counts of eggs placed in the trees. These data are shown in Table 29.

The data in Table 29 indicate, but not conclusively, that there was some increase in parasitism from the liberations, but they do show that Trichogramma was working effectively about August 5. The owner noticed some reduction in injury in the vicinity of the plot on early fruit, Belle of Georgia, but not in some of the later varieties, partly because of the small crop. With the amount of larval parasitism by Macrocentrus that occurred here during August and the egg parasitism, we look for a marked decrease in



TABLE 29. RESULTS OF TRICHOGRAMMA LIBERATION AT SOUTHINGTON, CONN. PARASITES HUNG ABOUT AUGUST 1

| Eggs exposed July 20, 22 | | | | | Eggs exposed August 5-8 | | |
|---|---|---|---|---|---|---|---|
| Tree No. | Total eggs | Parasitized | % | | Total eggs | Parasitized | % |
| 1 | 120 | 0 | | Inside test plot | 18 | 3 | |
| 2 | 62 | 0 | | " | 66 | 10 | |
| 3 | 159 | 4 | | " | 58 | 1 | |
| 4 | 41 | 4 | | " | 63 | 24 | |
| 5 | 185 | 21 | | " | 201 | 6 | |
| Totals | 557 | 29 | 5 | " | 406 | 44 | 10 |
| 6 | 68 | 12 | | North of test plot | 136 | 33 | |
| 7 | 112 | 0 | | " | 103 | 38 | |
| 8 | 3 | 2 | | " | | | |
| Totals | 183 | 14 | 7 | " | 239 | 71 | 29 |
| 9 | 14 | 0 | | South of test plot | 11 | 7 | |
| 10 | 35 | 2 | | " | 31 | 15 | |
| Totals | 49 | 2 | 4 | " | 42 | 22 | 52 |
| Totals | 770 | 45 | 5 | West of test plot | 93 | 29 | |
| | | | | " | 13 | 0 | |
| | | | | " | 106 | 29 | 27 |
| | | | | East of test plot | 91 | 32 | 35 |
| | | | | Totals | 885 | 197 | 22 |

abundance of the peach moth in 1930, unless other unforeseen factors interfere.

Following the discovery of Mr. Flanders in 1927 (84) of the fact that *Trichogramma minuta* may be bred on grain moth eggs,[1] many entomologists have taken up the work. This has resulted in the development of a technique which enables one to grow them in large numbers. There are, however, a number of difficulties to be overcome. Mites, such as *Pediculoides ventricosus,* and species of the family Gamasidae or Parasitidae cause much trouble, the first destroying the grain moth by feeding on various stages, and the second by feeding on the eggs. Apparently the most satisfactory method of dealing with these pests is to heat the grain that is used before infesting it with grain moths. Some workers have used sulfur to keep down mites, while others report failure of this means because of the fact that sulfur destroys or repels the parasite Trichogramma. Various incubators (89) and other apparatus have been devised for rearing the moths, the incubators being intended to maintain the temperature at 80° F. or above and the humidity at 50 to 70 per cent. The main problem seems to

[1] *Sitotroga cerealella.*

be in maintaining grain moths in large enough quantities to produce enormous quantities of eggs and the development of laboratory technique sufficient to handle them efficiently and economically.

### Modifications of Orchard Practices to Favor Parasites

It has been suggested that various measures be taken to favor parasites in the orchard. One of these schemes involves planting strawberries in or near the orchard in order to provide strawberry leaf roller hosts for Macrocentrus after the peach moth leaves the twigs. Another such scheme involves late stimulation of occasional peach trees throughout an orchard so that twig infestations by the peach moth may continue as long as possible, thus providing means for Macrocentrus to carry over from season to season. Neither of these plans has been tested commercially or scientifically, so that no definite recommendations can be made. It would also seem from our experience that the effect of various orchard spray and dusting practices as well as cultivation should be carefully studied in relation to their effect on Trichogramma egg parasites.

### Attempt to Rear Parasites under Artificial Conditions

Following the discovery that parasites work fairly well in Connecticut and that they will survive our winters, the peach growers under the leadership of Mr. H. M. Rogers, of Southington, have asked that a laboratory for their production be organized. Consequently an emergency appropriation was secured, together with subscriptions from about 150 growers, amounting in all to about $7,000.00. With this fund work has been started, both with Trichogramma and Macrocentrus. It is too early to say much about this work other than that considerable progress has been made.

## ACKNOWLEDGMENTS

In connection with our experiments in peach moth control, the author gratefully acknowledges the help given by various orchard owners as well as temporary assistants in our department who have helped in fruit counts and spray programs. The aid received from Mr. G. A. Drew and Mr. H. B. Reed of Conyers Farm, from the Barnes Brothers of the Barnes Orchard and Nursery Company, from the Bishop Brothers of Cheshire, and from Mr. S. H. MacDonald of Wallingford is especially acknowledged. These men have made treatments at our suggestion, have supplied spray outfits and labor or have helped in other ways. Mr. J. F. Townsend has been of great assistance in field and insectary work and his labors have resulted in much expansion of the work in 1929. His work in the construction of various appa-



ratus has been especially helpful. Mr. B. H. Walden made the photographs and deserves all credit for them. We are also greatly indebted to the Federal laboratories at Moorestown and Arlington, where we secured much valuable aid through the kindness of Dr. H. W. Allen and Mr. D. W. Jones. We are also indebted to Dr. R. C. Roark of the United States Bureau of Chemistry and Soils, who supplied a quantity of rotenone for study, and to Mr. Neely Turner for his help with various control experiments.

## REFERENCES TO LITERATURE

The literature on the Oriental peach moth is rapidly becoming so voluminous that space and time make it impossible to quote all references here. So rapidly in fact is the literature on this important pest increasing that many papers cited will soon be out of date or superseded by more extensive publications. The papers quoted will, however, show the general trend of investigations, and afford the exact titles for works cited in the text of this article.

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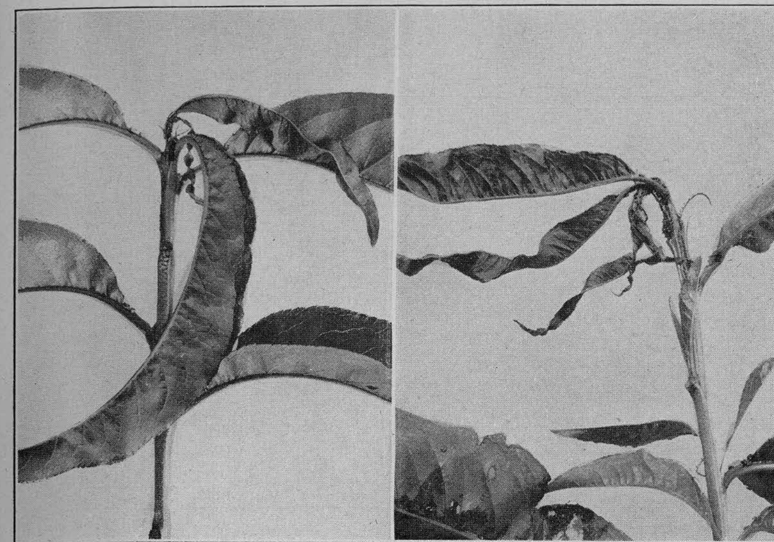
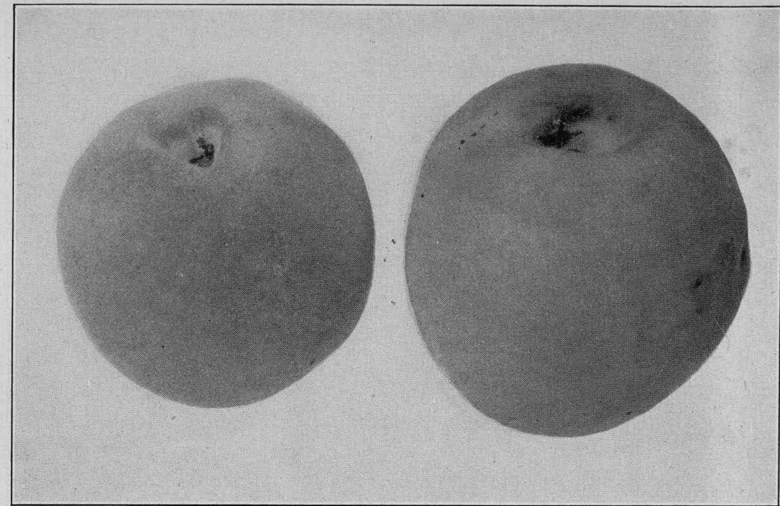
States that larvae kept at 10-11° C. (50-51.8° F.) enter a diapause and do not pupate.

PLATE I

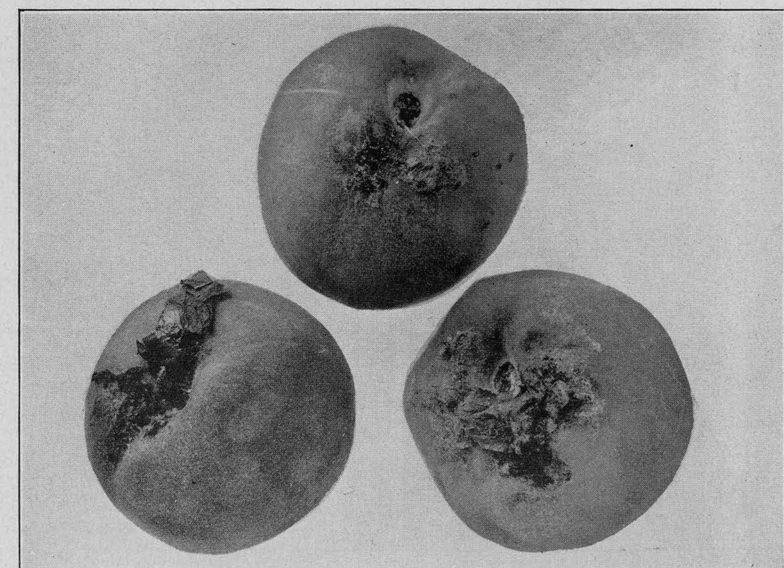


a. Newly infested twig, left; more advanced stage, right.

b. Injured twig after the larva has abandoned it, left; similar twig still later showing how laterals are forced out, right.



a. Ripe fruit with inconspicuous entrance marks of larvae near stems, late brood.

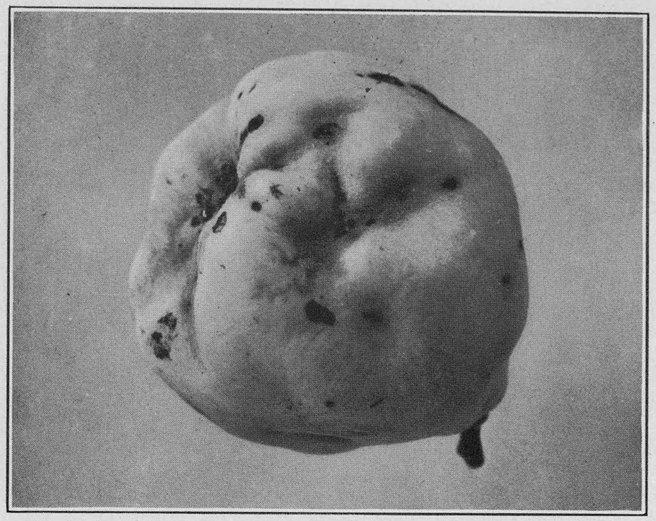


b. Exterior marks of infestation, early brood.

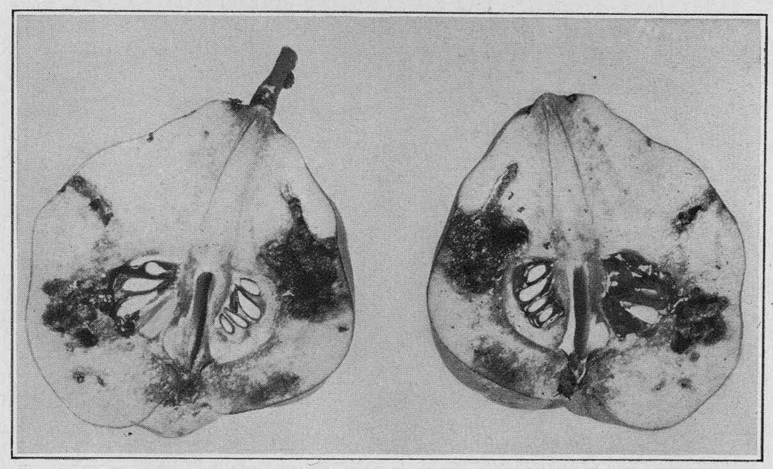


a. Peach with nearly full grown larva, left; exterior marks of infestation, right.

b. Ripe peach containing two larvae.

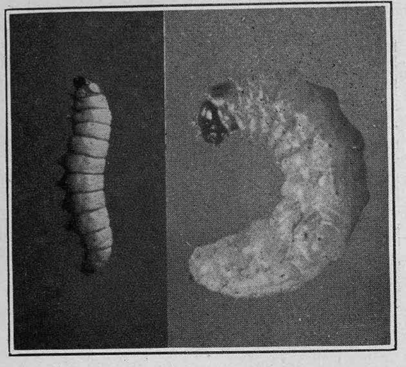


a. Mature quince infested with Oriental peach moth.



b. Quince cut open to show condition of the interior.

