# The University of Minnesota

# TWENTY-THIRD ANNUAL REPORT OF THE AGRICULTURAL EXPERIMENT STATION

JULY 1, 1914
TO JUNE 30, 1915

UNIVERSITY FARM, ST. PAUL
FEBRUARY 1916

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| | |
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A. D. WILSON, B.S. in Agr., Director of Agricultural Extension
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M. J. THOMPSON, M.S., Superintendent, Duluth Substation
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CHARLES HARALSON, Superintendent, Fruit-Breeding Farm, Excelsior
W. P. KIRKWOOD, B.A., Editor
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T. J. HORTON, Photographer

### DIVISION OF AGRICULTURAL CHEMISTRY

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C. H. BAILEY, B.S.A., Cereal Technologist
R. M. WEST, B.A., Assistant Agricultural Chemist
J. J. WILLAMAN, M.A., Assistant Agricultural Chemist
CORNELIA KENNEDY, B.A., Assistant Agricultural Chemist
D. O. SPRIESTERSBACH, M.S., Research Assistant

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J. T. STEWART, C.E., Agricultural Engineer

### DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Agronomist and Farm Management Investigator

*Section of Coöperative Seed-Production and Distribution*

C. P. BULL, B.Agr., Associate Agronomist, in Charge

*Section of Farm Crops*

A. C. ARNY, B.S. in Agr., Assistant Agronomist, in Charge

*Section of Cereal Breeding*

*H. K. HAYES, M.S., Associate Agronomist, in Charge
P. J. OLSON, M.S., Assistant Agronomist

*Section of Cost Accounting*

F W. PECK, B.S. in Agr., Assistant Farm Management Investigator, in Charge

*Section of Farm Organization*

ANDREW BOSS, Agronomist and Farm Management Investigator, in Charge
L. B. BASSETT, Assistant Farm Management Investigator
A. H. BENTON, M.S., Assistant Farm Management Investigator

### DIVISION OF BEE CULTURE

FRANCIS JAGER, Apiculturist

* Elected to assume duties during the year.

## DIVISION OF DAIRY AND ANIMAL HUSBANDRY

T. L. HAECKER, Dairy and Animal Husbandman

*Section of Animal Husbandry*

*H. R. SMITH, B.S., Animal Husbandman, in Charge
J. S. MONTGOMERY, B.S. in Agr., Assistant Animal Husbandman
T. G. PATERSON, B.S. in Agr., Assistant Animal Husbandman
R. C. ASHBY, M.S., Assistant in Animal Husbandry
K. F. WARNER, B.A., Assistant in Animal Husbandry

*Section of Dairy Husbandry*

R. M. WASHBURN, M.S.A., Associate Dairy Husbandman
E. O. HANSON, Assistant in Dairy Husbandry

*Section of Poultry Husbandry*

A. C. SMITH, B.S., Poultry Husbandman, in Charge
C. H. MATTHEWS, Assistant in Poultry Husbandry

*Section of Animal Nutrition*

T. L. HAECKER, Dairy and Animal Husbandman, in Charge
*E. W. MAJOR, B.Agr., Associate in Animal Nutrition
*STEPHEN ANTHONY, Chemist in Animal Nutrition
MILDRETH HAGGARD, B.A., Chemist in Animal Nutrition
AGNES ERICSON, Assistant Chemist in Animal Nutrition
W. F. CANTWELL, B.S. in Chem., Assistant Chemist in Animal Nutrition

## DIVISION OF ENTOMOLOGY

*Section of Vertebrate Pests of the Farm; Mill and Warehouse Insects; and Nursery and Orchard Inspection*

F. L. WASHBURN, M.A., Entomologist, in Charge

*Section of Tree Insects and Spraying*

A. G. RUGGLES, M.A., Assistant Entomologist, in Charge

*Section of Field-Crop Pests and Parasites*

C. W. HOWARD, M.S., Assistant Entomologist, in Charge
WARREN WILLIAMSON, M.A., Assistant in Entomology

*Section of Truck-Crop and Greenhouse Pests*

WILLIAM MOORE, B.A., Assistant Entomologist, in Charge
†S. MARCOVITCH, B.S., Assistant in Entomology

## DIVISION OF HORTICULTURE

*Section of Floriculture and Landscape Gardening*

LEROY CADY, B.S. in Agr., Associate Horticulturist, in Charge

*Section of Fruit-Breeding*

M. J. DORSEY, Ph.D., Assistant Horticulturist, in Charge

* Resigned during the year.
† Elected to assume duties during the year.



*Section of Fruit and Vegetable Investigation*

RICHARD WELLINGTON, M.S., Assistant Horticulturist, in Charge

*Section of Fruit and Vegetable Instruction*

W. G. BRIERLEY, M.S. in Hort., Assistant Horticulturist, in Charge

## DIVISION OF PLANT PATHOLOGY AND BOTANY

E. M. FREEMAN, Ph.D., Pathologist and Botanist

*Section of Plant Pathology*

E. C. STAKMAN, Ph.D., Assistant Plant Pathologist, in Charge
E. LOUISE JENSEN, M.A., Mycologist
A. G. TOLAAS, M.S., Assistant in Plant Pathology
F. J. PIEMEISEL, M.S., Assistant in Plant Pathology

*Section of Seed Laboratory*

W. L. OSWALD, Assistant Botanist, in Charge
R. C. DAHLBERG, B.S. in Agr., Seed Analyst

## DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

L. D. H. WELD, Ph.D., Agricultural Economist
O. B. JESNESS, B.S. in Agr., Assistant in Agricultural Economics

## DIVISION OF SOILS

F. J. ALWAY, Ph.D., Soils Chemist
R. A. GORTNER, Ph.D., Associate Soils Chemist
C. O. ROST, M.A., Assistant Soils Chemist
*DEFOREST HUNGERFORD, B.S., Assistant Soils Chemist
P. R. MCMILLER, MS., Assistant Chemist in Soils

## DIVISION OF VETERINARY SCIENCE

M. H. REYNOLDS, D.V.M., Veterinarian
W. L. BOYD, D.V.S., Assistant Veterinarian
H. P. HOSKINS, V.M.D., Assistant Veterinarian
C. C. PALMER, D.V.M., Assistant Veterinarian
H. C. H. KERNKAMP, D.V.M., Assistant Veterinarian

## FORESTRY INVESTIGATIONS

E. G. CHEYNEY, B.A., Forester
J. P. WENTLING, M.A., Associate Forester
J. H. ALLISON, M.F., Associate Forester
W. H. KENETY, M.S., in Charge of Cloquet Station
G. H. WIGGIN, B.S. in For., Assistant Forester at Cloquet

* Resigned during the year.

## LETTERS OF TRANSMITTAL

MINNEAPOLIS, MINN., June 30, 1915

*To His Excellency, Winfield S. Hammond,*
*Governor of Minnesota.*

SIR: I have the honor to transmit to you herewith the annual report of the Agricultural Experiment Station of the Univresity of Minnesota for the fiscal year ending June 30, 1915.

Respectfully,
FRED B. SNYDER,
*President Board of Regents*

UNIVERSITY OF MINNESOTA,
MINNEAPOLIS, MINN., June 30, 1915

*The Hon. Fred B. Snyder, President of the Board of Regents,*
*University of Minnesota.*

SIR: I have the honor to transmit herewith the report of the Director of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1915.

Respectfully,
GEORGE E. VINCENT,
*President of the University of Minnesota*

UNIVERSITY FARM, ST. PAUL, MINN., June 30, 1915

*George E. Vincent,*
*President of the University of Minnesota.*

SIR: I have the honor to hand you herewith the annual report of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1915.

Respectfully,
A. F. WOODS,
*Director*



## CONTENTS

## FINANCIAL STATEMENT

### THE MINNESOTA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES

APPROPRIATIONS 1914-1915

| | | |
|---|---|---|
| Dr. | | |
| To receipts from the Treasurer of the United States in accordance with the appropriation for the fiscal year ending June 30, 1915, under Act of Congress approved March 2, 1887 | | $15,000.00 |
| Cr. | | |
| By Salaries | $8,966.68 | |
| Labor | 6,033.32 | |
| Total Hatch Fund | $15,000.00 | $15,000.00 |
| Dr. | | |
| To receipts from the Treasurer of the United States in accordance with the appropriation for the fiscal year ending June 30, 1915, under Act of Congress approved March 16, 1906 | | $15,000.00 |
| Cr. | | |
| By Salaries | $13,689.16 | |
| Labor | 1,310.84 | |
| Total Adams Fund | $15,000.00 | $15,000.00 |

## FEDERAL FUNDS 1914-1915

| | Morrill | Nelson | Hatch | Adams | Smith-Lever | Total |
|---|---|---|---|---|---|---|
| Agronomy and Farm Management | $1,100 | $2,450 | $4,620 | ..... | ..... | $8,170 |
| Agricultural Education | ..... | 1,100 | ..... | ..... | ..... | 1,100 |
| Agricultural Engineering | ..... | 6,900 | ..... | ..... | ..... | 6,900 |
| Plant Pathology and Botany | 1,000 | 1,000 | ..... | 1,350 | ..... | 3,350 |
| Chemistry | ..... | 3,000 | 1,000 | 500 | ..... | 4,500 |
| Soils | 1,000 | 500 | 500 | 2,200 | ..... | 4,200 |
| Dairy and Animal Husbandry | 1,700 | 3,000 | 2,080 | 7,400 | ..... | 14,180 |
| Entomology | 1,200 | 1,400 | 1,500 | 1,900 | ..... | 6,000 |
| Horticulture | ..... | 1,800 | 900 | 1,650 | ..... | 4,350 |
| Veterinary | ..... | 1,000 | 1,400 | ..... | ..... | 2,400 |
| School and College | ..... | 2,850 | ..... | ..... | ..... | 2,850 |
| Experiment Station Administration | ..... | ..... | 3,000 | ..... | ..... | 3,000 |
| Agricultural Extension | ..... | ..... | ..... | ..... | 10,000 | 10,000 |
| Total | $6,000 | $25,000 | $15,000 | $15,000 | $10,000 | $71,000 |



## CLASSIFIED STATEMENT OF DISBURSEMENTS OF DEPARTMENT OF AGRICULTURE, 1914-1915

| | Substations | University Farm |
|---|---|---|
| Salaries | $38,853.04 | $308,082.52 |
| Labor | 33,230.26 | 83,908.08 |
| Publications | 120.69 | 7,550.53 |
| Postage and stationery | 2,357.49 | 10,155.31 |
| Freight and express | 1,830.87 | 3,322.15 |
| Heat, light, water, and power | 10,981.48 | 27,181.77 |
| Chemicals and laboratory supplies (including hog cholera serum, $10,545) | 328.06 | 15,883.35 |
| Seeds, plants, and sundries | 4,451.84 | 16,321.56 |
| Fertilizers | 86.01 | 268.30 |
| Feeding stuffs | 10,546.64 | 22,304.81 |
| Library | 534.64 | 4,639.49 |
| Tools, machinery, and appliances | 2,416.79 | 7,239.87 |
| Furniture and fixtures | 508.19 | 5,414.73 |
| Scientific apparatus | 65.41 | 2,800.28 |
| Livestock (including hogs for hog cholera work $33,169.53) | 4,323.08 | 39,911.72 |
| Traveling expenses | 2,171.71 | 24,011.53 |
| Contingent expenses | 576.53 | 4,799.87 |
| Buildings and land (exclusive of special appropriations) | 5,535.21 | 9,485.98 |
| | $118,917.94 | $593,281.85 |
| | | 118,917.94 |
| Total University Farm and Substations | | $712,199.79 |

## GENERAL SUMMARY OF DISBURSEMENTS FOR YEAR 1914-1915

| | General Support | Special | Federal | Total |
|---|---|---|---|---|
| Agricultural Economics | $3,523.30 | $3,159.52 | ..... | $6,682.82 |
| Agricultural Education | 13,946.10 | ..... | $1,100.00 | 15,046.10 |
| Agronomy and Farm Management | 20,711.04 | 18,868.71 | 8,170.00 | 47,749.75 |
| Agricultural Engineering | 11,914.02 | 2,657.78 | 6,900.00 | 21,471.80 |
| Bee-Keeping | 325.00 | 4,054.33 | ..... | 4,379.33 |
| Plant Pathology and Botany | 8,665.78 | 11,018.20 | 3,350.00 | 23,033.98 |
| Chemistry | 6,611.43 | 3,783.53 | 4,500.00 | 14,894.96 |
| Dairy and Animal Husbandry | 40,722.97 | 21,795.14 | 14,180.00 | 76,698.11 |
| Entomology | 2,821.79 | 3,762.80 | 6,000.00 | 12,584.59 |
| Forestry | 3,600.00 | 17,141.55 | ..... | 20,741.55 |
| Home Economics | 26,701.94 | ..... | 1,150.00 | 27,851.94 |
| Horticulture | 8,935.85 | 11,649.94 | 4,350.00 | 24,935.79 |
| Soils | 8,591.60 | 2,221.75 | 4,200.00 | 15,013.35 |
| Veterinary | 7,010.03 | 61,929.99 | 2,400.00 | 71,340.02 |
| Library | 1,734.25 | 9,808.62 | ..... | 11,542.87 |
| Agricultural Extension | ..... | 64,025.90 | 10,000.00 | 74,025.90 |
| General Station | 23,101.53 | ..... | 3,000.00 | 26,101.53 |
| General School and College | 37,550.26 | ..... | 1,700.00 | 39,250.26 |
| Campus Maintenance | ..... | 3,032.19 | ..... | 3,032.19 |
| Coal | 25,228.00 | ..... | ..... | 25,228.00 |
| Buildings and Repairs | 11,144.81 | 20,532.20 | ..... | 31,677.01 |
| Total Maintenance—University Farm | $262,839.70 | $259,442.15 | $71,000.00 | $593,281.85 |

DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1914-1915

| | Fund | Total | College and School | Experiment Station | Extension |
|---|---|---|---|---|---|
| Administration | Support | $19,666.32 | $9,833.16 | $9,833.16 | |
| Administration | Hatch fund | 3,000.00 | | 3,000.00 | |
| Registrar | Support | 3,977.39 | 3,977.39 | | |
| General School | Support | 9,108.27 | 9,108.27 | | |
| Custodial | Support | 13,628.47 | 10,221.36 | 3,407.11 | |
| Telephones | Support | 3,032.86 | 1,516.43 | 1,516.43 | |
| General service | Support | 1,846.13 | 923.06 | 923.07 | |
| Publications | Support | 4,014.15 | | 4,014.15 | |
| Hospital | Support | 741.75 | 741.75 | | |
| Dormitories | Support | 244.51 | 244.51 | | |
| English | Support | 4,391.94 | 4,391.94 | | |
| English | Nelson fund | 1,700.00 | 1,700.00 | | |
| Agronomy | Eradication of weeds | 1,607.24 | | 1,607.24 | |
| | Farm management | 4,505.70 | 2,252.85 | 2,252.85 | |
| | Tobacco investigation | 2,664.77 | | 2,664.77 | |
| | Field crops | 10,091.00 | | 10,091.00 | |
| | Morrill fund | 1,100.00 | 1,100.00 | | |
| | Nelson fund | 2,450.00 | 2,450.00 | | |
| | Hatch fund | 4,620.00 | | 4,620.00 | |
| | General support | 20,711.04 | 10,355.52 | 10,355.52 | |
| Engineering | Agricultural engineering investigation | 716.00 | | 716.00 | |
| | Drainage | 1,941.78 | | 1,941.78 | |
| | Nelson fund | 6,900.00 | 6,900.00 | | |
| | General support | 11,914.02 | 11,914.02 | | |
| Plant Pathology and Botany | Plant diseases | 3,095.47 | | 3,095.47 | |
| | Seed analysis | 1,856.09 | | 1,856.09 | |
| | Seed inspection | 4,985.07 | | 4,985.07 | |
| | Bacteriology | 1,081.57 | | 1,081.57 | |
| | Morrill fund | 1,000.00 | 1,000.00 | | |
| | Nelson fund | 1,000.00 | 1,000.00 | | |
| | Adams fund | 1,350.00 | | 1,350.00 | |
| | General support | 8,665.78 | 4,332.89 | 4,332.89 | |



DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1914-1915—*Continued*

| | Fund | Total | College and School | Experiment Station | Extension |
|---|---|---|---|---|---|
| Chemistry | Grain laboratory | 2,550.54 | | 2,550.54 | |
| | Sorghum sirup | 1,232.99 | | 1,232.99 | |
| | Nelson fund | 3,000.00 | 3,000.00 | | |
| | Hatch fund | 1,000.00 | | 1,000.00 | |
| | Adams fund | 500.00 | | 500.00 | |
| | General support | 6,611.43 | 3,305.71 | 3,305.72 | |
| Soils | Soil investigation | 2,221.75 | | 2,221.75 | |
| | Morrill fund | 1,000.00 | 1,000.00 | | |
| | Nelson fund | 500.00 | 500.00 | | |
| | Hatch fund | 500.00 | | 500.00 | |
| | Adams fund | 2,200.00 | | 2,200.00 | |
| | General support | 8,591.60 | 4,295.80 | 4,295.80 | |
| Horticulture | Fruit breeding | 5,172.04 | | 5,172.04 | |
| | Fruit farm maintenance | 3,198.09 | | 3,198.09 | |
| | Horticultural crops | 3,279.81 | | 3,279.81 | |
| | Nelson fund | 1,800.00 | 1,800.00 | | |
| | Hatch fund | 900.00 | | 900.00 | |
| | Adams fund | 1,650.00 | | 1,650.00 | |
| Dairy and Animal Husbandry | General support | 8,935.85 | 5,957.24 | 2,978.61 | |
| | Animal nutrition investigation | 5,333.01 | | 5,333.01 | |
| | Dairy extension | 2,962.89 | | | 2,962.89 |
| | Livestock | 6,895.24 | 3,447.62 | 3,447.62 | |
| | Poultry investigation | 6,604.00 | 4,953.00 | 1,651.00 | |
| | Morrill fund | 1,700.00 | 1,700.00 | | |
| | Nelson fund | 3,000.00 | 3,000.00 | | |
| | Hatch fund | 2,080.00 | | 2,080.00 | |
| | Adams fund | 7,400.00 | | 7,400.00 | |
| | General support | 40,722.97 | 27,148.65 | 13,574.32 | |
| Entomology | Investigation of injurious insects | 3,762.80 | | 3,762.80 | |
| | Morrill fund | 1,200.00 | 1,200.00 | | |
| | Nelson fund | 1,400.00 | 1,400.00 | | |
| | Hatch fund | 1,500.00 | | 1,500.00 | |

DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1914-1915—*Continued*

| | Fund | Total | College and School | Experiment Station | Extension |
|---|---|---|---|---|---|
| Entomology | Adams fund | 1,900.00 | ..... | 1,900.00 | ..... |
| | General support | 2,821.79 | 2,116.35 | 705.44 | ..... |
| Forestry | Forestry | 17,141.55 | 12,856.17 | 4,285.38 | ..... |
| | General support | 3,600.00 | 3,600.00 | ..... | ..... |
| Agricultural Economics | Marketing investigation | 3,159.52 | ..... | 3,159.52 | ..... |
| | General support | 3,523.30 | 1,761.65 | 1,761.65 | ..... |
| Agricultural Education | Nelson fund | 1,100.00 | 1,100.00 | ..... | ..... |
| | General support | 13,946.10 | 13,946.10 | ..... | ..... |
| Home Economics | Nelson fund | 1,150.00 | 1,150.00 | ..... | ..... |
| | General support | 26,701.94 | 26,701.94 | ..... | ..... |
| Veterinary | Hog cholera | 12,931.70 | ..... | 12,931.70 | ..... |
| | Hog cholera serum | 33,283.08 | ..... | 33,283.08 | ..... |
| | Hog cholera serum manufacturing | 15,715.21 | ..... | 15,715.21 | ..... |
| | Nelson fund | 1,000.00 | ..... | 1,000.00 | ..... |
| | Hatch fund | 1,400.00 | ..... | 1,400.00 | ..... |
| | General support | 7,010.03 | 3,505.01 | 3,505.02 | ..... |
| Library | Library special | 9,808.62 | 4,904.31 | 4,904.31 | ..... |
| | General support | 1,734.25 | 867.13 | 867.12 | ..... |
| Bee Culture | Bee-keeping special | 3,216.54 | 1,608.27 | 1,608.27 | ..... |
| | Bee-keeping investigation | 837.79 | 418.89 | 418.90 | ..... |
| Special Buildings and Repairs | General support | 325.00 | 162.50 | 162.50 | ..... |
| | Repairs | 20,532.20 | 15,399.15 | 5,133.05 | ..... |
| | General support | 11,144.81 | 8,358.61 | 2,786.20 | ..... |
| | Campus maintenance | 3,032.19 | 3,032.19 | ..... | ..... |
| Extension | Agricultural extension | 64,025.90 | ..... | ..... | 64,025.90 |
| | Smith-Lever fund | 10,000.00 | ..... | ..... | 10,000.00 |
| Coal | Coal | 25,228.00 | 12,614.00 | 12,614.00 | ..... |
| Total University Farm | | $593,281.85 | $261,773.44 | $254,519.62 | $76,988.79 |



RECEIPTS AND DISBURSEMENTS OF THE DEPARTMENT OF AGRICULTURE FOR THE FISCAL YEAR 1914-1915

| | | | |
|---|---|---|---|
| University Farm | | | |
| Allotment for General Support budget | | $235,749.00 | |
| Balance, General Support, Aug. 1, 1914 | | 3,656.80 | |
| Credit by transfer from Book Store | | 3,725.30 | |
| Receipts credited to Support budget | | 2,671.72 | |
| Total receipts, General Support | | | $245,802.82 |
| Appropriation for Special Funds budget | | 197,000.00 | |
| Balance Special Funds, Aug. 1, 1914 | | 20,167.91 | |
| Receipts from Farm sales credited to Special Funds | | 59,350.45 | |
| Total receipts, Special Funds | | | 276,518.36 |
| Allotment for Coal | | 25,000.00 | |
| Receipts credited to Coal budget | | 228.00 | |
| Total receipts for Coal | | | 25,228.00 |
| Receipts from Farm sales to General University | | 24,145.26 | |
| Receipts from School and College fees, General University | | 24,374.94 | |
| Total receipts to General University | | | 48,520.20 |
| Receipts from United States Government | | | 71,000.00 |
| Expenditures, General Support | $237,611.70 | | |
| Expenditures, Special Funds | 259,442.15 | | |
| Expenditures, Coal | 25,228.00 | | |
| Expenditures, Receipts to General University | 48,520.20 | | |
| Expenditures, Federal Funds | 71,000.00 | | |
| | $641,802.05 | | $667,069.38 |
| Balance, Aug. 1, 1915, General Support | 8,191.12 | | |
| Balance, Aug. 1, 1915, Special Funds | 17,076.21 | | |
| | $667,069.38 | | $667,069.38 |

To get actual disbursements, deduct receipts credited to General University, and Balances August 1, 1915, from total expenditures.

## Receipts and Disbursements of Substations

| | | |
|---|---|---|
| **Crookston** | | |
| Appropriations for Maintenance | | $39,900.00 |
| Balance Aug. 1, 1914 | | 4,187.03 |
| Receipts, Farm sales | | 7,660.70 |
| Receipts, School fees and miscellaneous sales | | 3,894.67 |
| Expenditures, Maintenance | $53,943.78 | |
| Balance Aug. 1, 1915 | 1,698.62 | |
| | $55,642.40 | $55,642.40 |
| **Morris** | | |
| Appropriations for Maintenance | | 25,000.00 |
| Receipts, Farm sales | | 3,860.12 |
| Receipts, School fees | | 2,108.80 |
| Expenditures | 30,128.01 | |
| Balance, Aug. 1, 1915 | 840.91 | |
| | $30,968.92 | $30,968.92 |
| **Grand Rapids** | | |
| Appropriations for Maintenance | | 7,000.00 |
| Balance, Aug. 1, 1914 | | 405.96 |
| Receipts from Farm sales | | 9,195.59 |
| Expenditures | 16,043.44 | |
| Balance, Aug. 1, 1915 | 558.11 | |
| | $16,601.55 | $16,601.55 |
| **Duluth** | | |
| Appropriations for Maintenance | | 6,100.00 |
| Balance, Aug. 1, 1914 | | 7,029.02 |
| Receipts from Farm sales | | 1,104.61 |
| Expenditures | 11,377.25 | |
| Balance, Aug. 1, 1915 | 2,856.38 | |
| | $14,233.63 | $14,233.63 |
| **Waseca** | | |
| Appropriations for Maintenance | | 3,900.00 |
| Balance, Aug. 1, 1914 | | 3,254.63 |
| Receipts from Farm sales | | 3,073.04 |
| Expenditures | 7,425.46 | |
| Balance, Aug. 1, 1915 | 2,802.21 | |
| | $10,227.67 | $10,227.67 |
| Total Expenditures | $118,917.94 | |

## Special State Appropriations

### Disbursements for Maintenance 1914-1915

| | | |
|---|---|---|
| Eradication of noxious weeds | $1,607.24 | |
| Farm management | 4,505.70 | |
| Tobacco investigation | 2,664.77 | |
| Field crops | 10,091.00 | |
| Total, Agronomy and Farm Management | | $18,868.71 |
| Agricultural engineering investigations | 716.00 | |
| Drainage problems | 1,941.78 | |
| Total, Agricultural Engineering | | 2,657.78 |



## Special State Appropriations—*Continued*

### Disbursements for Maintenance 1914-1915

| | | |
|---|---|---|
| Forward | | $21,526.49 |
| **Plant diseases** | 3,095.47 | |
| Seed analysis | 1,856.09 | |
| Seed inspection | 4,985.07 | |
| Bacteriology investigation | 1,081.57 | |
| Total, Plant Pathology and Botany | | 11,018.20 |
| Grain laboratory | 2,550.54 | |
| Sorghum sirup | 1,232.99 | |
| Total, Chemistry | | 3,783.53 |
| Soil investigations | 2,221.75 | |
| Total, Soils | | 2,221.75 |
| Campus improvement | 3,032.19 | |
| Fruit breeding | 5,172.04 | |
| Fruit farm maintenance | 3,198.09 | |
| Horticultural crops | 3,279.81 | |
| Total, Horticulture | | 14,682.13 |
| Animal nutrition investigation | 5,333.01 | |
| Dairy extension | 9,962.89 | |
| Livestock | 6,895.24 | |
| Poultry extension | 6,604.00 | |
| Total, Dairy and Animal Husbandry | | 21,795.14 |
| Investigation of injurious insects | 3,762.80 | |
| Total, Entomology | | 3,762.80 |
| Forestry | 17,141.55 | |
| Total, Forestry | | 17,141.55 |
| Marketing and agricultural organizations | 3,159.52 | |
| Total, Agricultural Economics | | 3,159.52 |
| Hog cholera | 12,931.70 | |
| Hog cholera serum | 33,283.08 | |
| Hog cholera serum manufacturing | 15,715.21 | |
| Total, Veterinary | | 61,929.99 |
| Total, Agricultural Extension | 64,025.90 | 64,025.90 |
| Repairs | 20,532.20 | 20,532.20 |
| Library | 9,808.62 | 9,808.62 |
| Bee-keeping | 837.79 | |
| Bee-keeping, special | 3,216.54 | |
| Total, Bee-keeping | | 4,054.33 |
| Total, Disbursements for maintenance | $259,442.15 | $259,442.15 |

DETAILED STATEMENT OF SPECIAL STATE APPROPRIATIONS

| | Appropriation | Balance Aug. 1, 1914 | Receipts | Transfers | Total Credits | Disbursements | Transfers | Total Disbursements | Balance Aug. 1, 1915 |
|---|---|---|---|---|---|---|---|---|---|
| Eradication of noxious weeds | $1,000.00 | $827.08 | $616.60 | ..... | $2,443.68 | $1,607.24 | $120.00 | $1,727.24 | $716.44 |
| Farm management | 4,500.00 | 5.84 | ..... | ..... | 4,505.84 | 4,505.70 | ..... | 4,505.70 | .14 |
| Tobacco investigations | 2,000.00 | 1,348.98 | ..... | ..... | 3,348.98 | 2,664.77 | ..... | 2,664.77 | 684.21 |
| Field crops | 6,500.00 | 1,677.78 | 3,456.45 | ..... | 11,634.23 | 10,091.00 | ..... | 10,091.00 | 1,543.23 |
| Total, Agronomy | 14,000.00 | 3,859.68 | 4,073.05 | ..... | 21,932.73 | 18,868.71 | 120.00 | 18,988.71 | 2,944.02 |
| Agricultural engineering investigations | 1,000.00 | 308.03 | ..... | ....450.00 | 1,758.03 | 716.00 | 510.00 | 1,226.00 | 532.03 |
| Drainage | 2,500.00 | 1,163.67 | ..... | ..... | 3,663.67 | 1,941.78 | 1,450.00 | 3,391.78 | 271.89 |
| Repairs | 17,500.00 | 2,111.44 | 2,144.20 | ..... | 21,755.64 | 20,532.20 | ..... | 20,532.20 | 1,223.44 |
| Total, Agricultural Engineering | 21,000.00 | 3,583.14 | 2,144.20 | ..... | 27,177.34 | 23,189.98 | 1,960.00 | 25,149.98 | 2,027.36 |
| Plant diseases | 2,000.00 | 98.51 | 56.17 | 1,119.96 | 3,274.64 | 3,095.47 | ..... | 3,095.47 | 179.17 |
| Seed analysis | 1,500.00 | 2.55 | 436.00 | ..... | 1,938.55 | 1,856.09 | ..... | 1,856.09 | 82.46 |
| Seed inspection | 5,000.00 | ..... | 1.80 | ..... | 5,001.80 | 4,985.07 | ..... | 4,985.07 | 16.73 |
| Bacteriology | 1,500.00 | 379.34 | ..... | ..... | 1,879.34 | 1,081.57 | 719.96 | 1,801.53 | 77.81 |
| Total, Plant Pathology and Botany | 10,000.00 | 480.40 | 493.97 | ..... | 12,094.33 | 11,018.20 | 719.90 | 11,738.16 | 356.17 |
| Grain laboratory | 2,500.00 | 106.44 | 12.34 | ..... | 2,618.78 | 2,550.54 | ..... | 2,550.54 | 68.24 |
| Sorghum sirup | 1,000.00 | 6.73 | ..... | ....410.00 | 1,416.73 | 1,232.99 | ..... | 1,232.99 | 183.74 |
| Total, Chemistry | 3,500.00 | 113.17 | 12.34 | ..... | 4,035.51 | 3,783.53 | ..... | 3,783.53 | 251.98 |
| Soil investigation | 2,000.00 | 57.82 | 32.10 | 150.00 | 2,239.92 | 2,221.75 | ..... | 2,221.75 | 18.17 |