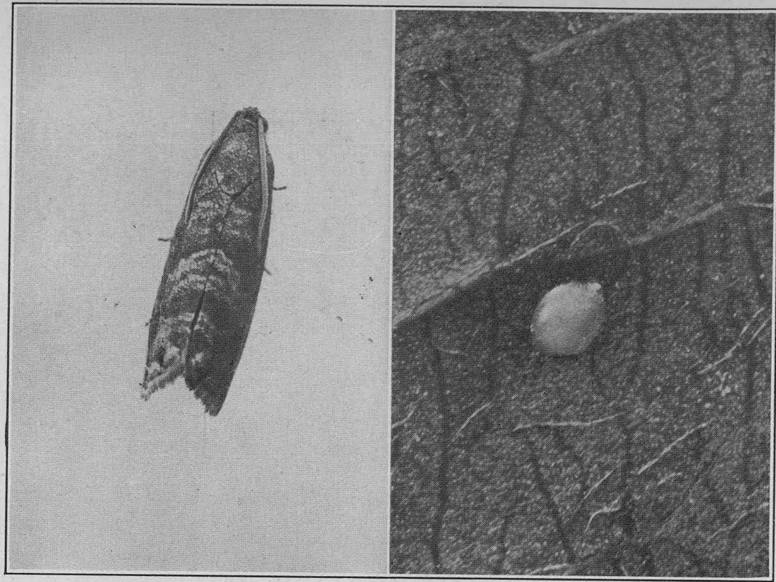




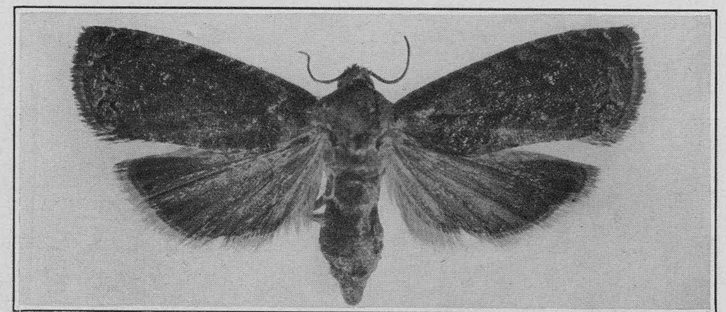
a. Larva of Oriental peach moth and plum curculio compared: left, Oriental peach moth full-grown larva; right, full-grown curculio larva. Both considerably enlarged.

b. Infested peach showing exit hole of larva.

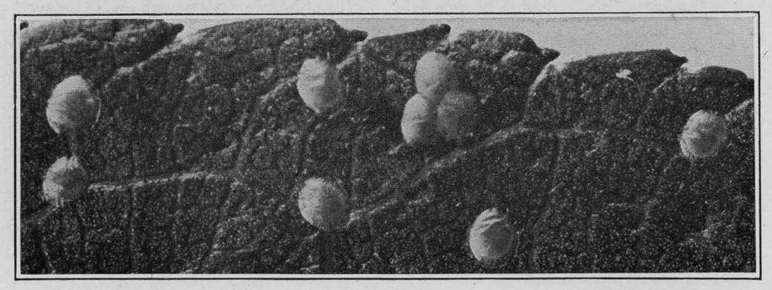
PLATE VI



a. Left, adult moth, enlarged six times; right, egg, enlarged eighteen times.

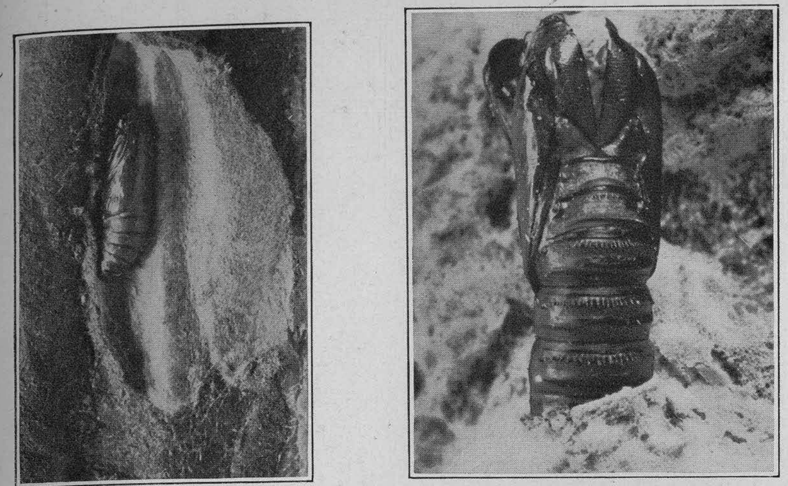


b. Adult female moth enlarged six times.

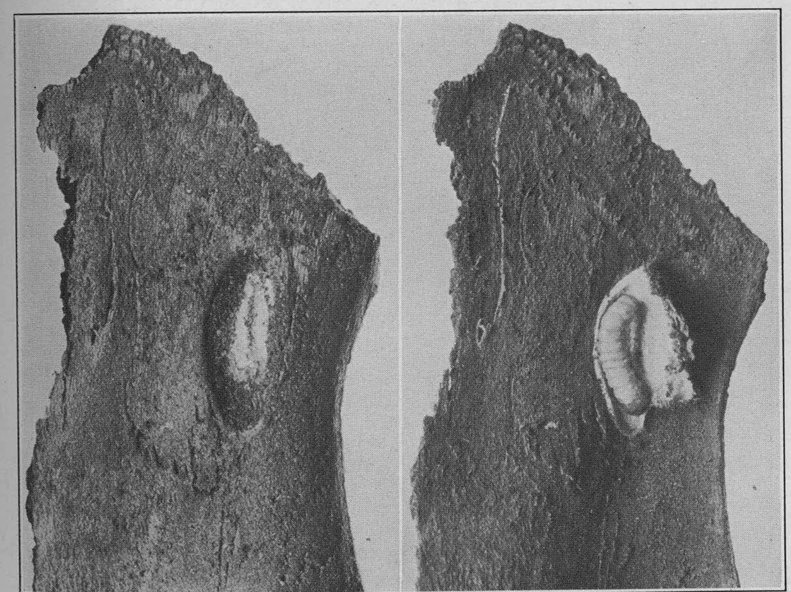


c. Eggs on surface of peach leaf obtained in insectary cage, enlarged ten times.

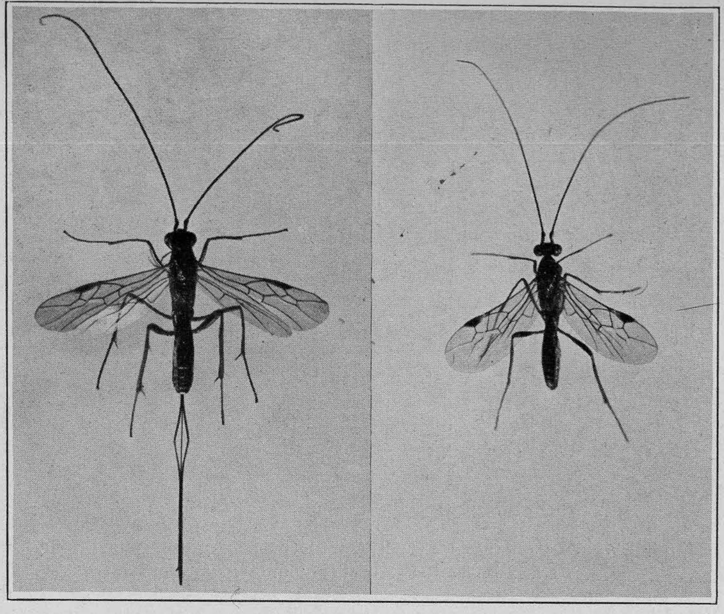
PLATE VII



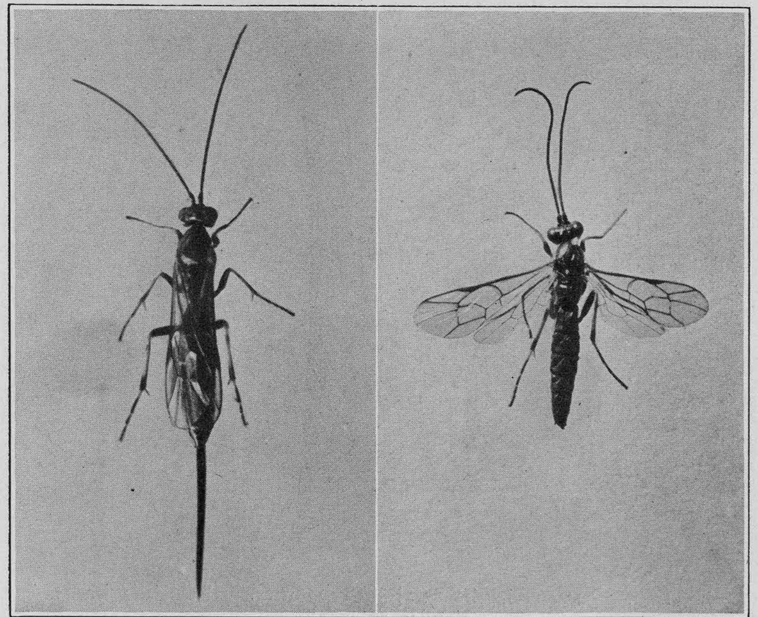
a. Pupa in cocoon enlarged four times, left; protruding pupal skin from which adult has emerged, right; enlarged ten times.



b. Left, cocoon under bark; right, cocoon opened to show insect. Twice enlarged.

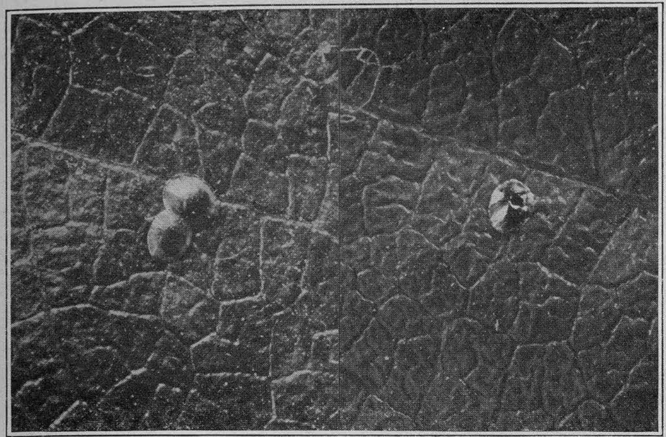


a. *Macrocentrus ancylivora* Rohwer, female, left; male, right. Enlarged four times.

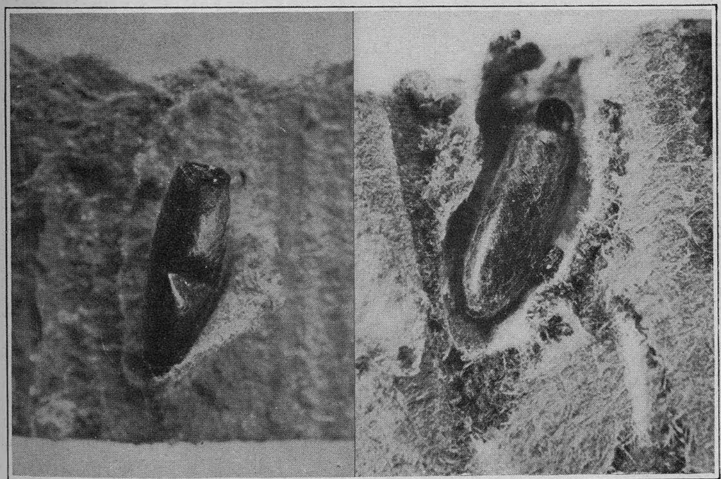


b. *Glypta rufiscutellaris* Cresson, female, left; male, right. Enlarged four times.



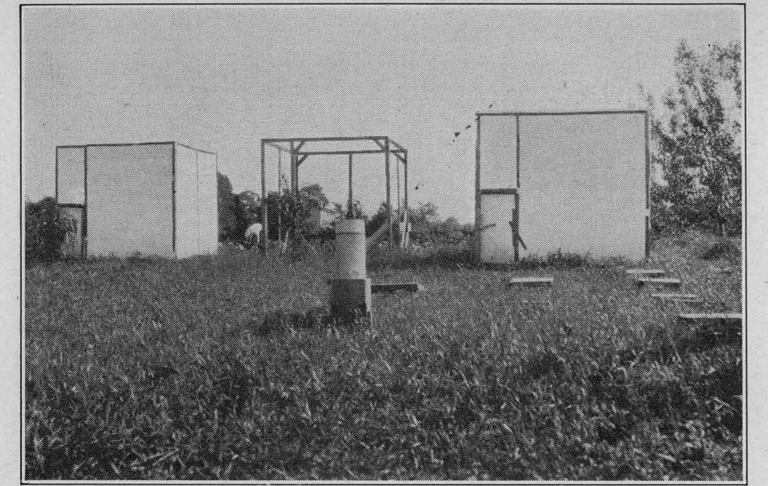


a. Eggs parasitized by Trichogramma, left; egg from which parasite has emerged, right.



b. Cocoons of *Macrocentrus ancylivora* Rohwer.

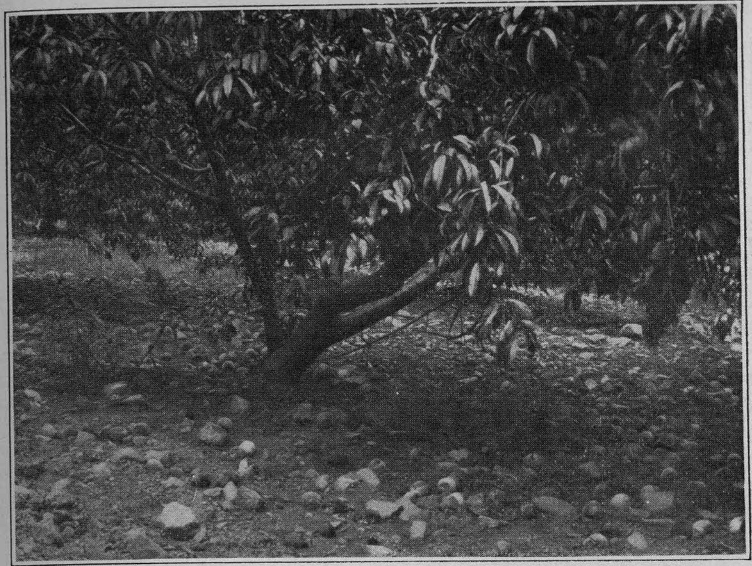
PLATE X



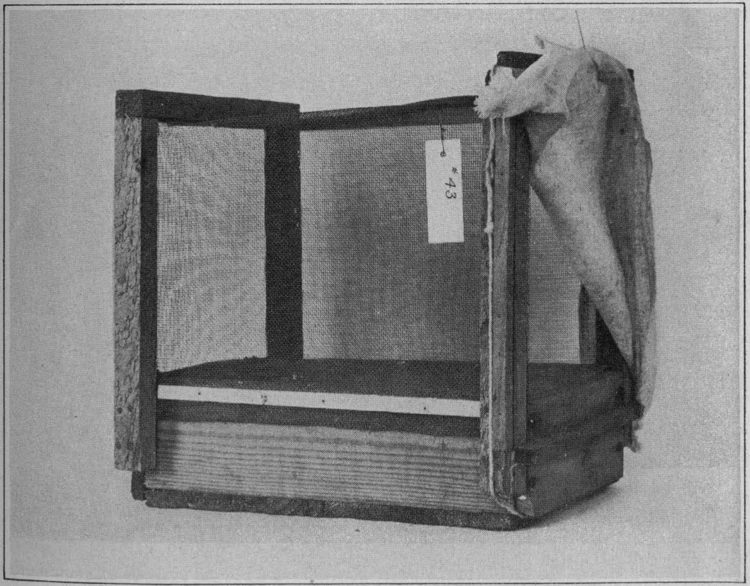
a. Tree cages at Mount Carmel farm used in studying the Oriental peach moth.

b. Trays used for emergence of *Macrocentrus ancylivora* in 1929.

PLATE XI



a. Drop fruits in a heavily infested orchard. Many more than this are sometimes seen.




b. Cage used for obtaining eggs of the Oriental peach moth. This cage is so constructed that no smooth surface is presented to the moths for oviposition. Peach shoots are placed within and moist sand in the bottom tray. Constructed by Mr. J. F. Townsend, slightly modified from a cage in use by the Federal Government at Moorestown, N. J.

a. Outfit used in spraying peach trees, Conyers farm, Greenwich.

b. Dusting outfit used at Conyers farm, Greenwich.

Bulletin 314 April, 1930

# WHITE PINE BLISTER RUST CONTROL IN CONNECTICUT

J. E. RILEY, JR.

*In Cooperation with Bureau of Plant Industry*
*United States Department of Agriculture*

**Connecticut**
**Agricultural Experiment Station**
**New Haven**

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THE TUTTLE, MOREHOUSE & TAYLOR COMPANY, NEW HAVEN, CONN.

## HOW TO PREVENT BLISTER RUST DAMAGE TO WHITE PINE

*White pine, Connecticut's most valuable forest tree, is seriously threatened by the white pine blister rust. The greatest single factor at the present time in the control of the blister rust is the elimination of the European black currant. The growing, sale or possession of this plant is prohibited by law in the State of Connecticut. Help control the blister rust by destroying all European black currants wherever found.*

1. Uproot all currant and gooseberry plants throughout the white pine and for a surrounding distance of 900 feet.

2. Pull the bushes. Do not cut them off at the ground. Grub out the root crown and main roots in order to prevent sprouting and hang the bushes so as to prevent the roots coming in contact with the ground.

3. Make sure that there are no European black currants within one mile of the pine stand. Notify the Connecticut Agricultural Experiment Station in case the owners do not destroy them.

4. For free advice and inspection write to the Station Forester, Connecticut Agricultural Experiment Station, Box 1106, New Haven, Conn.

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The bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.

# WHITE PINE BLISTER RUST CONTROL IN CONNECTICUT

J. E. Riley, Jr.

## INTRODUCTION

Many pine owners are misinformed as to the nature of the white pine blister rust. This bulletin seeks to explain the life history of the disease, to discuss the need for its control and to show the status of control work in the state. It offers some suggestions that the pine owner may adapt to his problem of protection.

### Importance of White Pine

Connecticut has no more valuable tree than the white pine and its protection and perpetuation is of prime importance to a sound forest program. Throughout most of the state it is one of the trees most suitable for reforestation and everywhere it is a tree to be encouraged in natural stands. It should not be used in pure plantings unless the owner is prepared to protect it from the weevil and it should not be planted at all unless it is protected from the blister rust through the elimination of currant and gooseberry plants, as described elsewhere in this bulletin. There has been a good deal of misconception concerning the practicability of growing white pine because of these two enemies but, given proper protection, it can be safely raised and will yield net returns as high, if not higher, than any other timber species in Connecticut. Frothingham in his bulletin "White Pine Under Forest Management," Bulletin 13 of the United States Department of Agriculture, says, "Of all the trees of eastern North America, white pine best combines the qualities of utility, rapid growth, heavy yield and ease of management." No other tree offers such a combination of advantages.

The wood of the white pine is light in weight, soft, and evenly textured. It takes a pleasing finish and has very little tendency to warp. Its durability is demonstrated in the many century-old

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Author's Acknowledgments. The author wishes to express his appreciation for the constructive criticism of the manuscript by Roy G. Pierce of the office of Blister Rust Control, United States Bureau of Plant Industry, and of others in the Department of Agriculture. The photographs used in the text of the publication were made by the federal office of Blister Rust Control, except those from the New York Conservation Department and the New York Agricultural Experiment Station, Geneva, which were obtained through the federal office.

houses now standing throughout New England sheathed with the original white pine lumber.

The two most serious enemies of the white pine in this region are the white pine weevil, *Pissodes strobi,* described in the appendix, and the white pine blister rust, *Cronartium ribicola* Fisch. The white pine blister rust is a plant parasite that threatens not only serious damage to the present crop, but like the chestnut blight on the chestnut, it may, if not controlled, destroy the commercial value of the species. Fortunately, this disease, although it cannot be entirely eradicated, can be and is being controlled in Connecticut, as it is in the other white pine growing states. Before discussing the work of blister rust control, let us first consider the history of the blister rust, its nature and how it acts.

## HISTORY

The blister rust is not of recent origin, although it is comparatively new to this country. In 1854, Dietrich, a German botanist, reported it in northwestern Russia on pine and Ribes as two distinct fungi. The relationship of the previously supposed separate fungi was shown by Klebahn of Germany in 1888. It has been known in Europe, England, Scotland, Siberia and Japan for many years. Spaulding, in Bulletin 206, United States Department of Agriculture, states that losses as high as 100 percent have been reported in Europe. Moir (Bulletin 6, American Plant Pest Committee) reports that in Norway, Sweden, Denmark and Belgium the use of white pine in the regeneration of forests has been practically discontinued because of the rust. There the American white pine is an exotic tree and the native five-needled species are of comparatively little importance, whereas currants and gooseberries, especially the European black currant, constitute a highly valued food crop.

The rust is now known to have existed in this country at Kittery Point, Maine, since 1898, having in all probability been imported on English black currants planted there about that time. It was found at Geneva, N. Y., on Ribes in 1906. Reliable evidence points to the fact that it had been discovered on nursery white pine at Philadelphia in 1905.[1] It is supposed to have existed in Pomfret, Conn., on imported white pine since 1902. Several of the eastern states had been for a few years previous to 1909 importing white pine stock from Europe and not until after the trees had been planted out was it discovered that they were diseased. In Connecticut, C. A. Metzgar first found it in the

[1] Phytopathology, 7: No. 3, 224-225, June, 1917, R. G. Pierce. Also published in Bull. 239 of Pennsylvania State College, School of Agriculture and Experiment Station, entitled "The Rusts of Pennsylvania," by Kern and other authors, May, 1929.



spring of 1909 on some imported white pine stock that he was planting in Wilton. He sent specimens to the Connecticut Agricultural Experiment Station, where the infection was identified as the white pine blister rust.

When the disease was first discovered in Connecticut it was hoped that by prompt destruction of all diseased pine the rust could be eradicated. However, by 1915 it was found that the disease was present on wild Ribes and in 1916 a state wide inspection in coöperation with the United States Department of Agriculture convinced the authorities that the rust was permanently established and that protection to pine through the elimination of Ribes was the only practical control. Since that time the natural pine areas of the state have been examined for the presence of wild currant and gooseberry plants and many thousands have been uprooted and destroyed.

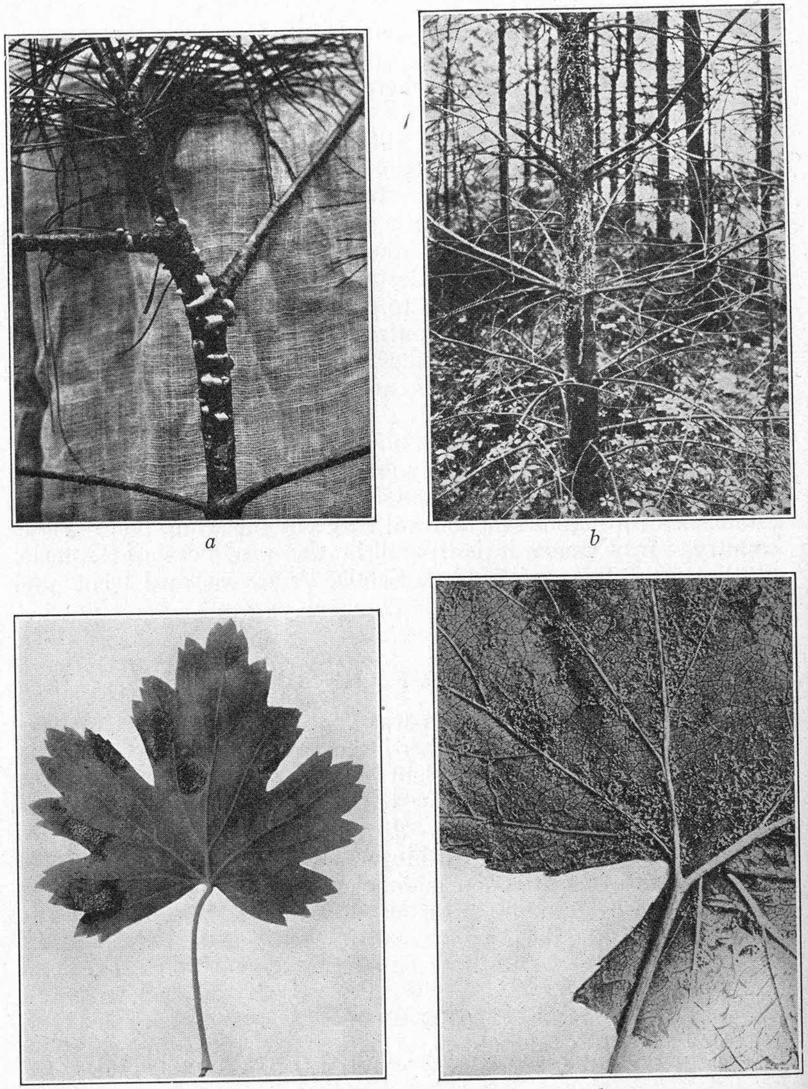
The white pine blister rust is now found in New England, New York, Pennsylvania, New Jersey, Michigan, Minnesota, Wisconsin, Washington, Oregon, Idaho and Montana and will eventually be established throughout the natural range of the white pines in this country. In Canada it is found in the provinces of Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and British Columbia.

## NATURE OF THE RUST

Blister rust is caused by a parasitic fungus known as *Cronartium ribicola* Fisch. It is neither insect nor worm, as is sometimes supposed, but a low form of plant life that lives alternately on the white or five-needle pines and on the leaves of all species of currant and gooseberry plants. In the white pine it grows in the bark and kills the tree by girdling. Death occurs from three to twenty years after infection takes place, depending upon the size of the infected tree and number and location of the cankers. The fungus reproduces itself by means of seed bodies called spores.

## LIFE CYCLE

The spores enter the tree through the breathing pores of the needles. The spores germinate, sending a thread-like growth, invisible to the naked eye, into the tissue of the needles. From there the fungus grows downward into the twigs, branches and trunk, eventually girdling the tree. Its presence can usually be detected after it has been in the tree two years or more, by swellings of the bark called cankers. These are characterized by an orange-yellow or a yellow-green discoloration at their advancing edge and, in one stage, by small blood-clot colored areas known as pycnial spots, which contain a sweet-tasting liquid, the function



a b c d

FIGURE 35. *a,* Fruiting stage of blister rust on young white pine; *b.* Fruiting canker on trunk of older tree (note that the bark in the center of the fruiting canker has been eaten by rodents); *c,* First summer stage of blister rust on flowering currant; *d,* Second summer stage of blister rust on European black currant leaf (the stage that produces spores, which infest pine).

NOTE—Plates *a* and *d* are presented by courtesy of N. Y. Cons. Dept.; *c* by courtesy of N. Y. Exp. Sta., Geneva.



of which is unknown. When the disease has been in the tree three years or more the bark on the cankered area cracks open, exposing orange-yellow blisters. These blisters are another positive identification of the rust. They appear in the early spring and are in evidence for several weeks. When they break, the orange-yellow powder within, composed of millions of spore bodies, is spread by the winds.

If these spores come in contact with the under side of currant or gooseberry leaves and the moisture conditions are right, many spores germinate and grow into the leaf, thus causing the first summer stage of the rust on these plants. In two or three weeks rust-colored spots appear on the under side of the infected leaf. These spots contain the summer spores, which spread the rust locally on currants and gooseberries. From late June until the leaves drop in the fall, brownish, hair-like growths replace the rust-colored spots in increasing numbers. These outgrowths produce the fall spores, which infect pine and thus complete the life cycle.

## CONTROL MEASURES

There are several interesting facts in connection with this life cycle, a knowledge of which makes possible practical control measures. They are—

1. The spring spores from pines cannot infect other pines. They infect the leaves of currants and gooseberries only. This infection may occur over long distances.

2. The summer spores from currants and gooseberries likewise cannot infect pines. They simply intensify the disease locally on currants and gooseberries.

3. The fall spores from currants and gooseberries spread the disease to white pines. The infecting range of these spores is short, ordinarily not more than 900 feet.

4. The cultivated English black currant will take infection from white pine over a distance of one hundred miles or more, and will transmit it to pines a mile away. The English black currants, therefore, act as infection centers and constitute an especially grave menace to white pines.

All true currants and gooseberries, both wild and cultivated, belong to the genus Ribes and hereafter in this bulletin the generic name Ribes will be used in place of currants and gooseberries. Control measures may be briefly stated as—

1. The elimination of Ribes throughout pine areas and for a surrounding distance of 900 feet.

2. The destruction of all English black currant plants, *Ribes nigrum,* within a mile of the pine stands.

Such control work can be effectively carried on by pine owners, but experience has shown that more effective and thorough initial work is obtained by a state-supervised crew under trained leader-

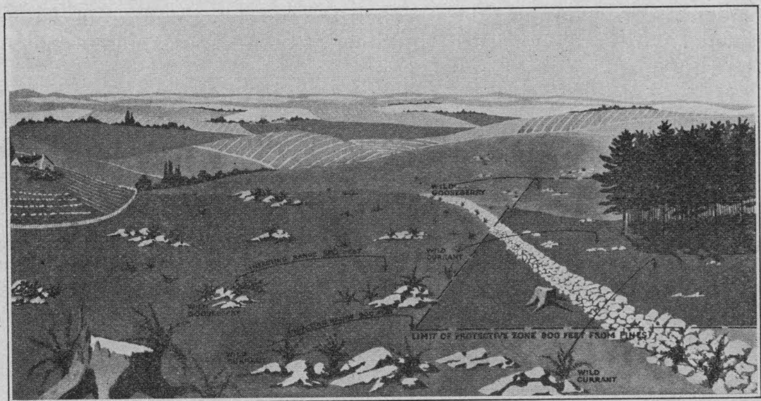



FIGURE 36. This stand of pine is afforded practical protection from the blister rust because there are no currants or gooseberries within 900 feet of the stand and no European black currants within one mile.