DETAILED STATEMENT OF SPECIAL STATE APPROPRIATIONS—*Continued*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Campus improvement | 3,000.00 | 43.71 | ..... | ..... | 3,043.71 | 3,032.19 | ..... | 3,032.19 | 11.52 |
| Fruit breeding | 5,500.00 | 82.64 | ..... | ..... | 5,582.64 | 5,172.04 | ..... | 5,172.04 | 410.60 |
| Fruit farm maintenance | 2,000.00 | 1,334.52 | 515.40 | ..... | 3,849.92 | 3,198.09 | ..... | 3,198.09 | 651.83 |
| Horticultural crops | 2,500.00 | 272.81 | 777.00 | ..... | 3,549.81 | 3,279.81 | ..... | 3,279.81 | 270.00 |
| Total, Horticulture | 13,000.00 | 1,733.68 | 1,292.40 | ..... | 16,026.08 | 14,682.13 | ..... | 14,682.13 | 1,342.95 |
| Animal nutrition investigations | 3,500.00 | 1,998.49 | 1,010.34 | ..... | 6,508.83 | 5,333.01 | ..... | 5,333.01 | 1,175.82 |
| Dairy extension | 3,300.00 | 81.49 | ..... | ..... | 3,381.49 | 2,962.89 | ..... | 2,962.89 | 418.60 |
| Livestock | 4,000.00 | 2,887.55 | 542.76 | ..... | 7,430.31 | 6,895.24 | ..... | 6,895.24 | 535.07 |
| Poultry extension | 5,000.00 | 684.22 | 1,245.31 | ..... | 6,929.53 | 6,604.00 | ..... | 6,604.00 | 325.53 |
| Total, Dairy and Animal Husbandry | 15,800.00 | 5,651.75 | 2,798.41 | ..... | 24,250.16 | 21,795.14 | ..... | 21,795.14 | 2,455.02 |
| Investigation of injurious insects | 3,500.00 | 143.24 | ..... | 120.00 | 3,763.24 | 3,762.80 | ..... | 3,762.80 | .44 |
| Total, Entomology | ..... | 143.24 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Forestry | 15,500.00 | 190.55 | 2,117.26 | ..... | 17,816.81 | 17,141.55 | ..... | 17,141.55 | 675.26 |
| Marketing investigations | 3,000.00 | 880.15 | ..... | ..... | 3,880.15 | 3,159.52 | 450.00 | 3,609.52 | 270.63 |
| Library | 9,000.00 | 1,145.74 | 8.25 | ..... | 10,153.99 | 9,808.62 | ..... | 9,808.62 | 345.37 |
| Agricultural Extension | 61,700.00 | 195.61 | 2,164.03 | ..... | 64,059.64 | 64,025.90 | ..... | 64,025.90 | 33.74 |
| Bee-keeping | ..... | ..... | ..... | 1,000.00 | 1,000.00 | 837.79 | ..... | 837.79 | 162.21 |
| Bee-keeping, special | 3,000.00 | 145.93 | 239.33 | ..... | 3,385.26 | 3,216.54 | ..... | 3,216.54 | 168.72 |
| Total, Bee-keeping | 3,000.00 | 145.93 | 239.33 | 1,000.00 | 4,385.26 | 4,054.33 | ..... | 4,054.33 | 330.93 |
| Hog cholera | 2,000.00 | 36.87 | 10,935.05 | ..... | 12,971.92 | 12,931.70 | ..... | 12,931.70 | 40.22 |
| Hog, cholera serum | 10,000.00 | 1,941.18 | 21,433.22 | ..... | 33,374.40 | 33,283.08 | ..... | 33,283.08 | 91.32 |
| Hog cholera serum manufacturing | 10,000.00 | ..... | 11,606.84 | ..... | 21,606.84 | 15,715.21 | ..... | 15,715.21 | 5,891.63 |
| Total, Hog Cholera | 22,000.00 | 1,978.05 | 43,975.11 | ..... | 67,953.16 | 61,929.99 | ..... | 61,929.99 | 6,023.17 |
| Total | $197,000.00 | $20,167.91 | $59,350.45 | $3,249.96 | $279,768.32 | $259,442.15 | $3,249.96 | $262,692.11 | $17,076.21 |

## Special Appropriations for Buildings and Improvements for Biennium 1913-1915

| | | |
|---|---|---|
| Home Economics Building | $75,000 | |
| Gymnasium and Drill Hall | 90,000 | |
| Trolley line | 60,000 | |
| Ice house and cold storage plant | 20,000 | |
| Greenhouse and equipment | 22,000 | |
| Addition and alterations to Veterinary Pathology Building | 18,250 | |
| Addition to Horse Barn | 5,000 | |
| Poultry house | 4,000 | |
| Alterations to Chemistry Building | 3,100 | |
| Addition to Dairy Hall | 8,000 | |
| Plant Pathology field house | 2,000 | |
| Alterations to Dining-Hall | 1,500 | |
| Storage cellar | 500 | |
| Renewal of equipment, Boys' Dormitory | 2,500 | |
| Campus grading, fences, etc | 15,000 | |
| Timber purchase at Cloquet | 8,600 | |
| Addition to heating plant | 26,000 | |
| Total, University Farm | | $355,450 |
| Heating plant and water softener | 40,000 | |
| Drainage, sewer, and greenhouse | 19,700 | |
| Grain storage and cleaning plant | 6,000 | |
| Machine shed, corn crib, and scales | 2,000 | |
| Addition to Swine Barn | 1,000 | (Available 1912) |
| Grading farm and school grounds | 2,000 | (Available 1912) |
| General improvements and repairs | 10,000 | (Available 1912) |
| Boys' Dormitory | 40,000 | |
| Total, Northwest School and Experiment Station | | 120,700 |
| Alterations, repairs, and equipment | 18,000 | |
| Total, West Central School and Experiment Station | | 18,000 |
| Purchase of livestock | 2,000 | |
| Clearing land | 3,000 | |
| Total, Northeast Demonstration Farm and Experiment Station | | 5,000 |
| Feeding sheds and yards | 1,500 | |
| Superintendent's house | 3,000 | |
| Alterations and remodeling old buildings | 3,500 | |
| Drainage | 1,000 | |
| Water system | 500 | |
| Fencing | 1,000 | |
| Institute Hall | 6,000 | |
| Purchase of livestock | 2,000 | |
| Purchase of seeds and plants | 500 | |
| Total, Southeast Demonstration Farm and Experiment Station | | 19,000 |
| Grand total, Department of Agriculture | | $518,150 |



## Statement of Receipts and Disbursements under Revolving Funds for University Farm and Substations for the Fiscal Year 1914-1915

| | Univ. Farm Din. Hall | Univ. Farm Book Store | Univ. Farm Photo Lab. | Univ. Farm Gym. |
|---|---|---|---|---|
| Pay rolls | $14,166.21 | $2,544.54 | $604.00 | $277.50 |
| Photo supplies | ..... | ..... | 905.89 | ..... |
| Postage and stationery | 285.69 | 2,634.62 | ..... | 19.60 |
| Freight and express | 107.82 | 145.16 | ..... | .25 |
| Heat, light, and power | 6,084.65 | ..... | ..... | ..... |
| Drugs and sundries | 49.43 | ..... | ..... | ..... |
| Confectionery | ..... | 4,290.05 | ..... | ..... |
| Feeding stuffs | 449.72 | ..... | ..... | ..... |
| Provisions | 37,650.38 | ..... | ..... | ..... |
| Text books | ..... | 5,155.77 | ..... | ..... |
| Tools and machinery | 441.95 | 74.42 | 2.77 | ..... |
| Furniture and fixtures | 1,037.12 | 9.20 | 71.75 | 57.61 |
| Gymnasium supplies | ..... | ..... | ..... | 379.46 |
| Traveling expense | ..... | ..... | ..... | ..... |
| Laundry | 4,426.52 | ..... | ..... | ..... |
| Repairs | 573.09 | ..... | ..... | 1.75 |
| Total | $65,272.58 | $14,853.76 | $1,584.41 | $736.17 |

| | Univ. Farm Hospital | Crookston Din. Hall | Morris Din. Hall | Total |
|---|---|---|---|---|
| Pay rolls | $1,333.96 | $3,172.19 | $3,568.88 | $25,667.28 |
| Photo supplies | ..... | ..... | ..... | 905.89 |
| Postage and stationery | ..... | 52.00 | ..... | 2,991.91 |
| Freight and express | .40 | 68.31 | ..... | 321.94 |
| Heat, light, and power | ..... | 1,141.05 | 2,275.20 | 9,500.90 |
| Drugs and sundries | 162.32 | ..... | ..... | 211.75 |
| Confectionery | ..... | ..... | ..... | 4,290.05 |
| Feeding stuffs | ..... | ..... | ..... | 449.72 |
| Provisions | ..... | 8,079.81 | 6,184.57 | 51,914.76 |
| Text books | ..... | ..... | ..... | 5,155.77 |
| Tools and machinery | ..... | 88.77 | ..... | 607.91 |
| Furniture and fixtures | 31.33 | 296.18 | 46.85 | 1,550.04 |
| Gymnasium supplies | ..... | ..... | ..... | 379.46 |
| Traveling expenses | 14.90 | ..... | ..... | 14.90 |
| Laundry | ..... | 931.22 | 835.89 | 6,193.63 |
| Repairs | ..... | ..... | ..... | 574.84 |
| Total | $1,542.91 | $13,829.53 | $12,911.39 | $110,730.75 |

| | |
|---|---|
| Receipts Dining Hall, University Farm | $66,926.59 |
| Receipts Book Store, University Farm | 17,497.63 |
| Receipts Photo Laboratory, University Farm | 3,002.97 |
| Receipts Gymnasium, University Farm | 803.09 |
| Receipts Hospital, University Farm | 1,545.68 |
| Receipts Dining-Hall, Crookston | 15,640.23 |
| Receipts Dining-Hall, Morris | 13,618.74 |
| Total receipts | $119,034.93 |
| Total expenditures | 110,730.75 |
| Balance, Aug. 1, 1915 | $8,304.18 |

# REPORT OF THE DIRECTOR

Very few changes were made in the staff during the year. Kenneth L. Warner of the section of Animal Husbandry resigned to accept a position in the extension service of the University of Nebraska. L. D. H. Weld, Chief of the Division of Research in Agricultural Economics, resigned to accept a similar position at Yale. E. Dana Durand has been appointed to this vacancy. O. B. Jesness, assistant in Agricultural Economics, accepted a position in the Division of Markets of the National Department of Agriculture. E. W. Major of the section of Dairy Nutrition, resigned to take charge of a large stock farm in California. Stephen Anthony, chemist in the nutrition laboratory, resigned to accept a position with the Bureau of Plant Industry of the United States Department of Agriculture. H. R. Smith, head of the section of Animal Husbandry, resigned to accept a position as livestock expert with the First National Bank of St. Paul. DeForest Hungerford, Assistant Soils Chemist, resigned to accept a position at Fayetteville, Arkansas. J. T. E. Dinwoodie was appointed in the section of Biological Products in the Division of Veterinary Science. L. V. France was appointed assistant in the Division of Bee Culture, beginning August 1, 1915.

A cold storage plant was completed during the year and will be equipped and made available for general Station use as needed. A new wing was added to the horse barn. A new hyperimmune building, a bleeding building, and a receiving shed and scale room were added to the hog cholera plant. A new poultry brooder-house was completed. A new field laboratory was begun for the use of the plant pathological investigations and plans were completed for an $18,000 addition to the research laboratories of animal pathology. At Waseca, a superintendent's house was completed and a new barn planned and partly constructed.

Important changes in the method of publishing the results of the Station's research work were inaugurated during the year. In addition to the general Station and Extension series of bulletins, a Special series was established, in which will be published material intended for special distribution to particular groups of readers or localities. Seven General, two Press, two Special, and four Extension bulletins were issued. The plan of submitting articles embodying the more technical results of Station work for publication in scientific journals was adopted and sixteen such articles were accepted by editorial boards for publication.

Eighty major projects were under investigation by the Station staff during the year, covering every important phase of agriculture of interest to Minnesota, including rural organization and marketing. In order to secure closer coördination of the work of the various divisions of the Station and Substations, a plan of special conferences was inaugurated at which plans and projects were fully discussed and compared. Two or more of these conferences will be held each year. All of the projects of the central Station and Substations are now correlated and definite coöperation arranged.

Minnesota is peculiar in having in the southern part of the state an agriculture that is as highly developed as that of Iowa and in the northern part a very large area of fertile land still in forest and swamp. The range of problems includes everything between these two extremes. In the southern part of the state, problems of farm management, organization, and marketing, the control of plant diseases and insect pests, diseases of livestock, problems of crop rotation, soil fertility, crop improvement by breeding and selection, and the adaptation of crops to soil types need investigation. In the north-central and northeastern parts of the state, the problems are mainly those connected with the clearing of the land, the determination of the types of agriculture to which the soil is adapted, and the securing of varieties adjusted to the limiting factors of the soil and climate. In the northwestern section, in the rich Red River Valley, where wheat-growing has dominated, there is now a transition to diversified farming and stock-raising. The important problems are rotation, soil improvement through the introduction of organic matter, and in some places the use of fertilizers and drainage. It is possible, therefore, to secure material for fundamental agricultural research work, which is at the same time of immediate importance.

The Adams Fund projects include nutrition investigations with special reference to meat-production; a study of inheritance of fruit characters with special reference to hardiness; investigations of the rusts of cereals with special reference to the problems of resistance and immunity; the movement of water in soils and a study of glacial soils on the Gray Drift, with special reference to the relation of chemical composition to age and texture of soil types; a study of the strength of wheat flour; the chemistry of plant disease-resistance, a project carried on in coöperation with the investigations on cereal rusts. A further discussion of the results under these projects will be found in the following paragraphs.

In previous reports a brief summary has been included covering the work of Agricultural Extension. Hereafter that report will be published separately.



## PUBLICATIONS

The following publications have been issued since the last annual report:

### EXPERIMENT STATION SERIES

Bulletin 143. Minnesota Wheat Investigations, Series III; Composition and Quality of Spring and Winter Wheats, Crops of 1912 and 1913, by C. H. Bailey, Cereal Technologist, Division of Agricultural Chemistry. 58 pp. 5,000 edition.

144. Pollen Development in the Grape with Special Reference to Sterility, by M. J. Dorsey, Division of Horticulture. 60 pp. 2,000 edition.

145. The Cost of Producing Minnesota Farm Products, 1908-1912; Field Crops, by F. W. Peck, Assistant Agriculturist, Division of Agronomy and Farm Management. 48 pp. 7,000 edition.

146. Statistics of Coöperation Among Farmers in Minnesota, 1913, by L. D. H. Weld, Chief of Division of Research in Agricultural Economics. 24 pp. 8,000 edition.

147. First Annual Seed Laboratory Report, 1913-1914, by W. L. Oswald, in charge of Seed Laboratory, Division of Plant Pathology and Botany. 20 pp. 7,500 edition.

148. Barley Investigations, by C. P. Bull, Associate Agronomist, Division of Agronomy and Farm Management. 48 pp. 5,000 edition.

149. Corn; Part I. Relation of Cultivation to Yield and Character of Crop; Part II. Relation of Number of Stalks per Hill to Yield, by C. P. Bull, Associate Agronomist, Division of Agronomy and Farm Management. 24 pp. 10,000 edition.

150. Tobacco-Growing in Minnesota, by C. P. Bull, Associate Agronomist, Division of Agronomy and Farm Management. 48 pp. 10,000 edition.

Bulletin 136, Rope and Its Uses on the Farm, by J. B. Frear, formerly of the Division of Agricultural Engineering, was reprinted. 88 pp. 10,000 edition.

### PRESS BULLETIN SERIES

No. 46. Foot-and-Mouth Disease, by M. H. Reynolds, Chief of Division of Veterinary Science. 12 pp. 5,000 edition.

After the publication of this bulletin the series was discontinued and a new Special series was established in its stead in which will be published bulletins which are not the results of original research, and those designed to meet a particular need but not of general interest.

### SPECIAL SERIES

No. 1. Spraying Calendar, by A. G. Ruggles, Division of Entomology, and E. C. Stakman, Division of Plant Pathology and Botany. 4 pp. 10,000 edition.

No. 2. Hog Cholera and the Use of Serum, by H. Preston Hoskins, Division of Veterinary Science. 32 pp. 15,000 edition.

AGRICULTURAL EXTENSION SERIES

MINNESOTA FARMERS' LIBRARY

No. 53. Sausage-Making, by W. C. Kalash, Division of Dairy and Animal Husbandry.

No. 54. Mosquitoes and Their Control, by C. W. Howard, Division of Entomology.

No. 55. Some Four-Footed Farm Pests, by F. L. Washburn, Division of Entomology.

No. 56. Farmers' Clubs; Report of Progress and Suggested Programs for 1915, by Division of Agricultural Extension.

ARTICLES PUBLISHED BY MEMBERS OF STATION STAFF IN SCIENTIFIC JOURNALS

Early in the year, the plan was adopted of submitting articles containing the more technical results of the Station's research work, which would be of interest to scientific workers rather than to farmers of the state, for publication in appropriate scientific journals. Each manuscript, before submission to the editor of a journal, is approved for publication by the Director, and three copies of the reprints, or separates, of the published article are supplied to the secretary of the Station staff for preservation as a part of the permanent records of the Station's work.

Following is a list of the articles which were published in this way during the last year, and a brief summary of the contents:

"A Fruit Spot of the Wealthy Apple," by E. C. Stakman and R. C. Rose. In *Phytopathology*, Vol. 4, No. 4 (August, 1914), pp. 333-336, pl. 1.

A brief account of the occurrence of the disease on different varieties, isolation of the causal organism, and infection experiments.

"The Artificial Fertilization of Queen Bees," by Francis Jager and C. W. Howard. In *Science*, N. S., Vol. 40, No. 1037 (November 1, 1914), p. 720.

A preliminary report of a successful attempt to artificially fertilize a queen bee.

"Identification of the Seeds of Species of Agropyron," by Robert C. Dahlberg. In *Journal of Agricultural Research*, Vol. III, No. 3 (December 15, 1914), pp. 275-281, pl. 4, figs. 4.

A careful description of the characters of lemma, palea, and rachilla of the seeds of three species of Agropyron; *A. repens, A. smithii,* and *A. tenerum;* which may be used to distinguish these species in commercial seed mixtures An accurate method of diagnosis is described.



"Observations on the Life History of *Agrilus bilineatus,*" by Royal N. Chapman. In *Journal of Agricultural Research*, Vol. III, No. 4 (January 15, 1915), pp. 283-293, pl. 2.

A report of new observations on the life history and ecological relations of the two-lined chestnut borer, which causes the death of many oak trees in this state, with preliminary investigations of methods of control by spraying.

"Life History of *Oberea tripunctata* Swed.," by A. G. Ruggles. In *Journal of Economic Entomology*, Vol. 8, No. 1 (February, 1915), pp. 79-85, figs. 6.

New observations of the life history of this insect, following serious damage by this new pest on elms in Minnesota.

"Some Observations on Hog Cholera and the Use of Serum," by H. Preston Hoskins. In *American Veterinary Review*, Vol. 47, Nos. 1 and 2 (April and May, 1915), pp. 46-56 and 188-196.

A semi-technical discussion of the methods of diagnosis of the disease, of the different immunization methods, of the proper sanitary precautions to be observed, and of the possibilities of a fixed hog cholera virus and of attenuated virus vaccines, with suggestions of modes of preservation and use of serum growing out of the author's extended experience in its use.

"Notes on the Hydrocyanic-Acid Content of Sorghum," by J. J. Willaman and R. M. West. In *Journal of Agricultural Research*, Vol. IV, No. 2 (May 15, 1915), pp. 179-185, figs. 2.

A report of a study of the effect of available nitrogen in the soil upon the hydrocyanic-acid content of sorghum grown on it, and of the distribution of the prussic acid in different parts of the plant at successive stages of growth. Also a description of a new modification of the method of determination of hydrocyanic acid in plant tissues.

"On the Origin of the Humin Formed by the Acid Hydrolysis of Proteins," by R. A. Gortner and M. J. Blish. In *Journal of American Chemical Society*, Vol. XXXVII, No. 6 (June, 1915), pp. 1630-1636.

A report of a study of the effect of the presence of various carbohydrates and of tryptophane upon the proportion of humin-nitrogen in the products of acid hydrolysis of proteins.

"The Action of Potassium Cyanide when introduced into Tissues of a Plant," by William Moore and A. G. Ruggles. In *Science*, N. S., Vol. XLII, No. 1070 (July 2, 1915), pp. 33-36.

A critical review of recent investigations on this subject, accompanied by observations made by the authors of the rate and method of diffusion of potassium cyanide and hydrocyanic acid through the plant, when the cyanide is introduced into the tissues in various ways, and of the value of the cyanide as an insecticide when so used.

## DIVISION OF AGRICULTURAL CHEMISTRY

R. W. THATCHER, Chief

Definite progress has been made during the year on most of the projects under investigation in this division. Two new projects were inaugurated. Several of the problems under investigation were brought

to definite conclusion, and as a result, certain of the projects, or subprojects, have been reported as completed. The results obtained have been published, generally in some scientific journal or in the *Journal of Agricultural Research,* or are being prepared for publication.

The plan of assigning certain phases of investigation of Station projects to graduate students as thesis problems continues to work very satisfactorily and a considerable proportion of the progress made has resulted from this plan.

Attention should be called again to the need for better laboratory facilities for research in agricultural chemistry. The present quarters of the division were originally intended chiefly for students' laboratories, especially for elementary work, and are not well adapted to research purposes. The addition of special research equipment has improved conditions very materially, but facilities for continuous operation of many research methods are urgently needed.

The progress of the work on the several projects may be briefly summarized as follows:

*Cereal and flour investigations.*—The original purpose of the cereal and flour investigations was to afford control tests for various state boards and institutions, and to conduct such investigations as might be needed to make these tests most efficient. The latter investigations were formulated as subprojects. The progress of the work on each of these subprojects during the last year is shown below.

Subproject: *Control work for state departments.*—The State Board of Control and the several institutions for which it makes purchases sent in sixty samples of flour during the eight months from August 1, 1914, to April 1, 1915, the period covered by this report. These samples were submitted to the necessary tests to determine their baking quality, and the results form the basis for flour-purchase contracts.

Subproject: *Wheat survey of the state.*—The systematic collection of samples from growers in all parts of the state was practically completed with the third year's work, which dealt with the crop of 1913. The work with the crop of 1914 consisted chiefly of a comparative study of samples of Marquis and Bluestem wheat grown under the same conditions. Seventeen samples were analyzed and tested. This subproject will now be discontinued, and further investigations confined to a study of different wheats grown under controlled conditions as a part of the project on coöperative wheat investigations.

Subproject: *Milling value of winter wheat.*—Only four samples of winter wheat were analyzed and tested during the last year. This subproject will be discontinued and further studies merged with the coöperative wheat investigations, just mentioned.



Subproject: *Wheat storage investigations.*—The investigations mentioned in last year's report were concluded in August and a report of their results furnished to all the coöperating institutions. Market conditions since that time have been such that grain could not be held continuously in store in sufficient quantities or for a sufficient length of time to permit further studies. These must necessarily be postponed until economic conditions become more settled.

*Coöperative wheat investigations.*—The investigations of the fundamental principles of the chemical composition of wheat and the factors governing them were in active operation during the year. The work on each subproject was as follows:

Subproject: *The influence of environment on the composition and milling quality of wheat.*—Fife, Bluestem, Velvet Chaff, and Marquis wheat were grown at Morris, Crookston, and University Farm. Complete meteorological and crop records were kept and samples of the different varieties analyzed and tested.

The wheats grown on the two-, three-, four-, five-, and seven-year rotation plots and on the continuous-cropping plots in Fields C and T at University Farm were also sampled and analyzed to determine the effect of cultural methods on the quality of the grain.

Subproject: *The progressive development of the wheat kernel.*—About 3,000 heads of each of three different varieties of spring-sown grain were tagged at the time when each showed its first anthers. Beginning seven days later, samples were taken from these tagged heads at three-day intervals until they were fully ripe. The grain from these samples was threshed and cleaned by hand and complete determinations of its physical and chemical composition were made. The data are ready for publication. They are very conclusive concerning the composition of the material which the plant moves into the kernels during the entire development period, and point the way to further investigations concerning the physiology and chemistry of kernel-development.

*The "strength" of wheat flour.*—The study of the enzymes of flours of varying strength was continued during the early part of the year, but was interrupted by the resignation of the assistant who was carrying on the work. Satisfactory methods for the quantitative extraction of diastases and invertases were worked out and a beginning was made in the investigation of the application of these to the study of flour strength. This work will be resumed early in the coming year and will be extended to include proteolytic enzymes and oxidases.

The investigations of the chemical constitution of the proteins of flours of varying strength were brought to definite conclusions. It was shown that the individual proteins have the same chemical constitution regardless of the quality of the flour; that variations in the gliadin-

glutenin ratio, which have been reported by many investigators, are not real variations, but are due to variable extractions by the solvents used; and that the real relation between the proteins and flour strength lies in the proportion of "soluble proteins" present in the flour. A method for estimating this factor in flours was worked out. The results of this study have been prepared for publication.

*Sorghum sirup investigations.*—Sorghum sirup investigations have been in very active progress throughout the year. The following phases of the work have been brought to a definite conclusion, and the results are being prepared for publication; the development of the different sugars during the maturing of the plant; the development of acids during the same period; the location of the sugars in the plant; the use of lime as a defecating agent, and its effect upon the quality and composition of the sirup; the utilization of the bagasse for silage; the effect of available nitrogen in the soil on the development of the cyanogenetic glucoside in the plant; a method of preservation of samples of juice for analysis, and a modified method for determining the moisture content of sirups by means of calcium carbide.

Definite progress was also made on the collection of statistics concerning the present conditions of sirup manufacture and marketing and of utilization of by-products; and on the studies of the effect of topping upon the development of sugar in the cane; the storing of cane as a means of lengthening the campaign; and the utilization of by-products. Further work on these phases of the project will be carried on during the coming year, together with that on certain new phases which have suggested themselves. It is hoped that all of these matters may be brought to successful conclusion during the coming year.

*Wild rice investigations.*—A visit was made to the rice fields in several parts of the state, and samples of the entire plant and of the grain in various stages of preparation for use as human food were secured. These were submitted to thoro analyses and a complete knowledge of the composition of the material is now available. Work for the coming year will deal with methods of preparing the rice for food in a sanitary and economical manner.

*Grains grown in mixtures.*—Wheat grown in mixtures with oats and flax was analyzed, milled, and tested. The results of this and of the preceding season's work show that no uniform relation exists between the quality of wheat grown alone and that grown in mixtures with barley, oats, or flax. This definite conclusion having been reached, work on this project will be discontinued.

*The cider- and vinegar-making quality of Minnesota apples.*—Six samples of cider, made from different varieties of Minnesota-grown apples by the Division of Horticulture, were analyzed and the data are on file for future comparisons.



*Investigation of proposed official methods of analysis.*—Coöperative work during the last year included studies of proposed methods for the analysis of insecticides and fungicides on samples submitted by the referee on that subject of the Association of Official Agricultural Chemists, and of the methods for milling and baking tests proposed by the executive committee of the American Society of Milling and Baking Technology. Reports of this work were furnished to the proper officials and will appear in the published proceedings of the societies.

*Analytical service for other divisions.*—One of the important duties of this division is the furnishing of analytical service to the other divisions and the Substations. A considerable volume of this kind of work is done each year and this will doubtless increase as the number of projects in other divisions, in which the chemical composition of the materials used is a factor, increases. During the last year, facilities were provided for making several hundred determinations of dry weight of corn in samples submitted to the Division of Agricultural Extension in connection with the state-wide boys' corn-growing contest; determinations of dry matter were made on 417 samples of alfalfa and 28 samples of mangel wurzels submitted by the Division of Agronomy and Farm Managemnt; determinations were made of the percentage of protein in the dry matter of each of 79 samples of various cuttings of alfalfa grown on plots which had been inoculated in different ways, submitted by the same division. One hundred and twenty-eight samples of sugar beets grown at Chaska by the same division were submitted to the usual determinations of the sugar content and coefficient of purity of the juice. Eight samples of feeds used in the pig-feeding experiments carried on by the Division of Dairy and Animal Husbandry were analyzed; and several individual tests of water, feeding-stuffs, insecticides, and fungicides were made for other divisions of the Station.

## DIVISION OF AGRICULTURAL ENGINEERING

J. T. Stewart, Chief

During the year the coöperative irrigation experiment with the Division of Irrigation Investigations, United States Department of Agriculture, and the Division of Plant Pathology and Botany, of this Station, has been continued as in former years.

The only work done during the year on peat investigations, tile tests, and methods and costs of drainage construction, has been the collecting of reports on work done in previous years and the gathering of information by correspondence.