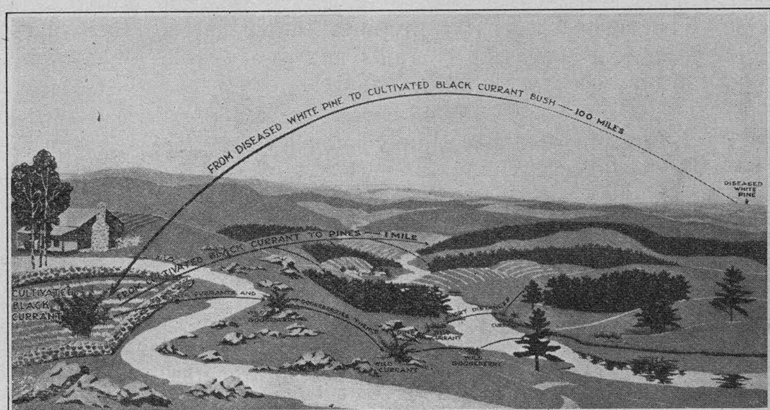



FIGURE 37. The European black currant will take infection over a distance of 100 miles from diseased white pine. This bush may be responsible for transmitting the disease to pines a mile away.

ship. Crew men employed on job after job, and often year after year, learn to know the various currants and gooseberries in their association with other vegetation and consequently become expert in locating them. Also from a knowledge of Ribes growth and



location gained through experience, trained scouts are able to protect many pine areas where Ribes are few with a minimum of effort and expense.

On the other hand there are certain advantages to the pine owner if he himself eradicates the wild Ribes on his land. He learns to identify the various species of Ribes and their habits and is therefore in a better position to keep his pine areas free from these plants, than if others did the work for him. His personal participation in the work results in a keener appreciation of the situation and a more intelligent interest in pine protection. For the information of those who wish personally to carry on the control work and are interested in identifying the species found, a description of the currants and gooseberries commonly found in Connecticut will be included in the appendix.

## HOW TO RECOGNIZE THE BLISTER RUST

There are several signs by which the blister rust may be positively identified in the field and others by which the presence of the rust in a tree may be indicated from a distance. One or more of these indications or signs will always be in evidence after the disease has been in the tree two years or more.

*"Flags."* This term is applied to the discolored foliage of a branch or portion of a tree infected with the rust. When the fungus has been in the tree long enough to cause partial or total girdling of the infected part, the needles often take on a sickly yellow color peculiar to rust-infected trees. These "flags" may, however, vary from slightly "off-color" needles to the red-brown color of dead leaves. Such flags are not positive identification of the rust, but serve to call attention to a tree that is abnormal. Closer inspection reveals other signs.

*Cankers.* When the rust has been in the tree two years or more a swelling occurs on the bark of the infected twig or limb. This swelling is called a canker. The canker bears certain signs that positively identify the white pine blister rust. Around the advancing edges may usually be seen an area of yellow-green to orange-yellow discoloration. This discoloration becomes more apparent when the canker is wet and it positively identifies the rust.

*Pycnial spots.* The year previous to the appearance of the blisters, or fruiting bodies, small blood-clot colored areas form on the bark of the canker. The color varies from a reddish brown to almost black. Within these spots is a sweet tasting liquid, which oozes out in clear drops. These pycnial spots are another positive identification of the rust. Very often when the pycnial spot disappears, it leaves a characteristic scar.

*Blisters.* Three years or more after infection takes place and a year after the pycnial spots appear, the bark at the canker cracks open and exposes bean-shaped blisters that are yellow in appearance, but in reality are composed of a white or colorless membrane within which is an orange-yellow powder composed of millions of seed bodies, or spores. These blisters appear in the early summer and last only a few weeks, when they break, liberating the spores, which are disseminated by the wind and leave the membrane clinging to the blister pits. These blisters are unmistakable evidence of the rust.

*Old cankers.* Old cankers are characterized by cracked bark, more or less evidence of blister pits, often constricted areas below the canker and swollen areas above the canker. If the branch or trunk containing the canker is not dead, the typical yellow-green or orange-yellow discoloration at the advancing edge of the canker may be in evidence. An exudation of pitch is often found on or below the older cankers. On dead cankers the discoloration, pycnial spots or blister pits may not show because of the deteriorated condition of the bark.

*Rodent work.* Field mice, squirrels and other rodents apparently like the blister rust infected bark. Often this bark is eaten to the bare wood. Such rodent work rarely occurs on white pine bark uninfected by the rust.

Sometimes these signs are partially obliterated by the presence of secondary fungi that gain entrance in the tree already weakened by the rust, but one or more of the above described signs will practically always be in evidence. Doubtful specimens may be sent to the Connecticut Agricultural Experiment Station for identification.

*Blister rust on Ribes.* Fruiting bodies on infected Ribes appear in early June on the under side of the leaf. They are rust-colored spots, a few in number at first, but as the season progresses they become more numerous, until sometimes they nearly cover the under surface of the leaf. The only other disease that they are likely to be confused with is the cluster cup fungus, but the difference is easily seen under an ordinary magnifying glass. The yellow cluster cup fungus spot, appearing on the upper as well as the lower surface of the leaf, is circular in shape and is composed of a group of perfectly circular cup-shaped depressions imbedded in the tissue of the leaf, usually toothed at the edge. The white pine blister rust is a rust-colored spot, irregular in shape, that appears only on the under surface, although there may be a dead area on the upper surface above the fruiting bodies.

Another kind of fruiting body of the blister rust appears on the under side of the leaf in late June and continues to increase in numbers until the leaves drop in the fall. These are brown hair-like growths about one-quarter inch in length, which take on a grey color in wet weather. They are the fruiting bodies that have been previously mentioned as producing the spores that carry the disease to the white pines.



Several tree diseases and insect pests are commonly mistaken for the white pine blister rust, but confusion may be easily avoided by a moment's close observation. In the appendix of this bulletin the few tree pests most often mistaken for the rust are briefly described and the means of distinguishing them from the blister rust are pointed out.

## BLISTER RUST CONTROL IN CONNECTICUT

### Authority

Authority for the control of the white pine blister rust is found in Sections 2106 and 2117 of the General Statutes of 1918. These have been briefly summarized by Filley and Hicock in Bulletin 237, as follows—

1. A general plant pest law authorizing the Director of the Connecticut Agricultural Experiment Station to control insects or diseases which are, or may become, serious pests to economic plants. He is given the power to destroy infected plants, prohibit or regulate the transportation of the same and to establish quarantine in such areas and against such pests as he may deem necessary. (G. S. 1918, Sec. 2106.)

2. A blister rust law authorizing the Director of the Connecticut Agricultural Experiment Station to control the white pine blister rust. He is given the power to order white pines uprooted and to destroy all wild currant and gooseberry plants and those under cultivation if infected. (G. S. 1918, Sec. 2117.)

In the past it has not been necessary to take drastic measures to enforce these laws. The blister rust control work has been conducted on a basis of coöperation, and the Station has enjoyed a gratifying support in its program of control from individuals and towns and from associations of pine owners.

On July 1, 1929, a European black currant law became effective, whereby the possession of the English black currant is prohibited. Chapter 172 of the Public Acts of 1929 reads:

SECTION 1. Any person who shall grow, plant, propagate, cultivate, sell, transport or possess any plant, root or cutting of the European black currant, or *Ribes nigrum,* shall be fined not less than five dollars nor more than twenty-five dollars.

SEC. 2. The Director of the Connecticut Agricultural Experiment Station is authorized to seize and destroy any plants, roots or cuttings of said European black currant found in the state.

### Organization

The blister rust control work in Connecticut is conducted under a coöperative agreement between the United States Department of Agriculture and the Connecticut Agricultural Experiment Station.

The Station Forester, designated as Federal Collaborator, is the administrative head of the organization and he obtains his regulatory authority from the Director of the Station, who is charged by law with control of plant pests. Assisting the Station Forester is a State Leader, who exercises general supervision over the field work. One or more federal agents are employed on educational work, gathering data and organizing local coöperation. Several state scouts and crews, the latter working under the direction of experienced state foremen, carry on the eradication of Ribes under the immediate supervision of the agents.

Since 1922 the coöperative agreement between the United States Department of Agriculture and the Connecticut Agricultural Experiment Station specifies in effect that federal funds shall be used for education, experimentation, collection of data and supervision only, and not for actual eradication of currant and gooseberries. State funds are used for collection of data, direction of eradication crews, and some crew labor.

### Individual Coöperation

In the early years of the control work, when it was hoped that the disease could be eradicated, no attempt was made to enlist the coöperation of the pine owner. As it became apparent that blister rust was here to stay and that pine protection had become a matter of local control, the coöperation of individual pine owners, associations of pine owners and towns was sought on the grounds that blister rust control was as much an individual and local problem as a state responsibility. Part of the financial burden of control is being gradually shifted from the state to the individual, although it is recognized that the state must continue to keep in touch with the situation through systematic inspections of pine areas, and that it must guide and supervise the control work.

A re-eradication problem will always exist, although the amount of re-eradication should diminish from year to year as control work diminishes the number of Ribes, and as the closing in of the pine canopy so shades the ground as to prevent Ribes reproduction. There is still a need for a good deal of research, particularly along lines of control methods, Ribes regrowth and improved forest practice. This is a function that can be best performed by the federal and state agencies who have the personnel and facilities for carrying on such work and for making the results available to pine owners.

### Nursery Sanitation

Of utmost importance to the success of the control work is the insurance of disease-free stock for reforestation and ornamental plantings. The interstate movement of white pines and of currant



and gooseberry plants is prohibited by federal quarantine No. 63, except under strict compliance with its very stringent provisions. Distribution of Connecticut grown stock is legally possible within the state only under permit from the state nursery inspector.

Stock showing a serious disease, such as the blister rust, is destroyed. This inspection, however, does not in itself guarantee that the Connecticut grown white pine stock is free from the rust when shipped, because it is impossible in many cases to recognize the disease by field inspection until the rust has been in the tree two or more years. Therefore, the only assurance to the purchaser of such white pine stock that it is free from the rust is when it has been grown under Ribes-free conditions. Federal quarantine No. 63, applying only to interstate shipments, provides among other

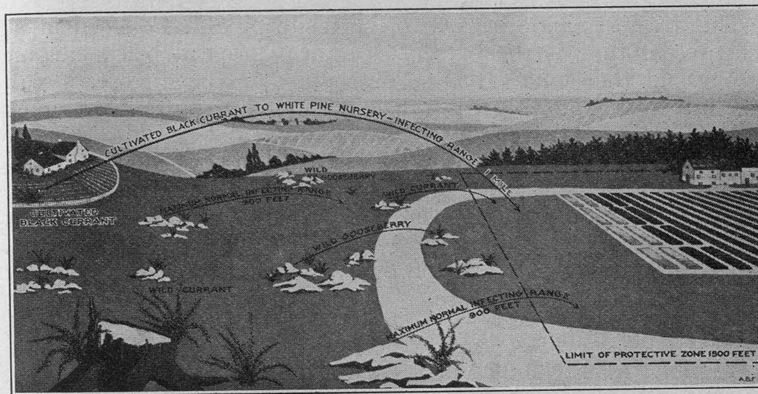



FIGURE 38. The white pine in this nursery is given complete protection because no currants or gooseberries are within 1500 feet and there are no European black currants within one mile.

regulations that all stock certified for interstate shipment shall be grown from seed in an approved control area. This control area, extending 1,500 feet around the white pine growing block, must be free from all wild and cultivated currant and gooseberry bushes and in addition there must be no European black currant plants within one mile of the pine block.

In order to give the same protection to the Connecticut grown white pine stock distributed within the state, such control areas should be established around all Connecticut white pine growing nurseries. This matter of nursery sanitation has brought a commendable response from the Connecticut nurseries growing white pine. There are now ten nurseries establishing such sanitation zones in coöperation with the Connecticut Agricultural Experiment Station, and as the advantages of such sanitation become recognized it is likely that the number of white pine growing nurseries maintaining control areas will increase. Those now coöperating are:

| | |
|---|---|
| Barnes Brothers Nursery Co. | Yalesville |
| Bristol Nurseries, Inc. | Bristol |
| Elm City Nursery Co. | Woodmont |
| North-Eastern Forestry Co. | Cheshire |
| Outpost Nurseries | Ridgefield |
| A. N. Pierson, Inc. | Cromwell |
| C. H. Sierman | West Hartford |
| Southport Nursery | Southport |
| Verkades Nurseries | Waterford |
| H. J. Zack Co. | Deep River |

### Black Currant Eradication

The greatest single hazard to the white pine in Connecticut at the present time is the presence of the European black currant throughout the state. It is so susceptible to the disease, it will take infection from so great a distance and will transmit it to pine so far, that control work in Connecticut will not be on a satisfactory basis until this species of Ribes has been entirely eliminated. As previously stated, the legislature has prohibited the growing, sale, transportation or possession of all roots, cuttings and plants of this species. States adjoining Connecticut have also banned it, either through legislative action or by proclamation from properly constituted authority.

## PRESENT STATUS OF CONTROL WORK

On the accompanying map the cross-hatched areas indicate those towns where the needed initial eradication of Ribes is completed. The remaining towns within the natural white pine area of the state are scheduled for working in 1930. The natural white pine area of Connecticut lies north of the heavy black line; the area of abundant wild Ribes lies north of the dotted line. These latter two are more or less arbitrary divisions based upon a pine survey of 1919-1921 and reported in Bulletin 237.

During the past eleven years, 1919-1929 inclusive, approximately 219,000 acres of pine land have been freed from wild Ribes and 22,700 acres of this has been re-eradicated. More than 1,700,000 wild currant and gooseberry bushes have been destroyed and approximately 17,300 cultivated currants and gooseberries have been removed. Undoubtedly much work has been done by individuals on their own land, of which no record has been made. The cost of this work varies greatly with varying local conditions, type of labor employed and favorable or unfavorable seasons. The chief factors in the eradication costs, however, are the kind, size and number of Ribes encountered, denseness of undergrowth and,



occasionally, topographic difficulties. In the early years of eradication, when the work was almost entirely in areas of heavy Ribes concentrations, a season's work averaged 75 cents to 93 cents per acre; later when the eradication work was done on areas of lighter Ribes concentrations, the average cost for the season was from 11 cents to 56 cents per acre. The increased efficiency gained through experience is also a contributing factor to the lower costs in the later years. The average per acre cost over the eleven years period is 31 cents and the average number of Ribes per acre destroyed is 7.77.

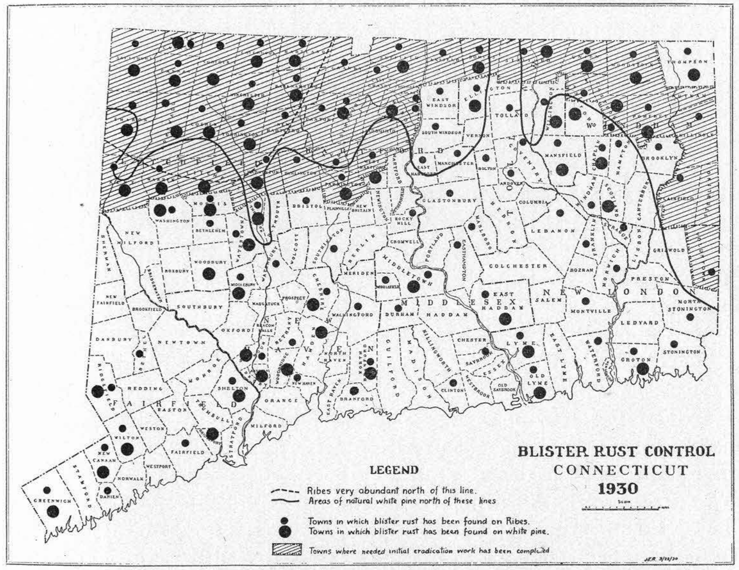



FIGURE 39. Map of Connecticut showing present status of blister rust control work.

It must be borne in mind that the costs per acre mentioned represent averages for all eradication work done during the years specified. They include areas thoroughly and systematically covered in crew eradication and areas eradicated by scouts alone. This latter type of eradication, which will not be described here, can be done often at a fraction of the cost of crew work. Pine owners eradicating Ribes on their own land, however, should use the crew method only, and the cost of such work, at prevailing day labor wages, will probably be a dollar or more per acre covered. The reason why pine owners are urged not to use the scouting method is that experience has shown that only trained and experienced men can secure satisfactory eradication of Ribes under most conditions by the scouting method.

## EFFECTIVENESS OF RIBES ERADICATION

In order to determine the effectiveness of Ribes eradication in preventing or reducing blister rust infection, a number of studies have been made throughout New England and New York where eradication work is being carried on. They invariably show that where good eradication work was done, the amount of subsequent infection has been reduced to a point that does not jeopardize the productiveness of the stand. It is not necessary to obtain 100 percent eradication of Ribes in order to secure effective control of the disease. In fact, in many areas 100 percent eradication of Ribes can be secured only at a prohibitive cost. There are often large numbers of seedling Ribes hidden by other vegetation in proximity to older Ribes, or in locations favorable to the accumulation and germination of seed that are of such small size and so shaded by associated vegetation that they do not expose enough leaf surface to be a serious factor in the spread of the disease. Studies have shown that a large majority of such seedlings are killed off when they are small. This statement, however, should not be taken as justifying careless eradication. It is only by systematic and careful work that the currant and gooseberry leaf surface can be reduced to a point assuring practical control of the disease.

## BLISTER RUST DAMAGE

No attempt has been made to determine the total damage that blister rust has already caused to white pine in Connecticut and other white pine growing states. It would be a difficult and expensive survey and its value would not justify the expense involved. The determination of the total financial losses already resulting from the rust would not help materially in future control. There is plenty of evidence, however, that shows what blister rust will do when it is once established and lives unchecked over a number of years in pine stands where Ribes are near.

Blister rust is an insidious disease and its real significance is not apparent to the casual observer. On many acres in Litchfield County white pine reproduction is being killed as fast as it appears. In numerous small areas of Connecticut infection on older trees runs 25 percent to 60 percent of the stand and many trees are already dead. Young trees are particularly susceptible to blister rust infection; they are quickly killed and within a few years all evidence that they were once on the ground is gone. This constitutes the most serious aspect of the blister rust menace and it is the one least likely to be observed.

Initial eradication and some re-eradication of Ribes has been accomplished throughout a large part of the white pine areas in the northeastern states. How much damage would have resulted



had not this work been done is unknown, but there is every reason to believe that it would have been large. Studies made throughout the northeastern states in a great many areas where the rust has

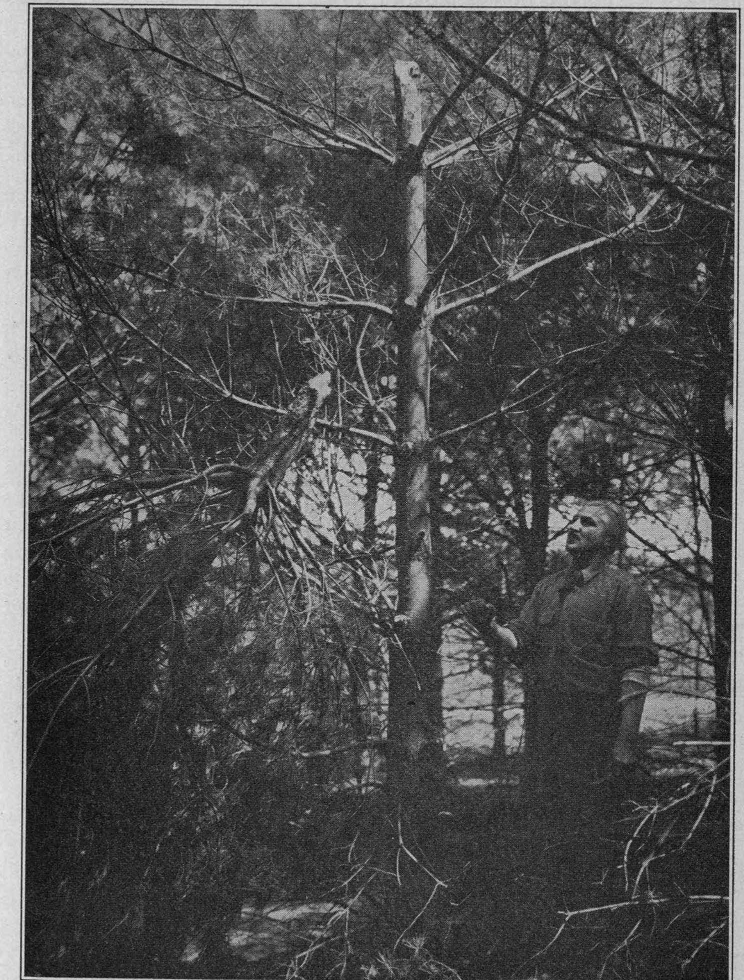


FIGURE 40. Top of tree broken off where blister rust girdled the trunk.

gone unchecked for a number of years show a high percent of infection. On numerous plots studied the infection occurring over periods of 5 to 15 years runs from 50 percent to 95 percent of the total number of trees on the plots.

Although blister rust is responsible for the death of a large percentage of the trees on many small areas in Connecticut it has to date caused comparatively small loss throughout the pine sections as a whole. This relatively light loss to pine in sections where Ribes are numerous is due to the application of control measures generally throughout the pine areas.

## FUTURE CONTROL POLICY

The Connecticut Agricultural Experiment Station will continue to take advantage of the coöperation of the United States Department of Agriculture while such coöperation is available. The Station will maintain a small state organization to complete needed initial eradication of Ribes in pine areas, to organize and supervise the re-eradication work, to eliminate the European black currant throughout the state and to further nursery sanitation. It will keep abreast of the developments in control work and make such knowledge available to the pine owners. It will continue to be the policy of the Station to make inspections when requested and to give advice and assistance as far as limited personnel and funds permit.

It is impossible to make satisfactory progress on these projects without the moral and financial coöperation of the pine and Ribes owners, nurseries and others directly affected by the blister rust situation. It will be the task of the Station to acquaint the public with the high value of white pine and of the danger from the blister rust, and to stimulate control work through personal contact and publications.

The Station will scout pine areas from time to time in order to ascertain Ribes and pine infection conditions and, as far as funds permit, it will inform pine owners when re-eradication of Ribes is needed and organize and supervise control work when conditions warrant.



## APPENDIX

### Insects and Diseases Commonly Mistaken for Blister Rust on White Pine

Under this heading it is proposed to discuss the insects and diseases most often mistaken for the blister rust, but only to the extent of identifying them and differentiating them from the rust. Additional information on the nature, economic importance and control of the insects may be obtained from the Entomology Department of the Connecticut Agricultural Experiment Station, and information regarding the tree diseases may be had by consulting the Botany Department. Material from the Station publications is freely used here.

*White Pine Tip Weevil.* This is one of the two serious pests of white pine in Connecticut. The white pine weevil is a small brown snout-beetle that feeds upon the bark of the leading shoot of the white pine for a few days in early May. The female then punctures the bark and deposits its eggs, which develop minute white grubs that feed upon the inner bark for a short while and then usually burrow downward into the pith. These grubs become fully grown in less than two months and then excavate cells within which they pupate for ten days or so. They emerge as adult beetles during July and part of September.

The first indications that the weevil is present in the leader are small, clear drops of pitch, which ooze out of the punctures in the bark made by the adult beetle in depositing her eggs. The pitch dries on the stem in whitish spots and sometimes runs down the stem. Along in July the tip of the affected leader curls over and gradually turns brown. Further evidence of the weevil may be seen by splitting the affected stem, which reveals the grub tunnels, the white grubs, the pupal cells, or the beetles ready to emerge, depending upon the time of year the inspection is made. The curling of the leading shoot or affected top side shoot, the pitch drops on the stem, the circular holes from which the beetle emerges or such evidence within the twig as has been described, all identify the weevil or its work. A moment's observation with these points in mind will differentiate it from the blister rust.

*The Pine Bark Aphids.* The pine bark aphids are small sucking insects that cover themselves with a white cottony substance and are often found at the base of the needles, on the twigs and in patches covering large areas on the trunks of the trees. They have a complicated life history that need not be discussed here. They bear no resemblance to blister rust damage, unless it is to the pitch streaks that often occur on the older blister rust cankers; yet they are sometimes reported as blister rust by those who simply observe something unusual on the tree.

*Ant Damage.* A less common injury to white pine but one easily mistaken for the blister rust is the work of the mound building ants. Occasionally some or all the young pines for a radius of 15 or 20 feet surrounding the ant mound are dead or dying from ant injury. Such damage rarely occurs except in open stands where plenty of sunlight reaches the floor, because the mounds are not built in shaded areas. In order to prevent the shading of the mounds, the ants inject a substance into the bark that kills the bark cells and thus girdles the tree. The result is often a constricted area at the affected part with a swollen area above, which in this respect resembles the blister rust cankered areas. In case of ant damage, however, there are no orange-yellow or yellow-green discoloration at the outer edge of the affected bark, no pycnial spots and no blisters or blister pits. Moreover, the ant mound will be found close to the injured trees.

*Needle Blight.* The so-called needle blight is usually a physiological condition of the tree due to one of several causes, such as (1) late frosts, (2) sun scald, (3) winter injury of the sap conducting tissue, (4) a drying of the needles due to a sudden thaw in late winter or early spring that starts excessive transpiration from the needles when the roots cannot replenish the lost moisture because of the frozen condition of the ground, or (5) unusually dry summers. Such injury is sometimes restricted to one side of the tree. It is often identified only by eliminating other possibilities and correlating the injury with known climatic conditions. It can be easily distinguished from blister rust damage by the absence of cankers with their identifying signs previously described. The only resemblance to blister rust damage is in the partially dead needles.

*Nectria-Like Fungus.* A branch disease of white pine very likely to be mistaken for blister rust cankers is caused by a Nectria-like fungus that produces a roughening of the branch, and is sometimes accompanied by a slight swelling. It may be readily distinguished from the blister rust because it lacks the peculiar discoloration at the advancing edge of the canker; there are no pycnial spots, blisters or blister pits. Instead, there are small reddish fruiting bodies, about the size of a pin head, on the cracked bark.

## Common Currants and Gooseberries in Connecticut

The wild currants and gooseberries are difficult to distinguish specifically, although they may be readily identified as belonging to the group of plants botanically known as Ribes. Since all native wild Ribes are susceptible to the blister rust and will transmit it to pine they may all be grouped in the same rough category as to the desirability of eradication. The cultivated Ribes, with



the exception of the European black currant, *Ribes nigrum,* may also be thus classified. The latter, however, because of its high susceptibility and because it transmits the rust to pine for long

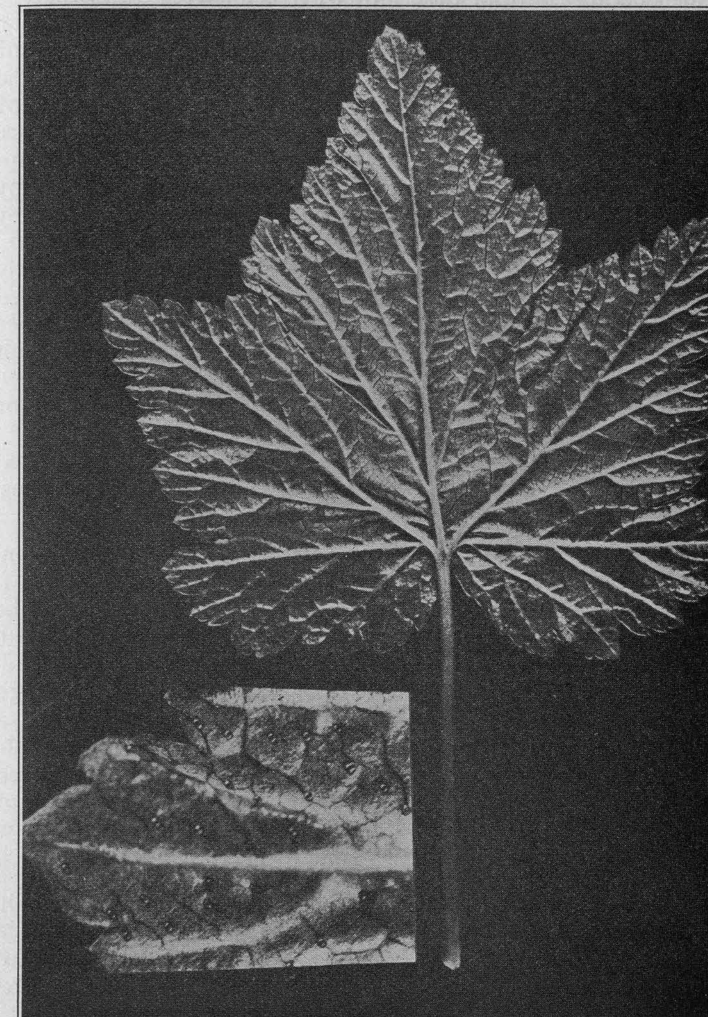


FIGURE 41. European black currant, *Ribes nigrum.* Insert shows the resin dots on the under side of the leaf.

distances, should be distinguished from the others. It calls for special consideration in the work of controlling the white pine blister rust.