Several visits were made to drained peat lands and other drainage work of interest. Considerable work has been done on the compilation of data on various subjects.

Manuscripts have been prepared on: Sanitation on the Farm, House Heating, Drainage by Wells, each 16 pages, and Lighting Farm Buildings, and House Water Supply, each 8 pages. Two of these, House Heating and Lighting Farm Buildings, have been published as Farmers' Library Bulletins.

## DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Chief

The organization of the division staff as proposed in the 1913-1914 report was maintained throughout the year without change. C. P. Bull returned from a year's leave of absence to take charge of the Section of Coöperative Seed Production and Distribution on August 1.

### SECTION OF COÖPERATIVE SEED-PRODUCTION AND DISTRIBUTION

*Seed-production and distribution.*—The plan of selling pedigreed seeds to farmers has been followed as in the past. A total of 718 bushels of the cereals and corn has been distributed among 208 farmers. Reports will be secured of the behavior of these varieties at the close of the crop year. There are nine coöperators in barley-testing, five in flax-testing, five in wheat-testing, twenty in oat-testing, and five in testing Canada field peas.

*Corn-breeding and testing.*—The corn trial stations established in former years have been continued for the most part and coöperative arrangements have been made with additional farmers and growers. There are now 29 coöperative corn-breeding and testing stations where varieties of field corn are being propagated and tested. Increased interest in sweet-corn breeding has been encouraged and eight sweet-corn breeding stations are now established. These coöperative trials will be continued in various parts of the state with a view to securing varieties that are adapted to restricted localities.

*Tobacco-growing investigations.*—Tobacco-growing investigations were continued throughout the year. A good crop was harvested, but owing to unfavorable casing weather during the early part of the winter the advantage of a good early market was lost. A considerable number of farmers in Sherburne county have undertaken to grow tobacco this year for the first time. It is believed that tobacco-growing is well established in this locality and that it will fill a fairly large place in the cropping systems followed. Additional knowledge is needed of methods of curing and handling the crop under Minnesota weather conditions.



*Sorghum sirup industry in Minnesota.*—Studies of the sorghum sirup industry in Minnesota in coöperation with the Division of Agricultural Chemistry have received some attention through the year, tho the tests of varieties were lost. A new planting has been made and the study will be continued.

*Wild rice investigations.*—Owing to the fact that wild rice was a poor crop in 1914, but little progress was made on the study of production and of its preparation as human food. Some general information was obtained by visiting the rice fields, and plans are made to continue the work through this crop year.

*Sugar beet seed-production.*—The Minnesota Sugar Company, of Chaska, has continued in the coöperative agreement for the breeding of sugar beet seed. Selections of plants were made last year. Seedlings were grown and these have been put out for seed-production this year. No seed stocks have been planted this year and work will be discontinued until the tests previously made have been summarized.

### SECTION OF FARM CROPS

*Investigations with small grains.*—Investigations with small grains have been continued as outlined in the projects. The work on the value of different grades of seed oats has brought out the following interesting points: (1) The heavier seed gave a larger increased return for the labor and trouble of preparation. (2) With certain varieties of oats there appears to be an advantage in thicker seeding. (3) The early oat, Minnesota No. 261, a selection from the Kherson variety, outyielded the medium early oats in this season's trials. The experiment on the rate of seeding wheat indicates, for the years 1913-1914, a substantial increase from thick seeding. A bushel and three quarters of seed per acre yielded 2.2 bushels more than only 1.25 bushels, the amount commonly used in Minnesota where grain is sown with a drill. Further tests will be made of the merits of thicker seeding.

Variety tests of wheat, oats, and barley were continued and comparable data secured. Several new varieties of wheat will be increased for trial in various parts of the state.

*Forage crop investigations.*—A comparison of different methods of planting field corn for ensilage was undertaken in the spring of 1914, to learn what conditions would give the largest yield of ensilage corn of the best quality. The corn was cut separately and fed to dairy cattle. The experiment is being repeated in 1915 with a view to getting additional data.

The studies of the methods of sowing alfalfa indicate that as good stands are secured where nurse crops are used as where the alfalfa is sown alone. Much depends, however, on the preparation of the land and its freedom from weeds. The tests indicate that where alfalfa

is sown alone best stands will be obtained from July seeding. Less trouble is experienced, also, in keeping down the weeds when sown at that time. Seeding in August after potatoes or barley are removed from the land did not give as good stands or as good yields the year following as did the early seeding. Inoculation of alfalfa increased the yield and gave a product richer in protein. The soil transfer method of inoculation gave somewhat better results than the commercial cultures. Lime added to the soil at University Farm gave a definite increase in yield per acre.

*Tests of Sudan grass.*—Tests of Sudan grass indicate that it may have a place among our forage crops. The average yield from all plots was 3.36 tons per acre. Where cut for seed, 700 pounds of seed were secured per acre. The best yield of hay was secured by drilling 24 pounds of seed per acre on June 15. The highest yield of seed was secured by sowing 40 pounds of seed with a grain drill on May 15.

*Tests of millet, oat-and-pea hay, and roots.*—Tests of millet and oat-and-pea hay, and of the production of roots for livestock-feeding, also were conducted during the year.

*Time, rate, and method of seeding sweet clover.*—Sweet clover was grown with oats as a nurse crop. Inoculation tests were made, also, using both alfalfa soil and sweet clover soil. Lime also was used in connection with this crop. Inoculation by transfer of sweet clover soil and the addition of lime gave by far the largest yield of sweet clover. Inoculation with sweet clover soil, without the lime, gave the next largest yield, and inoculation with alfalfa soil, plus lime, gave the third largest yield. Where no treatment was given the yield was comparatively small. Inoculation and lime, therefore, seem to be necessary on University Farm soil for the most successful growth of sweet clover.

### SECTION OF PLANT-BREEDING

*Investigations in cereal-breeding.*—About forty winter-wheat crosses and selections proved of sufficient promise so that they were placed in the preliminary variety test in the fall of 1915. Of these twenty-five are of such promise that they will be further tested, as they appear to be more hardy than Turkey red. This test will be made in several parts of the state. Further head-selections have been made, also a considerable series of new crosses, the object being to secure a combination of hardiness and yield.

The better crosses and selections of spring wheat and oats are being subjected to a final yield trial to determine. if possible, the most promising strains and to increase them for a state-wide test. In this connection a carefully planned test of the comparative reliability of centgener, rod-row, and field-plot methods of comparison of yield is



being carried out. Data will be secured in connection with recent selections and crosses on the mode of inheritance of various seed and plant characters. These new crosses are being made for the purpose of increasing stiffness of straw, rust-resistance, and yield. The work in barley-breeding is being carried on in coöperation with the Bureau of Plant Industry, United States Department of Agriculture.

A project which had as its object the shortening of the length of the stem of wheat between the head and the upper leaf, for the purpose of decreasing the amount of surface exposed to rust, has been discontinued, after fourteen years of selection. A careful study of the data accumulated has shown no progressive effect of continued selection.

*Corn-breeding investigations.*—Progress has been made on the new projects in corn-breeding started last year. In the study of inheritance of show points and the relation of yield, plants were secured from University Farm, Waseca, Crookston, and Monticello, and suitable ears have been used as foundations for further studies.

In the study of earliness in corn as affected by cross-breeding, temperature, and the use of commercial fertilizers, the results last year indicated that there was little corelation between earliness of germination and time of maturity and that there was no appreciable corelation shown to exist between the rapidity of germination of seed of the same ears when tested under different temperatures. All investigations will be repeated, however, as it is possible that a change in the methods followed may lead to different conclusions.

*Breeding of miscellaneous field crops.*—A new project has been prepared to cover work already started in breeding of miscellaneous field crops. A considerable number of individual soy bean selections are being grown for the purpose of obtaining a strain adapted to Minnesota conditions. Alfalfa-breeding is being continued. Those strains which have proved most promising from former centgener tests are being studied by the individual-plant method with a view to isolating higher yielding uniform types. Selection is being continued with millets and flax.

### SECTION OF COST ACCOUNTING

*Cost of farm products.*—The thirteenth year of consecutive statistical study regarding the cost of production has been completed on the route at Halstad, Norman county. Records of eight complete annual farm statements are on file. The same farms are on record this year and it is proposed to continue the work in that region until at least fifteen years' consecutive reports have been obtained. The statistical route at Cokato has been maintained, and two years' work completed. Records have been secured from twelve representative farms and the work is well established. Results from the Halstad and Cokato routes

are being compiled as fast as obtained and will be made the basis for future publications on time requirements and cost of production.

Cost accounting undertaken two years ago in coöperation with the United States Department of Agriculture is being continued. Eight farms furnished data last year. Ten farms are at present coöperating under the government requirements.

Studies of the cost of producing beef and pork were continued through the feeding-season. Owing to the fact that some of the men who had formerly coöperated did not buy cattle this year, records have been obtained from only eight. Feeding records have been obtained for three feeding-seasons and sufficient material is in hand to warrant publication.

The cost of producing market-garden crops has been studied again, thus ending the third season of the attempt to obtain cost figures on such crops as onions, cabbage, and cucumbers. The enterprise-survey method may be successfully used in securing cost data on similar crops, and during the latter part of the year some work was undertaken on learning the cost of production of sugar beets and of sweet corn for canning. Records have been kept during the last year of the time required for milking by hand as compared with that required when a milking machine is used. The work is not yet completed.

### SECTION OF FARM ORGANIZATION

*Eradication of noxious weeds.*—The investigations in methods of eradicating quack grass at Monticello were closed during the year. The results have been compiled and a bulletin is ready for publication.

Studies have also been made of the eradication of sow thistle and Canada thistle. Short-cycle crop rotations, clean cultivation, and prompt attention and tillage when the weeds are young are indicated as the best ways of preventing infestation.

*Crop rotation.*—The regular plan of cropping in the Field C rotations was followed, thus completing the twenty-year period. No change has been made in the cropping for the future, except to put in cleaning crops on fields that had become badly infested with weeds. These will be dropped back into the regular rotation as soon as they are in condition to take the regular crop.

The Field T rotations have also been continued as previously outlined. Studies have been made of the results of manuring and of the fertilizing.

*Farm management surveys.*—No additional data on farm management have been secured during the year. An effort has been made to compile the records already in hand.



## DIVISION OF BEE CULTURE

FRANCIS JAGER, Chief

The Division of Bee Culture has given special attention during the year to a study of the artificial fertilization of queens. Definite progress has been made and a brief preliminary report published. The apiary was greatly enlarged and equipment provided for developing pure-bred queens for the bee men of the state. About five hundred such queens were sold at 25 cents each but this proved to be less than cost so the price next season will be raised, probably to 50 cents. This work has been much appreciated by the bee men and it is hoped will do much to improve the quality of Minnesota apiaries. Assistance has been given to many bee men through the state, and interest in the work is growing rapidly.

## DIVISION OF DAIRY AND ANIMAL HUSBANDRY

T. L. HAECKER, Chief

Work on several projects had to be temporarily suspended because of the outbreak of foot-and-mouth disease in various parts of the country. It was impossible to secure the animals needed to carry on the work. Less progress was made than had been expected because of changes in the personnel of the staff. The resignation of E. W. Major, Associate in Animal Nutrition, and Stephen Anthony, Chief Chemist in the Section of Animal Nutrition, was a great loss to the division and has retarded and in a measure impaired our research work on the relation of Feed Nutrients to Animal Production and Animal Products. Both were specially adapted to research work and each has attained high rank in his special line.

The resignation of G. P. Plaisance has retarded progress in computations, in our nutrition studies. It is quite likely that all these changes could have been prevented if the attractive salaries offered elsewhere could have been met here.

Because of the loss of these assistants, similar work with sheep and swine will of necessity be delayed until the completion of the investigation with steers.

### SECTION OF ANIMAL HUSBANDRY

*Maintenance of dry brood sows.*—The swine investigation during the year, maintaining dry brood sows on pasture in comparison with dry feeding was carried on very satisfactorily, and the results again favored the lots kept on pasture both with respect to economy and the health and vitality of the swine.

*Nutrition of swine.*—Special studies in swine-nutrition will be inaugurated during the coming year, studying availability and utilization

of both organic and inorganic feed components and physical and economic effects of varying nutritive ratios in the feed.

*Lamb-feeding and steer-feeding.*—Experiments in the application of our present knowledge of feeding to the feeding of yearling steers and lambs for market the current year were omitted this year because of the outbreak of the foot-and-mouth disease. If conditions are favorable and available funds will permit, these experiments will be resumed the coming year.

SECTION OF DAIRY HUSBANDRY

*Creamery management investigation.*—The study of creamery management is being carried on with the coöperation of the state creamery, at Albert Lea. The special study at present is the relation of the reading of the Babcock milk test and the over-run of butter manufactured, and causes of the various losses of a mechanical nature in the process of manufacture. Definite and very important data have already been obtained, but further investigation on this phase of the work will be carried on during the coming year.

*Contagious bovine abortion.*—This project is conducted under the leadership of Dr. W. P. Larsen of the pathological section of the College of Medicine, with the coöperation of the Divisions of Veterinary Science and Dairy and Animal Husbandry. The work was started in the fall of 1911 and considerable progress has been made in spite of the shortness of time and money. The results thus far seem to warrant the work being carried forward on a larger scale.

SECTION OF ANIMAL NUTRITION

*Investigation in animal nutrition.*—The studies with beef-bred steers in relation of food to product and the composition of steers at various stages of growth and fattening have been continued. The animals in Group VII reached an average weight of 1,100 pounds on March 14, when one was slaughtered for analysis. When they weigh 1,200 pounds, another will be slaughtered and all sold but one, which is to be fed and slaughtered when weighing 1,300 pounds. This will close the feeding of groups of steers for determining their composition and the nutrients required for their production and fattening. In this work 206 steers were employed, of which 60 were slaughtered for analysis. A complete record has been secured of the amount of feed consumed each day during his lifetime, the digestible components in the feed calculated, and the components added to the body for periods of 100 pounds gained, from 100 pounds to 1,500 pounds. These data will be used in formulating standards for economic beef-production similar to those prepared for milk-production.

*Corn silage.*—The object of this project is to determine which method of planting and time of cutting will return the largest yield of



nutriment. The methods of planting are (1) drilled in rows 3 feet 6 inches apart, plants 7 inches apart in the rows; (2) plants 2 to 3 inches apart; (3) checked, 4 plants to the hill. The corn to be harvested (a) when kernels glaze, (b) when kernels dent.

The amount of forage produced by each method of planting and harvesting and the composition were determined as planned, but the digestion experiments could not be made for want of sufficient help, in both the barn and the nutrition laboratory. The experiment will be continued, as several crops will be required to determine the yield of silage by the several methods and the analysts in the nutrition laboratory will be able to make the analyses in the digestion experiments, since no steers will be fed during 1915-16. This project is conducted with the coöperation of the Division of Agronomy and Farm Management.

SECTION OF POULTRY HUSBANDRY

The equipment of the section of Poultry Husbandry has been so completely placed at the disposal of the nearly three hundred students who, according to the plan of instruction, get a certain amount of practical application of the principles of poultry culture, that it has been impossible to carry out any definite experimental work. Neither does it seem probable that this section will be able to investigate any projects requiring records for any protracted period as long as the present plan of instruction, which seems advisable, is maintained.