In describing the Ribes of Connecticut the use of botanical terms has been avoided and an attempt has been made to simplify the description as much as possible. The flowers have not been described because a brief description of them necessitates the use of technical terms probably unfamiliar to the majority of people. There is considerable variance among botanists as to the use of both common and scientific names for some of the Ribes. The names given in the Connecticut Botanical Society Catalogue of Flowering Plants and Ferns are used here. The local ranges are taken from the Station blister rust control records and the descriptions are based on the Standard Cyclopedia of Horticulture, by L. H. Bailey, and on Gray's New Manual of Botany as revised by Robinson and Fernald.

A rough identification of the Ribes of Connecticut may easily be made in the field by types of Ribes. They may be grouped into four types. The first three comprise the currants, which are characterized by smooth stems, without spines or bristles, except *lacustre;* leaves heart-shaped and large except *lacustre, aureum,* and *odoratum;* branches round, except *americanum;* racemes or flower clusters many flowered.

**Group I. Black Currants.** Characterized by black fruit, and golden yellow or amber resin dots on the underside of the leaves. To this group belong the

A. *Cultivated European Black Currant, Ribes nigrum* Linn. This currant has resin dots only on the under side of the leaf. The stems are round. It seldom escapes from cultivation. The leaves and stems have a strong disagreeable odor when crushed.

B. *Wild American Black Currant, Ribes americanum,* Mill. This currant has resin dots on both sides of the leaf, although those on the upper side are sometimes hard to see without a magnifying glass. The stems, particularly on the newer growth, are angular. The odor of the leaves and stem when crushed is heavy and disagreeable, but not nearly so noticeable as that of the European black currant. It is usually found growing wild, but it is sometimes cultivated. Found throughout the state.

**Group II. Flowering Currants,** spice bush or clove bush. Characterized by small leaves, thick and leathery, resembling in outline a gooseberry leaf more than the usual currant leaf. Flowers yellow with a pleasing odor. Found under cultivation throughout Connecticut.

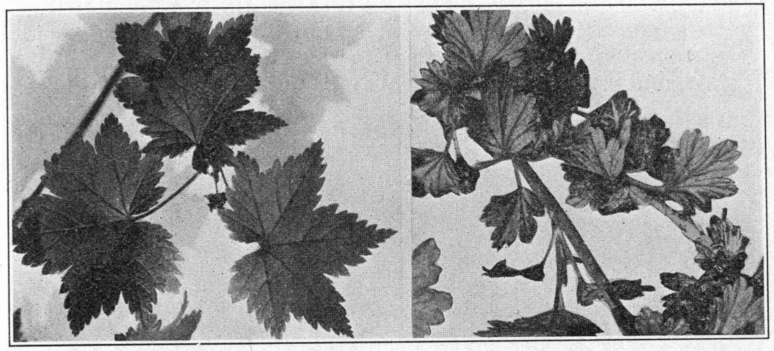
A. *Flowering Currant, Ribes aureum,* Pursh. Leaves are wedge-shaped at base and smaller than those of odoratum, either hairy or smooth. Fruit black, red or yellow.

B. *Flowering Currant,* Spice Bush, Clove Bush, *Ribes odoratum,* Wendl. Leaves square-shaped at base, smooth. Fruit black.



**Group III. Red Currants.** Characterized by red or white fruit. To this group belong

A. *Cultivated Red and White Currants, Ribes vulgare,* Lam. Bushes erect, occasionally five feet in height. Fruit red, white or striped, juicy. Found growing wild as well as under cultivation. Common in northern Connecticut, growing wild in fence rows along roadsides, in moist woods and on the borders of swamps. Less often found growing wild in southern Connecticut.



*a* *b*

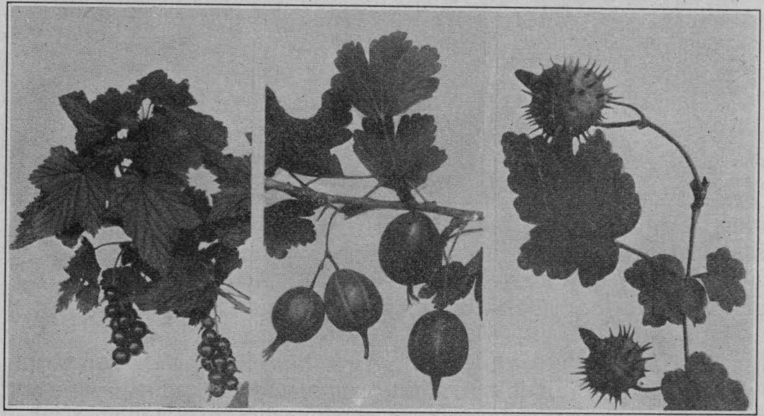
Figure 42. *a,* Skunk currant, *Ribes prostratum; b,* Smooth gooseberry, *Ribes oxyacanthoides.*

B. *Skunk Currant, Ribes prostratum,* L'Her. Found only growing wild. It is a reclining plant, with spreading stems and upright branches. It emits a strong, disagreeable odor when crushed. Has a very limited range in Connecticut. Reported only in Colebrook, Norfolk, northern Salisbury, and on Canaan Mountain. Very prevalent in Colebrook, Norfolk and on Canaan Mountain, less so in northern Salisbury.

**Group IV. Gooseberries.** Gooseberries are characterized by nodal spines and often bristly stems and fruit. They usually grow erect. The racemes or flower clusters have few flowers. The fruit of the wild species range in color from red to a dark purple.

A. *Prickly Gooseberry, Ribes cynosbati,* Linn. Sometimes reaches a height of six to seven feet. Branches spreading. Spines one to three at base of leaf stalks and one-quarter to two-fifths inches long. Stem bristles are few and weak or none. Leaves are usually heart-shaped at the base, often downy underneath. Fruit is red, prickly, edible. Very prevalent throughout northwestern Connecticut in dry woods, pastures, thickets and in moist places. It is less prevalent in northeastern Connecticut and rare in central and southern Connecticut.

B. *Smooth Gooseberry, Ribes oxyacanthoides,* Linn. Called by some authors *Ribes hirtellum.* Rarely reaching a height of four feet. Branches slender, usually unarmed, sometimes with small spines; occasionally the base of vigorous shoots are bristly. Leaves are usually wedge-shaped at the base, smooth or occasionally slightly downy. Leaf stem often with long hairs. Fruit smooth, purple, edible. Prevalent throughout northeastern Connecticut, principally in swamps but also found on dry locations. It is less prevalent in the northwestern part of the state, and rather rare in central and southern Connecticut.



*a* *b* *c*

FIGURES 43. *a,* American black currant, *Ribes americanum; b,* Cultivated gooseberry, *Ribes grossularia; c,* Prickly gooseberry, *Ribes cynosbati.*

C. *Cultivated Gooseberry, Ribes grossularia,* Linn. There are several varieties of the cultivated gooseberry. Varies in growing habit from upright bushes, reaching three feet in height, to low reclining bushes. It sometimes escapes from cultivation.

Two wild Ribes very rarely found in Connecticut do not fit into any of these four groups. They are the swamp black currant, *Ribes lacustre,* Poir. and the swamp red currant, *Ribes triste,* Pall. The swamp black currant has slender weak stems covered with dense bristles. The leaves resemble the prickly gooseberry, but are more slender and more deeply lobed; the fruit is purple to black, and bristly. The swamp red currant is a low shrub with creeping, often rooting stems; the stems and branches are smooth; leaves are large, broader than long and resemble a red maple leaf; they are densely hairy underneath; fruit small, smooth and a smoky-purple color.



## Where to Plant White Pine

The contents of this pamphlet may tend to create the impression that white pine is not a desirable tree to plant nor to favor in forest management. Such is not the case. As stated in the introduction, there is no more valuable forest tree in Connecticut than the white pine and there is no tree more likely to pay good returns on money wisely invested in its care. On the other hand, if planted in areas where Ribes are numerous, white pine is a decided risk. To obtain best results it should be planted on areas where Ribes are naturally scarce and where Ribes eradication may be made at a reasonably low cost. Southern Connecticut has few wild Ribes and is favorable to the growing of white pine in this respect.

Avoid planting white pine around swamps in northern Connecticut, because of the prevalence and difficulty of eradicating Ribes. It is best to plant white pine in mixture with other species, preferably hardwoods, in order to lessen the weevil danger. Mixed planting with hardwoods, however, should not be undertaken without first obtaining the advice of a competent forester as to species of hardwoods to use, spacing and relative numbers and position of the species used. Such advice may be had free by writing to the Station Forester, Connecticut Agricultural Experiment Station, Box 1106, New Haven.

*Always eradicate currants and gooseberries as instructed before planting white pine.*

Bulletin 315 April, 1930

# TWENTY-NINTH REPORT
# CONNECTICUT STATE ENTOMOLOGIST
# 1929

W. E. BRITTON, Ph.D.
*State Entomologist*

**Connecticut**
**Agricultural Experiment Station**
**New Haven**

The bulletins of this station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.

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### Authorship

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### Illustrations

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## TWENTY-NINTH REPORT
## CONNECTICUT STATE ENTOMOLOGIST

### 1929

*To the Director and Board of Control of the Connecticut Agricultural Experiment Station:*

I have the honor to transmit herewith my twenty-ninth report as State Entomologist of Connecticut. A comprehensive account of the Oriental peach moth, prepared by Doctor Garman, has been published as Bulletin 313. The official inspection and control operations prescribed by Statute are given in some detail, as well as a review of the various quarantines and their enforcement. One important development of the year was the discovery in Connecticut of the Mexican bean beetle. Other brief papers indicate the research and observations of members of the department staff.

Respectfully submitted,

W. E. Britton,
*State and Station Entomologist.*

## FINANCIAL STATEMENT

**Report of Receipts and Expenditures of the State Entomologist**
**July 1, 1928, to June 30, 1929.**

RECEIPTS

| | | |
|---|---|---|
| Insect pest appropriation, biennial period ending June 30, 1929 | $60,000.00 | |
| Deficiency appropriation | 15,000.00 | |
| Miscellaneous receipts, refunds, etc. | 570.68 | |
| | $75,570.68 | |
| Expended to June 30, 1928 | 38,915.41 | |
| Balance available July 1, 1928 | | $36,655.27 |

EXPENDITURES

| | | |
|---|---|---|
| Salaries | $18,710.00 | |
| Labor | 7,936.43 | |
| Stationery and office supplies | 142.39 | |
| Scientific supplies (chemicals) | 22.94 | |
| Scientific supplies (other laboratory supplies) | 22.58 | |
| Scientific supplies (photographic supplies) | 95.11 | |
| Insecticides, etc. | 804.11 | |
| Lumber and Small Hardware | 3.40 | |
| Miscellaneous Supplies | 110.46 | |
| Automobile Oil | 144.53 | |
| Fertilizer | 10.00 | |
| Telegraph and Telephone | 188.02 | |
| Postage | 71.50 | |
| Travel expense (outlying investigations) | 2,759.29 | |
| Travel expense (meetings, conf., etc.) | 364.14 | |
| Travel expense (gasoline for automobiles) | 731.44 | |
| Freight, express and parcel post | 38.98 | |
| Publications (bulletins, annual reports) | 33.25 | |
| Electricity | 39.24 | |
| Furniture and fixtures (new) | 491.19 | |
| Furniture and fixtures (repairs) | 23.45 | |
| Library (books and periodicals) | 89.44 | |
| Scientific equipment (new) | 570.39 | |
| Scientific equipment (repairs) | 1.35 | |
| Automobiles (new) | 581.00 | |
| Automobiles (repairs) | 339.99 | |
| Tools, machinery and appliances (new) | 145.49 | |
| Tools, machinery and appliances (repairs) | 2.25 | |
| New buildings and structures | 709.69 | |
| Build'ngs (repairs and alterations) | 15.15 | |
| Rent of land and buildings | 58.75 | |
| Contingent insurance | 54.92 | |
| Miscellaneous contingent expenses | 131.84 | |
| Total disbursements | $35,442.71 | |
| Balance on hand June 30, 1929 | 1,212.56 | |
| | | $36,655.27 |



## DEPARTMENT STAFF AND WORK

W. E. BRITTON, PH.D., *State and Station Entomologist.*
B. H. WALDEN, B.AGR., *Photographic and General Work.* }
M. P. ZAPPE, B.S., *Inspection and General Work.* } *Assistant*
PHILIP GARMAN, PH.D., *Research Work.* } *Entomologists.*
ROGER B. FRIEND, PH.D., *Research Work.* }
J. F. TOWNSEND }
B. W. MCFARLAND }
JOHN C. SCHREAD, M.S. } *Technicians.*
W. THEODORE BRIGHAM, B.S. }
J. PETER JOHNSON, B.S., *Deputy in Charge of Asiatic and Japanese Beetle Quarantines.*
JOHN T. ASHWORTH, *Deputy in Charge of Gipsy Moth Work.*
JAMES A. MCEVOY, *Assistant in Gipsy Moth Work.*
ROBERT C. BOTSFORD, *Deputy in Charge of Mosquito Work.*
MRS. GLADYS BROOKE, B.A., *Secretary.*
H. W. COLEY, Westport }
A. W. YATES, Hartford } *Apiary Inspectors.*

Mr. Walden has continued as chief photographer for the department and has been in charge of the office during the absence of the Entomologist. He has had charge of certain exhibits, and devoted a part of his time to the identification of insects and work on the collection, together with inspection and general work of the department. He has also continued his researches on the imported currant worm, *Pteronidea ribesi* Scop.