*Cost of feeding chicks during the brooding period.*—This section has, however, kept records of the food-cost of chicks of different ages for the double purpose of instructing pupils and determining the most economical period of growth.

That the labor cost per pound of rearing chicks is greater before they are placed on range than afterwards, is most obvious and it has been considered by many that the food cost per pound was also greater with very small than with larger chicks. These records seem to controvert this latter assertion as the average cost of feed was a trifle less, pound for pound, than was the case in similar tests with chicks beyond the brooding age.

These chicks were artificially hatched and reared, and were fed at less cost than when reared by the natural process, that is, when the cost of feeding the mother hens was reckoned with the cost of feeding the chicks. With a plentiful supply of skim or sour milk, the feed cost per pound of chicks five weeks old or less varied from a little over four cents to a little under six.

*Hatchability of eggs from range and confined flocks, compared.*—Success with laying flocks even in extremely confined areas is so universal that the advantages of free range, which amounts to a practical

necessity for breeding-flocks, is very often overlooked and too infrequently emphasized. The records of this section emphatically confirm the opinions of those who maintain that a confined area for breeding-flocks results in an excess of infertile eggs and chicks of less vitality.

Several trials with eggs from flocks confined to small yards (10x30 feet) compared with those from flocks that had free range at least half the time, showed more than twice the percentage of infertile eggs from flocks in small yards. This ratio held true inversely in the number of eggs hatched, the percentage of chicks hatched from the flock practically on free range being nearly twice as large as from the flocks confined to small yards.

## DIVISION OF ENTOMOLOGY

F. L. WASHBURN, Chief

### SECTION OF VERTEBRATE PESTS OF THE FARM; MILL AND WAREHOUSE INSECTS; HYMENOPTERA; AND NURSERY AND ORCHARD INSPECTION

*Field mice.*—Field mice, which cause an annual loss to the nurserymen of Minnesota and others of many thousand dollars, constitute a field of experiments and are listed as a project. Tests of the virus Ratentrit have been made with negative results. Collections of different species have been made in different parts of the state, and notes secured on habits, breeding dates, and other points.

*Mill and elevator insects.*—Fumigation experiments have been made against the grain elevator insect *(Sitro trega cerealella)*. That this insect can be controlled by the use of carbon disulfide has been demonstrated. Further data are sought before publishing details.

*Nursery and orchard inspection.*—The State Entomologist, with deputies, under provision of a state law, inspected about one hundred and thirty nurseries and issued about one hundred and forty certificates. Citizens for the most part appreciate the purpose of this inspection law and are amenable to its provisions. San Jose scale has been found in two or more nurseries and crown gall is quite prevalent on raspberry plants. About twenty-five thousand plants, mostly from Belgium and Holland, have been inspected. There has been no appreciable falling off in shipments from these two countries on account of the European war.

*Hymenoptera of Minnesota.*—Bibliographies of all families of Minnesota Hymenoptera have been compiled and technical descriptions of all suborders, as well as descriptions of all stages of types, with ecology and some popular notes on the first families listed. Three colored plates of Minnesota Hymenoptera have been prepared.

*Zoological museum.*—As work on the museum is practically entirely dependent upon the University funds, and as none have been



available for this purpose for the last two years, but few additions have been made, by purchase, to our collections.

### SECTION OF SPRAYING AND TREE INSECTS

*Spraying for injurious insects.*—In coöperative experiments, spraying has reduced curculio ravages from 74 per cent to 8 per cent, while the percentage of injury from the codling moth has been reduced to almost nothing.

*Insects of orchard, shade, and forest trees.*—The entire life of the two-lined chestnut borer has been carefully worked out and published. Work on the oak tree girdler is being continued and a comparative study of the larvae of the family of *Buprestidae* and *Cerambycidae* with a view to determining characters by means of which species can be separated.

*Insect collection.*—The insect collection at the station has not been enlarged. That at Itasca Park has been largely increased.

### SECTION OF PARASITES AND FIELD-CROP PESTS

*Arthropods injurious to man and domestic animals.*—Experiments are being continued in connection with the control of the house fly on farms and in small towns. Evidence has been secured indicating that adult flies hibernate only under exceptional conditions in Minnesota. Information has been obtained on habits, breeding-places, and life history of the biting stable fly. The survey of Minnesota species of mosquitoes, and tests of oils and other methods of control have been completed. Considerable progress has been made in the study of the life history of the chigger mite.

*Blackhead of turkey.*—A study of the blackhead of turkey has been begun, both in the laboratory and in the field.

*Clover seed chalcid.*—Definite records on the incubating period of the clover seed chalcid were obtained for the first time. Field control experiments against this insect have been conducted on University Farm with fairly conclusive results. Two species of chalcid parasites were reared from this pest, and an apparent increase in the abundance of parasites was noted.

### SECTION OF TRUCK CROP AND GREENHOUSE INSECTS

*White grubs.*—Work has been continued with white grubs and collections of June beetles have been made in different parts of the state in order to determine the species which seems to be most abundant. Studies were made of the length of life cycle of the different species collected. Three or four species are apparently most abundant in Minnesota.

*Fumigation with hydrocyanic acid gas in greenhouses.*—Extensive experiments in fumigation with hydrocyanic acid gas have been under-

taken with some striking results as to the effect on insect and plant life, which will be reported in detail later.

*Cabbage and onion maggots.*—Spraying experiments for cabbage and onion maggots have been conducted and some striking results secured, details of which will be reported later.

*Insectary work.*—In the insectary, 127 general experiments were conducted during the last year. A large number of specimens were obtained and some valuable data. Much progress has been made in indexing records and placing the work on a uniform system.

## DIVISION OF HORTICULTURE

LeRoy Cady, Chairman

### SECTION OF FRUIT AND VEGETABLE INVESTIGATION

*Coöperative orchard management.*—The portion of the apple orchard planted at the State Hospital for Inebriates at Willmar made a fair growth and looks promising, and the apple trees set out in nursery rows at the Northeast Experiment Farm, Duluth, have also made satisfactory progress. J. P. West, of Rockford, and the Rochester state hospital have given over their orchards for experimental purposes, so already four different regions are represented in this experimental work.

*Potato investigations.*—The hill-selection work in potatoes, started in the fall of 1913 with the Early Ohio and Sir Walter Raleigh varieties, gave in 1914 very satisfactory results. Many of the hills gave low-yielding progeny, but a few produced only uniform and heavy-yielding hills. A large number of these strains have been selected for further testing in 1915 at University Farm and the Northwest Experiment Farm at Crookston. Neither the old varieties nor those recently acquired produced well-shaped tubers, altho the latter were superior in regard to growth of vine and yield. The varieties grown in 1912 at Moorhead and Zumbra Heights and in 1913 at University Farm alongside of the original stock, lost their acquired vigor in 1914, for in all respects the three lots were nearly on a par. This preliminary experiment indicates that if change of seed is made, beneficial results can be expected for only one year. Most of the seed grown for future experimental purposes was so degenerated that it had to be discarded. Fortunately, immature and mature seed was secured at the North Central Experiment Station, Grand Rapids, and tests of this seed will be made in 1915 at Crookston, Grand Rapids, Duluth, and University Farm. The Station seedlings, namely, Minnesota Nos. 1, 2, 3, 4, and 5 proved less promising than during 1913 and therefore will require further testing. Every possible effort will be made next year to determine the cause of the running-out or degeneration of varieties, for unless this



evil can be prevented the experimental work must be carried on either furthr north or under different soil conditions.

*Breeding and selection of vegetables.*—Seed has been collected from individual plants of canning varieties of beans and peas, and from self-fertilized and crossed varieties and types of onions. A small quantity of self-fertilized seed of two types of Hubbard squash was also secured. Tests were made in the greenhouse of varieties and crosses of melon and cucumbers, and seed of the promising ones will be saved. The $F_1$ tomato crosses gave exceptionally fine results, as they not only ripened their fruit slightly earlier than the average of their parents but outyielded the more productive parent in every case except one. One cross gave an increase in yield of over thirty per cent, and the fruit possessed desirable commercial qualities. All of the tomato crosses have been repeated in the greenhouse and seed sown for further trials.

*Variety tests of fruits.*—Most of the varieties of apple, cherry, and plum planted in 1914 made a satisfactory growth and survived the winter without injury. The peach and pear trees were protected by a covering of straw and burlap, and, with the exception of the killing of the twigs of the peach, they withstood the severe winter very satisfactorily. A few varieties of strawberries also suffered slightly from winter-killing, even tho well protected by straw. Records of the performance of each variety and technical descriptions of varieties of apples and plums have been made.

### SECTION OF FRUIT AND VEGETABLE INSTRUCTION

*Pruning the apple and plum.*—On the pruned trees the development of new wood during the last season has been very satisfactory, giving a good opportunity to continue the work. The trees under the experiment have been pruned for the second time, some in the winter and some in the early spring, as in the preceding year. Pruning must be carried on for several seasons before definite results can be obtained. Results to date, however, would indicate that there is little, if any, difference between winter and spring pruning in regard to the health of the trees or vigor of growth. Heavy pruning seems to be an injury to older trees, as it disturbs fruiting and produces an abundant sappy growth which is very likely to suffer from blight. Heavy pruning of young trees has given an abundant new growth from which the desired frame-work can be selected. This new growth, however, is fully as likely to blight as the new growth on older pruned trees.

*Cider- and vinegar-making qualities of Minnesota apples.*—Some preliminary work on cider- and vinegar-making qualities of Minnesota apples was done, but the scarcity of apples greatly limited the work. Two types of hand presses were used and four varieties of apples run

through in limited quantities. Samples of the juice were obtained in this way and a preliminary comparison of yields obtained. The bulk of this material was used for analyses by the Division of Agricultural Chemistry. A preliminary comparison was made between the two machines in regard to their efficiency.

No attempt was made to develop the fermentation portion of the project on account of the very limited quantity of cider extracted.

### SECTION OF FRUIT-BREEDING

*Sterility in fruits.*—Since the report of last year the study of sterility has been continued in much the same manner as previously. Further material has been collected for the study of sterility in the strawberry from plants growing in the greenhouse, also self-sterility tests have been made on some of the standard varieties and a few of the promising seedlings at the Fruit-Breeding Farm. No results are available in regard to the plum other than reported last year.

*Inheritance of fruit characters.*—The Abundance X Wolf and Burbank X Wolf seedlings, with a few exceptions, fruited last year, and descriptions and measurements were made of the fruit for the character studies, of which these crosses form the basis. Descriptions were also made of the twig, leaf, and fruiting-habit. Leaves were collected from each of these seedlings for the purpose of studying the inheritance of leaf-size. This completes the data to be taken before presenting finally the evidence of these hybrids as to the inheritance of characters.

*Breeding fruits for hardiness.*—No experimental work was done on this project during the last year, as funds were not available for the purchase of apparatus needed in some of the freezing work and the studies of controlled temperature humidity. Literature review, however, has been continued and quite a complete bibliography of the general subject of hardiness is available for use in the laboratory. Observations have been continued on the material on hand at the Fruit-Breeding Farm.

### SECTION OF LANDSCAPE GARDENING AND FLORICULTURE

*University Farm campus.*—The work of the last year up to March 31 has been largely a matter of maintaining the old campus and getting a part of the new land in condition for planting this spring. Notes have been taken as to the behavior of various plants used in the work.

*Ornamental plants and shrubs and their uses.*—The study of ornamental plants and shrubs was started about 1890. About seventy-five annual varieties and forty perennials were grown for the purpose of studying their value. About two hundred and fifty peony seedlings were in flower last season and notes were taken as to their value. Some



work was done with new shrubs from the United States Department of Agriculture and the hedge plot was continued.

## DIVISION OF PLANT PATHOLOGY AND BOTANY

E. M. FREEMAN, Chief

### SECTION OF PLANT PATHOLOGY

*Disease survey.*—The disease survey was continued as in other years. A fairly accurate idea of the distribution and seriousness of various diseases has been obtained. The pathological herbarium for reference and demonstration purposes is being built up.

*Rusts of cereals.*—Studies on the nature of disease-resistance have been continued. It has been found that in almost totally immune forms, as well as in very highly resistant forms, the host very frequently seems to be hypersensitive. Preliminary work has been done on the factors governing varietal resistance. This work is not yet complete.

Work was also done to determine the rapidity of adaptation of biological forms to new hosts. This was done largely in connection with the work on grass rusts, which is being pursued vigorously. A fairly large number of the rusts occurring on native grasses were tested for pathogenecity on the cereals. An attempt was also made to determine the possible role of bridging-hosts. Hybridizing work was continued and a large number of new crosses were made. It was found that the Iumillo-Minnesota No. 188 hybrids are quite uniformly resistant and of fair quality. Selection work was continued with indications of success.

The first reports of field tests were made during the last year and were fairly satisfactory. The milling and baking tests were also fairly satisfactory. The seed of some of the most promising strains is being grown in increase plots this year.

*Cereal and forage crop diseases.*—A study of the life history phenomena of *Ustilago zeae* has been made. This has been directed particularly to an attempt to explain the epidemiology of the disease, and consisted of infection experiments to determine the extent of the infection and of studies of spore and sporidia germination. It included an investigation of the vitality and viability of spores and sporidia under varying conditions. The work is nearing completion.

The attempt to develop strains of flax resistant to wilt and rust has been continued. Further selections have been made and these will be tested next year.

Further work has been done on the imperfects of cereals and roots. Special attention was given to the determination of the pathogenecity of some of the forms. Histological studies were made of the infection phenomena of loose smuts of wheat and barley. An attempt was made

to correlate these phenomena with possible simpler methods of treatment. A large number of field tests were also made but the results are not yet conclusive.

*Potato and garden-truck diseases.*—The spraying of tomatoes proved commercially profitable as in other years. The serious diseases were fairly well controlled. Experiments to determine the possibility of growing clean seed beans in special seed plots were carried on both at the station and in the chief bean-growing district. The results were encouraging and the work will be continued.

The work on cucumber nubbin was mainly an attempt to determine the effect of various soil conditions on the prevalance and destructiveness of the disease. The results are suggestive but not definite.

Several experimental and demonstrational potato plots were established in Clay and Wilkin counties in coöperation with the Divisions of Horticulture and Agricultural Extension. It was shown without question that serious diseases, especially those of soil and tubers, can be successfully controlled by means of seed plots. It was also shown that the maintenance of seed plots by farmers is very profitable. Spraying experiments were continued and were financially profitable. They will be continued.

Further work was done on the etiology of a very destructive wilt common in the Red River Valley and as yet undescribed.

*Fruit diseases.*—It has been found that varietal resistance of plums to brown rot is probably due in some cases to morphological and in other cases to physiological characters of the plums. Further work will be done, probably in coöperation with the Division of Agricultural Chemistry.

The fruit spot of the Wealthy apple, at least in one of its commonly occurring forms, was shown to be due to a species of *Alternaria*. The effect of storage conditions on the development of the spots received considerable attention during the year. However, since the disease was not serious, the results are not conclusive. The plum and apple spraying experiments were continued in coöperation with the Division of Entomology.