Mr. Zappe has continued as chief nursery inspector and with his helpers has inspected all stock in the nurseries of the State. The number of nurseries has increased from year to year. He has also inspected the nursery stock imported into Connecticut from foreign countries. With Mr. Stoddard, of the Botany Department, he has visited a number of orchards in order to gather data on the prevalence of insect pests and to advise owners regarding treatment. Mr. Zappe has spent considerable time identifying insects and caring for the collection as a specialist in the order Coleoptera, or beetles. With Mr. T. M. Cannon and other Federal men, he has helped distribute information regarding the European corn borer throughout the infested area and will have charge of clean-up work next spring, as in former years.

Doctor Garman has devoted some time to mites and dragonflies, but most of his efforts have been placed on the control of the Oriental peach moth, *Laspeyresia molesta* Busck, which has increased in abundance and caused serious injury in many peach orchards. Doctor Garman has succeeded in rearing several parasites of the Oriental peach moth, two of which are quite common in certain orchards and can be reared artificially for liberation in orchards where they are not abundant. In late summer the peach growers requested the Station to undertake the rearing of these parasites, made contributions to a fund and obtained a state appropriation for this purpose. Equipment has just been installed for parasite work and will be described later. Doctor Garman has also given much attention to the subject of oil sprays.

Doctor Friend has continued his observations and experiments on treating lawns with lead arsenate as a control for the Asiatic beetle, *Anomala orientalis* Waterhouse. He has also continued observations on the life history and habits of the imported birch leaf-miner, *Fenusa pumila* Klug, which we hope can be completed in another season. Doctor Friend has experimented in the control of the cabbage maggot and the squash-vine borer at the Station farm at Mount Carmel and in coöperation with the gipsy moth men has gathered data on the cost of spraying woodland areas. During the year Doctor Friend has given two courses in entomology in Yale University, and has given considerable attention to the Diptera in the Station collection.

Mr. John T. Ashworth has continued as deputy in charge of gipsy moth control work with headquarters at Danielson, with Mr. J. A. McEvoy as assistant. This work includes scouting and creosoting egg-clusters, spraying around infestations, collecting parasitized material, liberating parasites, and is conducted in coöperation with the Federal Plant Quarantine and Control Administration and Bureau of Entomology; it has been carried on vigorously during the past season.

Mr. J. Peter Johnson has continued in charge of the quarantine enforcement and control of the Japanese beetle and the Asiatic beetle that is conducted in coöperation with the Federal Plant Quarantine and Control Administration. An office has been maintained in Shelton, but on July 1, 1929, it was moved from the Hurley Building to the Pierpont Building on Howe Street. Mr. Johnson has had a force of men sufficient to make the necessary inspections, issue the required certificates, patrol the principal highways leading out of the quarantined area, visit growers, and in summer to scout for beetles in other cities and towns in Connecticut outside of the quarantined area.

Mr. Robert C. Botsford has continued as deputy in charge of the work of eliminating mosquitoes. He makes preliminary surveys, supervises the ditching work, and maintains the ditches that have been accepted for state maintenance under Section 2, Chapter 68, Public Acts of 1923. Important new work has been done during the season in Old Lyme and Hamden.

Four technicians are now employed: B. W. McFarland, on Asiatic beetle investigations and control; J. F. Townsend, on Oriental peach moth investigations and control; J. C. Schread and W. Theodore Brigham, on Oriental peach moth parasites, beginning late in the season.

Mr. A. F. Clark was employed from July 1 to August 31; Mr. J. G. Conklin from June 18 to September 21, and Mr. Harold B. Bender from July 1 to September 30, to assist Mr. Zappe in the work of inspecting nurseries.



Mr. W. E. Devine was employed for the school vacation as a general helper in office and laboratory.

Mr. Neely Turner, who is employed by the Crop Protection Institute on horticultural oil spray investigations, has been associated with the department and has been furnished office and laboratory facilities by the Station.

Mr. A. W. Yates, Hartford, and Mr. H. W. Coley, Westport, have continued to serve as apiary inspectors as in former seasons on a *per diem* basis.

Mrs. Gladys Brooke has served as Secretary to the department. During her vacation, Mrs. A. D. McDonnell was employed for part time to attend to the correspondence and other necessary work.

Miss Hazel B. Gillespie, a graduate student in Yale University, was employed during the summer vacation period to index the entomological literature in the journals, and the bound volumes are now nearly all indexed.

All members of the department staff and others mentioned have rendered faithful and efficient services, without which it would have been impossible to obtain the results already accomplished. To them the Entomologist hereby expresses his appreciation and thanks.

The attention of the Entomologist has been given to the office correspondence and to directing the research, inspection, quarantine and control work of the department. Much time has been devoted to meetings and conferences regarding some phase of insect control. The Entomologist has retired from the associate editorship of the *Journal of Economic Entomology*, but he is still chairman of a committee on the project of horticultural oil sprays of the Crop Protection Institute, insect pest reporter in Connecticut for the Insect Pest Survey of the Bureau of Entomology, chairman of the Tree Protection Examining Board of Connecticut, and Superintendent of the Connecticut Geological and Natural History Survey, and has devoted some time to each of these matters.

The principal activities of the department appear in greater detail in the following pages of this report.

## Exhibits

Several exhibits were made by the department during the season. The New Haven Garden Club requested that an exhibit of the Asiatic beetle be made at the spring flower show in Trinity Parish House, New Haven, on May 17. This exhibit was shown and later was repeated at the New Haven Lawn Club. The same material was shown for two weeks in the show window of a hardware store.

On August 5, an exhibit under the auspices of the Litchfield Garden Club was set up in the high school at Litchfield and remained for a week. On October 8 an exhibit was made at the meeting of the Madison Garden Club, at Madison.

A small exhibit of insects attacking vegetable crops was shown in Hartford, December 3 and 4, at the annual meeting of the Connecticut Vegetable Growers Association. A small exhibit of European corn borer and injury caused by this pest was arranged for a meeting to consider the corn borer quarantine, held at the Station, November 7.

An exhibit of Oriental peach moth material was also prepared for use in Glastonbury.

### Collection of Insects

Additions to the Station insect collection are constantly being made by members of the staff and by correspondents. Though no important collecting trips were made, Doctors Garman, Friend and Britton collected in Portland, East Haddam, Salem and Montville in June.

Mr. W. E. Manchester, Pleasant Valley, sent in some specimens of mayflies, flies and dragonflies taken near his home. Prof. C. P. Alexander of Amherst, Mass., collected in Norfolk and Granby chiefly for craneflies, but saved all Diptera and sent many specimens for our collection. Dr. E. P. Felt and Mr. S. W. Bromley, of Stamford, also contributed many specimens of Diptera and some captures in other orders.

### New Equipment

Some second-hand filing cabinets and book sections were purchased and a portion installed in the office of the department; the remainder and our old adding machine were assigned to the Japanese beetle office in Shelton. A new adding machine and typewriter were purchased for the office and a new high-power compound microscope and 5 x 7 view camera for the laboratory of the department. An engineer's dumpy level and planimeter were bought for use on mosquito elimination work.

Late in the season, there was purchased for the parasite work a large electric refrigerator and a humidifier. Several incubators, breeding cages, and a constant high-temperature room were constructed by our own technicians.

## SUMMARY OF OFFICE AND INSPECTION WORK

409 samples of insects received for identification.
288 nurseries inspected.
288 regular certificates granted.
222 duplicate certificates issued for filing in other states.



1 special raspberry certificate granted.
8 special miscellaneous certificates granted.
104 nursery dealer's permits issued.
258 shipper's permits issued to nurserymen in other states.
352 parcels of nursery stock inspected and certified.
42 bales of mountain laurel and other decorative material inspected and certified for shipment.
22,000 narcissus bulbs inspected and certified.
1,084 shipments of corn and other seed inspected and certified.
334 blister rust control area permits issued.
32,926 Japanese beetle certificates on nursery and floral stock and farm products.
855 Asiatic beetle certificates on soil and plants.
76 orchards and gardens examined.
23 shipments, containing 225 cases, 2,022,475 plants imported nursery stock inspected.
11 shipments or 47 per cent found infested.
990 apiaries, containing 9,559 colonies, inspected.
2 apiaries and 3 colonies found infested with European foul brood.
46 apiaries and 115 colonies found infested with American foul brood.
4,369 letters[1] written on official work.
942 circular letters sent out.
270 post cards sent out.
23 reports to Federal Plant Quarantine and Control Administration.
2,453 bulletins, etc., mailed on request or to answer inquiries.
36 packages sent by mail or express.
54 lectures and addresses at meetings.

## PUBLICATIONS OF THE DEPARTMENT, 1929

W. E. Britton:

Twenty-Eighth Report of State Entomologist, Bull. 305, 100 pages, 16 plates, 8 figures. June, 1929.

The European Corn Borer, a Menace to Corn, Vegetable and Garden Plants, Bull. Imm. Inf. 63, 4 pages, 2 figures, 12,000 copies. April 17, 1929.

Japanese Beetle Quarantine, Bull. Imm. Inf., 4 pages, 4 figures, 6,250 copies. May 1, 1929.

Asiatic Beetle Quarantine, Bull. Imm. Inf. 65, 4 pages, 4 figures, 5,000 copies. May 3, 1929.

Satin Moth Quarantine, Bull. Imm. Inf. 66, 3 pages, 2 figures, 1,200 copies. May 3, 1929.

Control of Ant Invasions, Bull. Imm. Inf. 67 (Revision of No. 17), 6 pages, 2 figures, 5,000 copies. August 22, 1929.

Report of Committee on Injurious Insects, Proceedings 38th Annual Meeting Conn. Pom. Society, 28. April, 1929.

Insects Injuring Vegetable Crops in 1928, Report of Committee on Insects, Conn. Veg. Growers Assn., 26.

Thirteenth Biennial Report of the Commissioners of the State Geological and Natural History Survey, 1927-1928, Bull. 45, 32 pages, 3 plates, 2,500 copies. August 13, 1929.

Three Corn Crop Pests, Rural New-Yorker, **88**: 1225. October 5, 1929.

[1] Including 1,078 written at the Shelton Japanese Beetle office.

Philip Garman:

The Oriental Peach Moth Situation, Proceedings, 38th Annual Meeting, Conn. Pom. Society, p. 102. April, 1929.

The Use of Oil Sprays, Proceedings, 38th Annual Meeting, Conn. Pom. Society, 50. April, 1929.

M. P. Zappe:

Russeting of Apples in 1928, Proceedings, 38th Annual Meeting, Conn. Pom. Society, 54. April, 1929.

Philip Garman and M. P. Zappe:

Control Studies on the Plum Curculio in Connecticut Orchards, Bull. 301, 68 pages, 8 plates, 12 figures. May, 1929.

R. B. Friend:

The Asiatic Beetle in Connecticut, Bull. 304, 84 pages, 4 plates. June, 1929.

Control of the Asiatic Beetle in Lawns, Bull. Imm. Inf. 62, 6 pages, 5 figures, 4,000 copies. March, 1929.

Control of Insects Affecting Truck Crops, Report Conn. Veg. Growers Assn. for 1928, 28.

R. C. Botsford:

Progress in Mosquito Elimination in Connecticut during 1928, Proceedings, 16th Annual Meeting N. J. Mosquito Exter. Assn., 120. July, 1929.

Neely Turner:

Tests for Oil Sprays, Proceedings, 38th Annual Meeting, Conn. Pom. Society, 49.

Variation in Resistance of Aphids to Toxic Sprays, Jour. Econ. Ent., 22: 323. April, 1929.

## ENTOMOLOGICAL FEATURES OF 1929

The weather for the season of 1929 was unusual. After a rather mild winter without heavy snowfall or very low temperatures, the growing season started with cool and moist weather during April and May. Then higher temperature prevailed, but there was a shortage in precipitation for the months of June, July and September.

The rainfall for August was only slightly below normal, but nearly all of it fell in one shower on August 11.

In general, aphids were present and caused considerable damage. There was a marked spread of the European corn borer, and the Mexican bean beetle was discovered in the state for the first time. For the insect notes on the following pages, the writer is indebted to Mr. Zappe and Doctor Garman (fruit insects) and to Mr. A. E.



Wilkinson, Vegetable Specialist, extension department, Connecticut Agricultural College, Storrs (vegetable insects), for a part of the information.

### Fruit Insects

As the apple crop was rather light, other things being equal, insect injury to the fruit was perhaps more conspicuous than in a year of heavy yield, and the percentages of perfect fruit were smaller.

Early in the season, eggs of the green apple aphid, *Aphis pomi* DeGeer, were abundant in apple orchards in New Haven County. After the eggs hatched, this species and the rosy apple aphid, *Anuraphis roseus* Baker, were rather abundant, but both Syrphid larvae and lady beetles were present and feeding upon them. It seemed probable that these predatory insects would control the aphids so that little or no aphid injury would result. But later in the season both kinds were very abundant in some orchards and the foliage was severely curled, though this happened too late to result in serious injury to the fruit crop. Mr. Zappe reported the rosy aphid as being present in apple orchards as follows: Bantam, May 13; Meriden, May 16; Branford and Guilford, May 29; Niantic, June 5; Farmington and Somers, June 6; East Hampton, June 10; Montville and Lebanon, June 12; Ledyard and Center Groton, June 13, and Waterbury, August 13. The writer observed a heavy infestation of rosy aphids on a large apple tree in a city yard in New Haven, June 18. Lady beetles were abundant. Specimens of the green apple aphid were received from Hamden, April 18.

The woolly apple aphid, *Eriosoma lanigerum* Hausman, was present in usual numbers, and specimens were received from Hamden, June 22.

The currant aphid, *Myzus ribis* Linn., and the cherry aphid, *Myzus cerasi* Fabr., are usually present each year throughout Connecticut. Specimens of the former were received from Woodbury and of the latter from New Haven on June 3.

The pear psylla, *Psylla pyricola* Forst., was reported as being prevalent and injurious in the eastern part of the state. According to Doctor Garman, this insect was fairly abundant in one orchard, but rather scarce in all other orchards visited in New Haven County on May 24. In Fairfield and New Haven Counties it seemed to be present in average abundance on July 24, though less abundant than in 1928.