*Dendropathology.*—A considerable amount of work has been done in attempting to determine the part played by fungi in the death of oaks in Minnesota. Many inoculations have been made but further work will be required. The experiments at Lake Itasca have been continued. Several trees inoculated in previous years have been cut and examined. Material for histological study has been prepared.

*The microflora of peat lands.*—Further work was done on the microflora of peat lands and positive results were obtained. The work will be pursued more vigorously next year.



SECTION OF SEED LABORATORY

*Seed-testing.*—During the year, 8,476 seed samples were sent to the Seed Laboratory for testing. This is an increase of 53 per cent over the samples received in 1913-1914, and shows that the number of farmers in the state who are testing their seed before planting is increasing. Inspection work was carried on as formerly, and 124 official samples were collected by the state inspector. Practically everyone selling seed for seeding purposes is now labeling according to the provisions of the seed law. This year more than 4,000 samples were tested for germination, in duplicate, in the greenhouse, under controlled soil conditions, and a comparative table of results has been worked out. Some work was also done in testing seeds under sunlight conditions. The First Annual Seed Laboratory Report was published (Bulletin No. 147), and a seed exchange list was also prepared.

*Seed studies.*—Identification work on the seeds of the Agropyrons has been completed and the results were published. Lawn grass mixtures were studied quite carefully during the year, and the work was developed in two lines: (1) To determine quality of lawn grass mixtures sold on the open market. (2) To develop a lawn grass mixture suitable to Minnesota conditions. Practically all of the lawn grass mixtures sold on the open market have been planted in permanent square-rod plots. Thirty square rods have been planted to perennial grasses and legumes and at the present time these plots contain approximately seventy-five different grasses, and eighty different legumes. Investigational work was started in the determination of germination of weed seeds after having passed through the digestive tracts of different animals.

*Weed seed cases.*—During the year a fourth series was added to the weed seed collection, making a collection of ninety-six different kinds of seeds. Approximately nine hundred cases were sold during the year. This is an increase of 100 per cent over the number sold during 1913-1914. Quite a number were sold outside the state.

*Weed investigations.*—During the year thousands of weeds were identified for residents of the state, and a record kept of each species. In this manner a weed survey of the state is gradually being worked out, and it has been found that such weeds as ox-eye daisy, flowering spurge, buckhorn plantain, and dodder are gaining a foothold in some sections. Some work was done on the effect of chemical sprays on ragweed. The results did not develop any data on which definite conclusions could be based. Considerable work is being done in studying the structure of the root systems of different grasses. A weed garden has been started and practically 150 different weeds have been planted for careful study.

## DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

L. D. H. WELD, Chief

The work of the Division of Research in Agricultural Economics has been devoted to problems of marketing and coöperation.

*Collection of statistics of coöperative organizations in Minnesota.*—In compliance with state law, information and statistics were obtained from coöperative organizations in Minnesota, and the results for 1913 were published under the title "Statistics of Coöperation among Farmers in Minnesota," Bulletin 146. Similiar statistics have been gathered for 1914 and will be presented for publication. A special study has been made of farmers' elevators and the results presented for publication.

*Social and economic surveys.*—Two surveys made during the summer of 1913 were published during the year, one a "Social and Economic Survey of a Community in the Red River Valley," by L. D. H. Weld, Current Problems Series of the University of Minnesota, No. 4; and "Social and Economic Survey of a Community in Northeastern Minnesota," by G. P. Warber, No. 5, of the same series.

*Studies in marketing of Minnesota farm products.*—During the year certain studies made by advanced students in the Seminar in Agricultural Economics of 1913-1914 were edited and put in shape for publication, together with studies made by the chief of division. These studies, including eight separate papers, were published under the title "Studies in the Marketing of Farm Products," University of Minnesota, Studies in the Social Sciences, No. 4. Similar studies were made during 1914-1915, and important data collected, especially on the marketing of hay and potatoes, on the South St. Paul livestock market, and on the problem of grading and inspection of grain.

*The Marketing of Butter.*—An extensive investigation was made of the methods and costs of marketing Minnesota butter in coöperation with the Office of Markets and Rural Organization, United States Department of Agriculture, and the State Dairy and Food Department. The reports are reaching completion.

## DIVISION OF SOILS

F. J. ALWAY, Chief

*Soil absorption studies.*—The work on soil absorption was discontinued before the close of the last fiscal year. The report on it being prepared by J. W. Derby of the School of Chemistry, University of Minnesota, and G. W. Walker, formerly of this division, is not yet ready for publication.



*Fertilizer experiments.*—The experiments with commercial fertilizers at University Farm, Morris, Waseca, Crookston, and Grand Rapids, described in the last annual report, are now all under way. Except those at University Farm, all are in coöperation with the different Substations. The results for the first year will be a disappointment to those who expected a great increase in yield as a result of the use of phosphates. On none of the farms did ground rock prosphate, either alone or in combination with manure, show any distinct effect upon the crop yields. This may, however, be due partly to the fact that the phosphate was poorly mixed with the soil during the first season. Acid phosphate, which also was applied both alone and with manure, showed no distinct effect, except at University Farm and at Crookston, and even here the increase produced was only slightly greater than the unavoidable experimental error. At Crookston, potatoes showed no distinct benefit from either potassium, nitrogen, or phosphorus fertilizers, either alone or in combinations of two or three. However, the results of the first season's work can by no means be considered as evidence that any or all of these different forms of commercial fertilizers will continue to fail to produce marked increases in yield. The use of three plots with each treatment in the case of each crop permits us to form a fair idea as to the significance of the differences in yield between the treated and untreated plots.

The alfalfa plots at Morris and Crookston which were treated with different fertilizers will produce their first hay crop this summer.

Arrangements have been made to start fertilizer experiments at the Duluth Substation as soon as the land can be drained and sufficiently freed of stones and leveled to permit of its being laid out in satisfactory plots.

*Peat soils.*—Experiments were carried out on a small field of peat soil at the North Central Experiment Station, at Grand Rapids, using potatoes, oats, clovers, and grasses. Lime, steamed bone meal, raw rock phosphate, potassium sulfate, and sodium nitrate were used, both singly and in various combinations. An assistant was detailed to keep the plots under close observation throughout the growing season and make a careful study of the changes in the moisture and the temperature conditions of the soil and of the temperature conditions of the air over the peat and over the adjacent mineral soil. The peat on this bog is very inferior for agricultural purposes, being markedly deficient in lime and very deep. On the plots where lime was used good stands of clover and timothy were secured. Night frosts were frequent, occurring in every month of the growing season, altho on the adjacent mineral soil there were no frosts from about the middle of May to the last week in September. Smudges were employed to pro-

tect the potato crop from these frosts. The yield on the different plots ranged from 176 to 400 bushels per acre. The surprisingly good yields on the unfertilized plots may be due to a torrential rain which occurred during the night of June 26-27, flooding the experimental field and probably carrying considerable amounts of sodium nitrate and sulphate of potash from the fertilized to the unfertilized plots. This rain seriously interfered with the value of the results.

In quality, the tubers differed much from plot to plot. Varieties especially adapted to peat soils should be either introduced from Europe or developed within the state.

The work will be continued during the coming summer in coöperation with the Grand Rapids Substation. A guard ditch will be dug about the new experimental area to protect it from the run-off from torrential rains, such as that mentioned above, and which, from the records of the adjacent United States Weather Bureau at Pokegama Falls, may be expected to occur on an average of once a year.

The coöperative experiment on peat soil which was conducted at Meadowlands showed marked benefit from the application of lime and potash. Good yields of barley, clover, and grasses were secured where these two were applied in combination, while with either missing the yields were extremely unsatisfactory.

Detailed laboratory investigations were made of the peat soils from thirty-four bogs in Blue Earth County, three in Ramsey County, and from a large number from Pennington and other northern counties.

The urgent need of experimental fields on four different areas of peat soil is fully recognized, but, on account of the lack of appropriations by the Legislature, it will not be possible to carry on work except on the Grand Rapids bog, which represents the very poorest type of peat so far encountered in this state. In northern Minnesota there should be an experimental area on the better type of peat, and in the southern part of the state one on the poorer and one on the better type. Both of the latter could be located within a few miles of the Experiment Station, thus permitting them to be worked economically.

The extent to which prisoners of war are, at the present time, being used for the reclamation of the peat lands of Central Europe may serve to call the attention of our peat-land owners to the agricultural possibilities of this type of soil. The great progress made in the reclamation of peat lands during the last forty years is chiefly due to the disappointing results obtained on the peat lands of Germany which had been drained by the French prisoners during the Franco-Prussian war.



*Composition of the soils of the different glacial drift sheets.*—The study of the composition of the soils of the different glacial drift sheets, outlined in the last annual report, has been continued and on the basis of the first year's work liming experiments are planned for a large number of fields with acid soils on the southeastern loess and on the Early Gray Drift, both of which are found to be extremely poor in carbonates. A recent publication by the Iowa Experiment Station, which was working on the same problem just south of the state line, confirms the results outlined in the last annual report.[1]

*Glacial soils on the Gray Drifts.*—The investigation of glacial soils on the Gray Drifts was started late in the autumn and but little progress is to be reported. A large proportion of the samples needed has been collected. The field work has so far been confined to Rice county.

*Studies of the movement of water in soils.*—The investigation of the movement of water in soils has been interrupted by the prolonged illness of the chief assistant in the work.

*Organic constituents of soils.*—The study of the organic constituents of soils, which has just been approved, will include the different types of peat soil as well as the ordinary, or mineral soils. Its importance in this state is especially striking, the peat soils owing their unproductiveness to an excess of organic matter, while the low fertility of mineral soils is more frequently due to insufficient organic matter than to any other one cause.

## DIVISION OF VETERINARY SCIENCE

M. H. Reynolds, Chief

In 1914-1915 the hog cholera situation was much better than in 1913-1914. Attention was centered very largely on serum-production and distribution. This great improvement is probably due to several causes—largely to persistent educational work on a large scale by the State Live Stock Sanitary Board, the Division of Agricultural Extension and the Veterinary Division, so that there has been much less unnecessary and careless dissemination of the disease and more intelligent precaution in avoiding infection. A more intelligent use of serum by the serum-only method and very much less reckless and uncontrolled use of virus by the serum-virus method has also contributed in a very important way to this great improvement. The improved situation is undoubtedly due, in part, to natural causes and conditions. Abundant experience during the year has confirmed still more strongly the position that the serum-only method should be the main reliance

[1] Brown, Percy Edgar. The Fertility in Iowa Soils. Iowa Agr. Exp. Sta. Bul. 150. June, 1914.

and the common procedure, and that the serum-virus method should, with rare exceptions, be used only in infected herds or those very near them, and under rigid official control. The last Legislature made some important modifications in the law relating to this work, which will enable us to give the state better service. One of the especially significant features of the law as it now stands is that virus may not be sold, given away, or otherwise distributed or used, except on permit from the State Live Stock Sanitary Board. The price of serum has been raised from the specified price of one-third of a cent per cubic centimeter to approximate cost, and the serum is now selling at one cent, with a prospect that we may be able to reduce this later in the season.

The Renville County demonstration experiment was continued through the year. The work done by the Government men was very vigorous and efficient and thoroly satisfactory in every way. The especially significant developments in connection with this work are (1) that serum only, accompanied by intelligent precautions before and after herd infection, has been so satisfactory that virus did not seem to be necessary; and (2) that with careful serum administration and reasonably careful sanitary procedure on infected farms, it is unnecessary to treat herds on adjacent farms, unless the two herds are near together. Ordinarily, sanitary precautions have great value in preventing the spread of this disease.

The growth of production at the state serum plant is shown in the following table. The figures are approximate.

| | | | |
|---|---|---|---|
| 1908..... | 25,000 cc. | 1911..... | 240,000 cc. |
| 1909..... | 75,000 cc. | 1913..... | 1,000,000 cc. |
| 1910..... | 150,000 cc. | 1914..... | 4,000,000 cc. |

The section of Pathology has done a considerable amount of field expert laboratory diagnosis and research work in connection with abortion, sterility, and accompanying diseases. (See section report.) Plans are now under way for extensive alterations of the present Veterinary Building and for the erection of several stable units for experimental work with infectious diseases of animals.

Work in our section of Veterinary Physiology was greatly hampered during the year. Dr. Palmer took up the work late in the fall but was so busy with class-room work during the winter months that he had no time for research work. The work has been taken up this summer and has been prosecuted vigorously with most encouraging results.

### SECTION OF BIOLOGICAL PRODUCTS

As in 1913, the demand for hog cholera serum was heaviest about the latter part of July. This heavy demand continued through August,



September, and October. The state serum plant came nearer to meeting the demand for serum during 1914 than in the preceding two years. During the calendar year of 1914 the plant produced 3,661,595 cc. of serum.

Production and distribution of serum for the nine months covered in this report was as follows:

| Month | Production cc. | Distribution cc. |
|---|---|---|
| July (1914) ..... | 453,000 | 575,225 |
| August ..... | 438,760 | 609,790 |
| September ..... | 425,685 | 390,685 |
| October ..... | 295,055 | 550,835 |
| November ..... | 413,540 | 220,630 |
| December ..... | 181,810 | 179,105 |
| January (1915) ..... | 236,960 | 143,460 |
| February ..... | 275,350 | 56,800 |
| March ..... | 272,560 | 66,910 |
| | 2,992,720 | 2,793,440 |

In August, 1914, when it was found that the plant was unable to meet the demand, 1,000,000 cc. of commercial serum was purchased and about three-fourths of it distributed at cost, namely, 1.5 cents per cubic centimeter. The results obtained from the use of this commercial serum were very irregular. In several cases where the serum was used against virus, in the double treatment of healthy herds, the results were rather disastrous.

Toward the end of 1914 considerable difficulty was experienced in securing susceptible pigs for virus purposes, on account of the prevalence of foot-and-mouth disease in the United States, and the possibility of introducing the disease by using virus pigs bought in stockyards. As a result, serum-production during December dropped to the lowest point of the year. The distribution of virus was completely discontinued for several months at the direction of the State Live Stock Sanitary Board.

Results obtained with the use of state serum were uniformly good. Considering the amount of serum distributed, the number of complaints received is relatively small.

No additions or extensive alterations were made to the plant during this period, altho it was apparent that if our production were to be increased in 1915 additional buildings would be absolutely necessary. The Legislature was asked for an appropriation of $10,000 to enlarge the plant and improve the equipment. This will enable the plant to produce from eight to ten million cubic centimeters of serum annually.

As it was necessary to push the plant to its capacity all the time, it has been impossible to do any research work or any experimental work, except in connection with routine serum-production. Observations have been received on several important points. With larger plant and staff, it is believed that each of the three veterinarians in this section should have a part of his time available for research work.

No publications have been issued during this period, altho material has been prepared for a new popular bulletin on hog cholera and the serum treatment.