The apple red bug, *Lygidea mendax* Reut., was absent in nearly all apple orchards throughout the state.

The San José scale, *Aspidiotus perniciosus* Comst., is now rather scarce and hard to find, but it was present in several nurseries and specimens were received from Waterbury, August 13.

The European fruit scale, *Lecanium corni* Bouché, and the rose scale, *Aulacaspis rosae* Bouché, were both received on blackberry canes from West Haven, on June 14.

The strawberry whitefly, *Trialeurodes packardi* Morrill, caused considerable injury in a strawberry field at Branford.

The pear midge, *Contarinia pyrivora* Riley, was present in certain orchards and caused the immature fruit to drop. Work of this insect was observed at Branford, May 29, and specimens were received from Mystic, June 10.

There was perhaps more than the usual amount of injury from the apple maggot or railroad worm, *Rhagoletis pomonella* Walsh. The best control is obtained by sprays of lead arsenate in July and early August and by the destruction of drops. Specimens were received from Plantsville, September 24; New Haven, September 28 and October 11, and from Vernon, November 6.

In Wallingford early in the season, slight injury was reported to fruit from green fruit worms, *Xylina antennata* Walker.

The Eastern tent caterpillar, *Malacosoma americana* Fabr., has at last become scarce over a greater portion of the state. A few nests were observed in Litchfield County, where several successive freezes killed the cherry leaves and the caterpillars died. These nests failed to increase in size and they did not contain living caterpillars. This insect may be considered as having now reached its minimum. In a few years it will probably again become prevalent.

Larvae of one of the lappet moths, *Tolype velleda* Stoll., feeding upon apple foliage were received from Woodmont, August 2, and from Waterbury, August 13. This insect is never sufficiently abundant to be considered as a pest.

Occasionally apple trees are found with large burrows of the leopard moth, *Zeuzera pyrina* Linn., in trunk or branches. Specimens of such injury were received from South Manchester, May 31, and from Milford, August 29.

The fall cankerworm, *Alsophila pometaria* Harris, though less prevalent than last year, was present and caused some damage in certain localities. This was true in portions of New Haven and New London Counties, where trees were stripped in 1928. Specimens were received from Clintonville, May 16, and from East Hampton, June 10.

The bud moth, *Tmetocera ocellana* Schiff., caused some injury in the vicinity of Litchfield, in May, by devouring the buds on young trees. It was also reported from Kensington, May 16. There was little injury in other portions of the state.

Considerable surface injury to stored apples by the red banded leaf roller, *Eulia velutinana* Walker, was noticed about November 1, in New Canaan and Wilton. This insect was reported as being rather abundant in Fairfield County.



Rather more than the usual proportion of fruit was injured by the codling moth, *Carpocapsa pomonella* Linn. Not only was this true of the first brood but there was also considerable side injury by the larvae of the second brood. On the whole, this insect was well controlled where the trees were properly sprayed.

One of the most destructive insects of the year is the Oriental peach moth, *Laspeyresia molesta* Busck, which was prevalent in the central portion of the state and caused serious injury in some of the peach orchards.

In certain orchards in Wallingford, it caused less damage than five years ago, but in other orchards not many miles distant between 75 and 100 per cent of the peaches were wormy at harvest time. Quinces were also ruined. Twig injury to peach trees was prevalent in June and July in Hartford and New Haven Counties.

Unusually abundant everywhere in 1929 was the plum curculio, *Conotrachelus nenuphar* Herbst., which injured a large proportion of the fruit in apple orchards, especially near woodlands. Mr. Zappe reports it as being very abundant on apple in the following localities: Niantic, June 5; Somers, June 6; East Hampton, June 10; Ledyard, June 13; a few at Lebanon, June 12. Reported as present at South Windsor, and Farmington, June 6; Glastonbury and Montville, June 12; Burlington and Unionville, June 26; Waterbury, August 13; Collinsville, August 26, and Norwalk, August 27. It was reported on peach from Putnam, July 26, and Collinsville, August 26.

The pear leaf blister mite, *Eriophyes pyri* Pag., is usually present to some extent on pear and apple. Specimens were received on pear from Glastonbury, May 22.

The European red mite, *Paratetranychus pilosus* C. and F., was probably less prevalent than in 1928, though moderately abundant in apple orchards in Hartford and New Haven Counties. There were many eggs in orchards in New Haven County in March, and there was a rather heavy infestation in Kensington in May. Mr. A. T. Henry, of Wallingford, reports few eggs present this winter, 1929-1930, but Prof. J. A. Manter of the Connecticut Agricultural College at Storrs writes that the eggs are abundant there.

## Vegetable Insects

Perhaps the most important item to include under this heading is the discovery that the Mexican bean beetle, *Epilachna corrupta* Muls., has appeared in Connecticut. It was first discovered and reported by Dr. E. P. Felt, and afterwards found to be distributed throughout the western half of the state. A more complete account is given in another part of this report, page 581.

Flea beetles, *Epitrix cucumeris* Harris, were very abundant and caused injury to crops of potato, tomato, egg-plant, cucumber, early squash, melon and tobacco. Sprays of pyrethrum-soap preparations have been successfully used as a remedy by some growers.

The striped beetle, *Diabrotica vittata* Fabr., was very abundant at the Station farm at Mount Carmel.

The Colorado potato beetle, *Leptinotarsa decemlineata* Say., was unusually abundant in most localities throughout the state.

The asparagus beetle, *Crioceris asparagi* Linn., was present in the usual abundance. Specimens were received from Rockville, May 28, and from West Haven, July 30.

The squash lady beetle, *Epilachna borealis* Fabr., was received from Higganum, July 15.

The margined blister beetle, *Epicauta marginata* Fabr., was reported as injuring Swiss chard at Hamden, July 23.

In general, cutworms were less troublesome than usual at the time when cutworms usually cause injury, but in late June and early July, certain kinds, especially a black cutworm, appeared in certain fields in New Haven County and caused considerable injury to sweet corn and potatoes. Such injury was reported from Meriden, Yalesville, Wallingford, Foxon, Branford, Highwood, Woodbridge, Woodmont, Orange, and North Haven. Though specimens were collected, we were unable to rear the adults.

The squash vine borer, *Melittia satyriniformis* Hübner, was very abundant at the Station farm at Mount Carmel.

The stalk borer, *Papaipema nitela* Guen., was exceedingly abundant throughout the state and in the stems of various plants. Specimens were received in corn from Bethlehem, Cheshire, Durham, Hamden, New Haven, Shelton, Wallingford, Waterford, Westport and Winsted; in tomato, from Cheshire, and in beans from West Haven.

The corn ear worm, *Heliothis obsoleta* Fabr., was more abundant than usual and was present over a longer period.

The first specimens were received on July 15, and from then until frost, it was observed. Specimens were received from Hamden, Hartford, New Haven, Plainville, Plantsville, West Suffield and Woodbridge. It was also reported from Niantic.

The zebra caterpillar, *Mamestra picta* Harr., feeding upon the shoots of asparagus, was received from Meriden, June 10.

The cabbage worm, *Pontia rapae,* Linn., and the cabbage looper, *Autographa brassicae* Riley, were present in usual abundance. The diamond-back caterpillar, *Plutella maculipennis* Curtis, was unusually abundant and was present in nearly every field where cabbages were grown.

The European corn borer, *Pyrausta nubilalis* Hübn., has spread rapidly in 1929, and 38 new towns have been placed under quarantine. This insect will be discussed in greater detail in another part of this report. Larvae were received from Uncasville, October 7.



A green noctuid larva eating into a green pea pod was received from West Hartford, June 3.

The army worm, *Heliophila unipuncta* Haw., was brought to the Station, June 24, from Woodmont, where it was injuring corn in connection with cutworms.

The cabbage maggot, *Hylemyia brassicae* Bouché, was everywhere abundant throughout the state and untreated plants were ruined. Plants kept treated with corrosive sublimate after setting produced a good crop.

No reports were received of injury by the carrot rust fly, *Psila rosae* Fabr., and there was little or no damage from the spinach leaf miner, *Pegomyia hyoscyami* Panz.

The squash bug, *Anasa tristis* DeGeer, was present in usual numbers. Specimens were received from Higganum, July 15.

Aphids caused great injury to potato, tomato, egg-plant and turnip during midsummer and later. Early in the season, though aphids were present, Syrphid larvae and lady beetles were abundant and were expected to keep the aphids in check.

## Shade and Forest Tree Insects

The arborvitae leaf miner, *Argyresthia thuiella* Pack., continues to injure trees in certain portions of Connecticut. Specimens were received from Old Lyme, May 15, and from Riverside, May 18.

The larch case bearer, *Coleophora laricella* Hübner, was received from Middlebury, May 18; Norfolk, June 5, and from Storrs, August 5. It was reported from Greenwich by Dr. E. P. Felt.

The European pine shoot moth, *Rhyacionia buoliana* Schiff., is becoming rather common on Scotch and red pine in Fairfield County. Specimens on red pine were received from Darien, August 27, and it was found on red pine in Hamden and vicinity by Doctor Friend.

The white oak leaf miner, *Lithocolletes hamadryadella* Clemens, was received from South Manchester, August 5.

The spiny elm caterpillar, *Euvanessa antiopa* Linn., was received from Fairfield, June 4.

The fall webworm, *Hyphantria cunea* Dru., was reported by Mr. Zappe as being very abundant in the western half of the state.

A small moth, *Nepticula sericopeza* Zell., was reared from the petioles of Norway maple by Doctor Felt, of Stamford. The larva is a leaf miner in the stems and causes many leaves to drop.

The bronze birch borer, *Agrilus anxius* Gory, continues to kill white birch trees on private grounds. These trees are chiefly the cut-leaf form of the European white birch. Specimens were received from South Glastonbury, May 22.

The white pine weevil, *Pissodes strobi* Peck, was unusually abundant throughout the state.

The imported willow leaf beetle, *Plagiodera versicolora* Laich., has skeletonized many smooth-leaf willows throughout Connecticut. Specimens were received from Wallingford, June 6, and from Southport, July 22.

A small Scolytid beetle, *Pityogenes hopkinsi* Swains., was found breeding under the bark of some dying white pines in a flooded area in Middlebury, May 18.

The imported sawfly birch leaf miner, *Fenusa pumila* Klug., which has spread throughout the state, causes an unsightly appearance to small paper and gray birches often planted for ornamental trees. Specimens were received from Bridgeport, June 10, and from Bantam, August 22.

The larch sawfly, *Lygaeonematus erichsoni* Hart., was received from Gilead, July 2.

Pine sawflies were rather common in 1929. One species, *Neodiprion pinetum* Norton, was received from Portland, July 18, and from New Haven, August 29.

The catalpa leaf miner, probably *Agromyza clara* Mel., has become rather abundant and was found in 31 nurseries, chiefly on *Catalpa bungei*. Specimens were received from Manchester, September 12.

Aphids were rather abundant on trees in 1929. One species, probably *Dilachnus strobi* Fitch, on white pine, was received from Suffield, October 8. The cockscomb elm gall, *Colopha ulmicola* Fitch, was received from Stamford, July 5. The beech woolly aphid, *Prociphilus imbricator* Fitch, which is common on the under sides of the leaves of purple beech, was received from New Haven, June 10. The pine bark aphid, *Adelges pinicorticis* Fitch, is common on the needles and bark of white pine trees everywhere. Specimens were received from New Haven, May 29 and June 3, and from Waterbury July 1. The spruce gall aphid, *Adelges abietis* Linn., is becoming increasingly common on Norway and white spruce and was found in 85 nurseries. Specimens were received from Riverside, May 28; Woodbury, July 22; Branford, September 16, and Greenfield Hill, Fairfield, November 18. The blue spruce gall aphid, *Gillettea cooleyi* Gill., is also on the increase and was found in 62 nurseries.

The oyster-shell scale, *Lepidosaphes ulmi* Linn., continues to be one of the most prevalent of all insect pests. It was found in 78 nurseries in 1929, and was received on willow from New Haven, and on poplar from Greenfield Hill, Fairfield.

The pine leaf scale, *Chionaspis pinifoliae* Fitch, is common on



young pine trees growing in protected situations. Specimens on red pine were received from Old Lyme.

The tulip tree scale, *Toumeyella liriodendri* Gmel., is fairly abundant on tulip tree and magnolia throughout the state. During the season, specimens of this scale were received from Torrington and Bridgeport, and it was reported by Doctor Felt as being locally abundant around Stamford.

Maple trees, especially silver maple, are often attacked by the terrapin scale, *Lecanium nigrofasciatum* Perg. This scale occurs on the small twigs. Specimens were received from Wallingford, July 16.

There are several species of oak gall scales in Connecticut that are globular and attached to the twigs. Specimens identified as *Kermes galliformis* Riley, on pin oak, were received from Wallingford, July 16, and similar gall scales were very abundant on black oak trees in East Rock Park, New Haven.

The golden oak scale, *Asterolecanium variolosum* Ratz., was reported on April 25, as being very abundant on native chestnut oak around New Haven.

The cottony maple scale, *Pulvinaria vitis* Linn., was reported by Dr. E. P. Felt as being locally very abundant in the vicinity of Stamford. It occurs chiefly on silver maple.

Another scale, *Leucaspis japonica* Ckll., is reported by Doctor Felt to have injured Norway and soft maples in Greenwich.

During the past few years there has been much injury to coniferous trees from the attacks of the spruce mite, *Paratetranychus ununguis* Jacobi. Possibly spruce is more commonly injured than other kinds, but occasionally it also attacks pine, arborvitae, and other trees. Specimens of this mite were received from Bristol, June 13.

## Insects Attacking Ornamental Shrubs and Vines

A leaf roller, *Archips rosana* Linn., on privet was rather common around New Haven during the season. Specimens were received from New Haven, May 28, and the insect was noticed on several hedges.

The box leaf miner, *Monarthropalpus buxi* Labou., is now present in several localities in Connecticut. Specimens were received from New Canaan, June 1.

The abbot sphinx, *Sphecodina abbotii* Swains., was prevalent on Virginia Creeper and grape throughout the state. Specimens were received from New Haven, July 9; Shelton, July 16; Granby, July 27, and Clinton, July 29.

A mite, *Phyllocoptes schlectendali* Nalepa, was found on the writer's privet hedge in May. Specimens were also received from New Haven, June 13. This mite curls the leaves on the new tips but on trimming the hedge, most of these tips are clipped off.