### SECTION OF PATHOLOGY

*Contagious abortion.*—During the last year this section, coöperating with Dr. W. P. Larsen of the College of Medicine, and the Division of Dairy and Animal Husbandry, has continued to investigate infectious abortion, to study methods of disease dissemination, and to advise methods of control. Thirty field trips were made for the State Live Stock Sanitary Board, to establish diagnoses, and collect material for pathological and bacteriological study.

Sterility, or barrenness, which accompanies abortion, has been studied from the standpoint of surgery. Cystic ovaries and ovaries containing persistent *corpora lutea,* have been studied, both bacteriologically and pathologically.

Work with abortion, in the field, is now under way.

There has been a satisfactory increase in the number of specimens received for bacteriological and pathological study. Some of the most interesting cases are here recorded.

| Disease | Animal | Number received |
|---|---|---|
| Johne's | Cow | 1 |
| Cottonseed-oil poisoning | Hog | 5 |
| Sarcoptic mange | Horse | 1 |
| Haemorrhagic septicaemia | Cattle | 8 |
| Actinomycosis | Cow and hog | 2 |
| Black-leg | Cattle | 2 |
| Necrobacillosis | Calves and pigs | 6 |
| Rabies | Dog | 1 |
| Intestinal calculus | Horse | 1 |
| Hog cholera | Swine | 9 |
| Goitre | Calves | 3 |
| Pulmonary emphysema | Cow | 1 |
| Tuberculosis | Cattle, sheep, poultry | 12 |
| Nodular disease | Sheep | 1 |
| Verminous bronchitis | Swine | 6 |
| Tumors | Cattle | 6* |

* Five malignant, 1 benign.

### SECTION OF RESEARCH IN VETERINARY PHYSIOLOGY

The work in this section was very seriously hampered during the year, owing to the resignation of Dr. Lipp and later to the resignation



of Dr. Willey, who succeeded Dr. Lipp, both leaving the University for more advantageous positions. Dr. Palmer, who succeeded Dr. Willey, took up the work late in the fall, but had little opportunity for research. Since March 31, Dr. Palmer has prosecuted this work vigorously and has some very interesting and promising work under way in the collection of data concerning the normal physiology and histology of hog's blood as a prerequisite for future study of certain diseases of swine.

*Swamp fever.*—Work with swamp fever was continued during the year in connection with the Bureau of Animal Industry, United States Department of Agriculture, and the State Live Stock Sanitary Board, and under the immediate direction of Dr. C. F. Flocken, Bureau expert. Work was limited chiefly to a study of diagnosis in an effort to secure a reliable laboratory method. In view of the present uncertainty and inaccuracy in diagnosis and the fundamental necessity of diagnosis as a basis for experimental work, it is quite generally agreed that this is one of the most urgent and most important things to develop. Dr. Flocken was absent on other government work from April 20 to August 1, 1914, and again from November 25, 1914, to February 8, 1915.

No results have been published, except brief statements each year in annual reports by the Chief of the Bureau of Animal Industry.

During the coming year work will be confined largely to questions of fly transmission and laboratory diagnosis.

## FORESTRY INVESTIGATIONS

E. G. Cheyney, Director

The Forestry work during the last year has been chiefly: (1) Experimental; (2) Investigational; and (3) Demonstrational.

### EXPERIMENTAL WORK

The Experimental work has been carried on at the Cloquet Forest Experiment Station, which is now well established and fairly well equipped. There, in the nursery with an annual capacity of one million three-year old transplants, many experiments were carried out in order to determine the amount of seed to sow, the best time to sow, the preliminary treatment of seed, the proper depth to cover the seed of different species, methods of sowing, fertilizing, shading, watering, the comparative root development of seedlings and transplants, and the best time and method of transplanting. Many valuable data have been obtained on these problems, but another year will be needed to check the results and determine their constancy.

An arboretum was established to test the adaptability of different species of trees and shrubs to the soils and climate of northern Minnesota. Different classes of nursery stock were planted in different

sites with many different tools in order to determine the best stock for each type of site and the best method of planting. In this connection, a study is made of the effect of the season of planting and the effect of different ground cover. Some rather remarkable results were obtained, especially in the comparison of costs of the different methods of planting in different sites. These experiments also must be repeated another year to check results.

Another subproject was the study of seed, its source, its production, and its physiological characteristics, the methods of extraction, and the comparative germination. These studies and experiments will produce results of considerable value to the nurserymen and foresters of the country.

Some important experiments were started to determine the effect of different methods of cutting and the effect of thinning. These will, of course, require years before any definite results can be obtained.

### INVESTIGATIONAL WORK

The investigational work was carried on in the forest and on the prairies. Volume studies of different commercial species are being made to determine the rate of growth as a basis for calculating the money yield from forest growth. This work will require a long time, but is absolutely essential to any intelligent plan of management.

The meteorological and soil studies started three years ago to determine the differences of the forest types are being continued.

In the prairie regions a careful study of the existing groves and windbreaks has been made. The great diversity of results, some brilliant successes and other quite as brilliant failures under the same conditions, indicate the great importance of the selection of the proper species and more especially of the method of planting. The astonishing effect of the windbreaks on the adjoining crops shows that the proper protection of homes, orchards, stockyards, and crops from the rigors of the cold winter and the dry winds of summer is one of the most important factors in successful farming in this windswept region. It is unfortunate that the lack of funds prevents the continuation of this work next year.

### DEMONSTRATIONAL WORK

Through a coöperative agreement with the Water Department of the city of St. Paul, the division has undertaken the supervision of a forest planting place and its operation on the reservoir property around Lake Vadnais. Over thirty thousand trees have been planted and provision was made for carrying on the work in the future. This is an important step as a possible basis for a municipal forest for St. Paul in the future.



Numerous plans were also made for farm plantings in different parts of the state and the planting, wherever on a large enough scale to warrant it, was directly supervised by the division.

A greatly increased interest in forestry has been shown in the state the last year, especially in regard to farm planting and the importance of forest protection to agriculture.

## SUBSTATIONS

### NORTHWEST EXPERIMENT STATION, CROOKSTON

C. G SELVIG, Superintendent

Last year was the fifth since the Station was reorganized and the twentieth since it was established.

The growing season of 1914 was unfavorable in having extremely hot weather and excessive rainfall. Black rust greatly diminished the yields. Corn, potato, and grass crops, however, yielded well. Late frost (October 26, 19 degrees) made fall farming conditions particularly favorable. Rye, clover, timothy, and alfalfa came through the winter in excellent condition.

The spring of 1915 opened early with very favorable weather conditions during April. Seeding was finished April 24. Rains then set in and a cold, wet May followed. This seriously delayed corn- and potato-planting. During June, abnormal conditions of rainfall and temperature prevailed. A heavy frost on June 9 froze down corn and barley, and a light frost occurred on the 15th. June rainfall was injuriously excessive, 8.45 inches being recorded. Of this, 3.7 inches fell in a two-hour downpour on the 26th, with 5.03 inches during a period of four days. Crops, except corn, came through in excellent condition, generally, with the result that the grain crop outlook is favorable.

### THE DRAINAGE SYSTEM

Last year was the sixth since the drainage system was installed. Except in the fall of 1912, when 11 inches of rain fell during August, September, and October, and during June, 1915, the rainfall was distributed so evenly that there has been no excessive water on the fields at any time, and no noticeable difference was observed between tiled and untiled land.

The first serious damage came in June of this year. This was due to inflow of flood waters from five sections of land east and southeast of the Station. Water on this land has no outlet except through the Station ditches which proved inadequate during a flood. Work has been begun whereby this land and the east 210 acres of the Station land will be drained southeast to the river, the expense to be borne by the

residents and the Station jointly. This work of completing the Station drainage system is of greatest importance.

### SEED DISTRIBUTION

The coöperative distribution of seeds and plants was extended during the year. Fifty farmers were added to the list of coöperators this spring. Requests came from many others for Station-grown seed. It is planned to still further enlarge this important phase of service.

### EXPERIMENTAL WORK

Additional work in testing cultural methods was started in 1915 in rate of sowing wheat, oats, and barley. Rye and barley have been added in the date-of-seeding test. The work with winter wheat gave no results this year on account of winter-killing. Covering winter wheat with straw just before freezing down in the fall, using various amounts per acre, will be added to this work. Extensive additions to work with alfalfa have been begun, using different nurse crops and seeding these crops at different rates. The same work will be started in 1916 for red and sweet clover. Twenty-two plots, in duplicate, have been planted to determine the best dates of plowing for wheat, oats, and corn, with duplicate plots for disking before plowing for wheat and corn.

The variety tests were continued in 1915 the same as in the last four years. Alfalfa continued to show excellent adaptation to the conditions of this part of the state.

The work with corn suffered severely during the wet and cold weather of May and June and very little corn is expected to mature.

The crop-rotation work is being continued with results that indicate increasing advantage in following a definite system. The results for 1914 were included in last year's report. The clover in the three-year rotation came through in excellent condition.

The fertilizer plots are in better condition than during previous years and are beginning to show effects of the different treatments of soil.

Considerable work in eradication of quack grass has been carried on, including several experiments involving different methods of attack.

The season of 1914 was a good year for tree growth. Trees and shrubs withstood the winter in good condition. The less hardy trees, such as the catalpa species, suffered a little. The late frosts of 1915 did considerable damage to the trees and shrubs; however, this injury was largely counteracted by the ideal growing conditions prevailing after the frosts. The June frosts injured the younger growth of green ash, catalpa, hackberry, and birch. Over twelve thousand trees, cuttings,



and shrubs were planted during the season of 1915, with excellent results.

Tests of variety and hardiness of trees and bush fruits was continued during the year. The standard and seedling varieties of plums, with the exception of the Compass cherry, are not fruiting yet. Marked differences in hardiness are being recorded. Black raspberries and blueberries planted in 1914 failed to make a satisfactory growth. Gooseberries and currants made a good growth in 1914, the currants each setting a few clusters of fruit. A few Sunbeam raspberries fruited this year but not in sufficient quantities for record purposes. Tree and bush fruits that were given protection wintered well. Strawberries, with the exception of the Warfield, were killed back even tho covered with a heavy straw mulch.

The late frosts of June, 1915, destroyed the fruit of all apples, crabs, and plums that were in the experimental orchards. The plum seedlings under the windbreak trees, however, escaped these frosts, so a light crop will be harvested from them. Four hundred trees and small fruits were planted in 1915 with 95 per cent of them growing.

Records of growth and yield were taken from fifty-seven varieties of garden crops during 1914. This work will be continued and enlarged. A total of 121 gallons of vegetables, including beans, tomatoes, and sweet corn, were canned in 1914. It was found that these crops could be sold with greater net profit as canned products than as fresh vegetables in season.

Nine varieties of potatoes were tested during the year 1914, the early varieties yielding an average of 124 bushels per acre as compared with 134 bushels from the desirable late varieties. Sixty additional varieties are being tested in 1915, in a coöperative test with the Division of Horticulture of the Minnesota Experiment Station.

Corrosive sublimate proved the best fungicide for treating seed potatoes for scab, rhizoctonia, and fusarium wilt.

The results obtained from the spray test-plots show that early blight can be controlled with profit by spraying with 5-5-50 Bordeaux mixture. Data on the effect of different solutions on germination are being kept.

Potatoes planted at the rate of ten bushels per acre gave the highest yield per bushel of seed planted, while the larger amounts of seed gave higher total yields.

Seed potatoes cut in quarters gave the highest yield per acre of seed planted; whole potatoes, however, gave the highest total yield. A marked difference in growth and in vigor of vines was shown between plants from medium-sized whole potatoes and whole "little potatoes." The former were large, strong, and sturdy while the latter were weak and spindling.

Marked increase in yield was obtained from seed taken from high yielding hills. The best hill-selected plot yielded at the rate of 231 bushels per acre as compared with the yield of 82.5 bushels from "field run" seed and 100 bushels from "cellar-selected" seed. The hill-selected seed yielded potatoes of a much better type.

The root-crop tests during 1914 included fourteen varieties. The mangels yielded an average of 22.5 tons per acre for all varieties, with the highest yield 33.6 tons per acre of sugar white mangels. During the present season 25 varieties are being tested.

The principal work of the Section of Dairy and Animal Husbandry has centered around maintenance of the Station livestock. Two projects were begun this year: (1) The determination of the influence on swine of over-feeding with protein; and (2) the use of flax in a balanced ration for swine. Two litters of pigs were raised successfully and raising early lambs was a paying project.

The work of the poultry department was largely a continuation of that carried on during the preceeding two years. The hatching power of the eggs incubated was much higher than usual, April and May eggs being especially high in fertility. The results of the season's work in the investigation of artificial vs. natural incubation are more marked than in preceeding years in favor of eggs naturally hatched. There was also a noticeable difference in general thrift of the two flocks in favor of the naturally hatched lot. The experiment with poultry house construction and influence was begun the first of November. It is a comparison of two types of poultry houses, one of which is of solid-wall concrete construction, and the other of frame. The sixty Barred Plymouth Rock hens in the concrete house produced 1,085 eggs, and a similar sixty hens in the frame house, 905. The temperature of the two houses varied according to the velocity of the wind. On windy days the difference in temperature was greater than on calm days; but as a rule, the concrete house was about 8 degrees colder. Other observations showed no decisive results.

## WEST CENTRAL EXPERIMENT STATION, MORRIS

E. C. Higbie, Superintendent

The experimental work in agronomy and soils, with special reference to conditions in west central Minnesota has been definitely organized during the last year. Four projects, covering the work on 475 plots, are now in progress.

*Alfalfa, clover, and timothy investigations.*—The investigations with alfalfa, clover, and timothy include the breeding and testing of pedigreed strains and types of alfalfa, seeding tests with alfalfa with



reference to the use of various nurse crops, the method. time, and rate of seeding; inoculation tests; seeding tests with clover and timothy with reference to the use of various nurse crops, rate of seeding, effect of lodged nurse crops, and winter-killing.

*Fertilizer tests.*—Fertilizer tests include the use of acid phosphate, rock phosphate, and manure, as well as rock phosphate with manure and acid phosphate with manure, and the use of lime with all the above combinations on a four-year rotation of corn, wheat, oats, and clover. The use of gypsum, manure, rock phosphate, acid phosphate, and sulphate of potash is also considered, the last two in combination, and the use of lime with all the above combinations, on alfalfa.

*Selecting Minnesota No. 13 and Silver King corn.*—Selecting corn for yield and early maturity has been done by centgener method.

*Varietal tests of farm crops.*—Farm crops tested include clovers, grasses, alfalfas, millets, forage crops, corn, wheat, oats, barley, rye, and peas.

### GENERAL FARM WORK

The five-year rotation of corn, corn, barley, oats, and clover will this season complete the first cycle. These one hundred acres have in the meantime been thoroly cleaned of mustard, wild oats, and other troublesome weeds. The yields have been steadily increasing and this season will be far above the average of the surrounding country. It is the purpose to use this rotation in conjunction with the dairy herd. Thirty acres of alfalfa are also operated in connection with the farm. This field is made up of four standard varieties and will yield five tons to the acre this season.

It is the aim of the farm proper to supply the alfalfa, other hay, silage, and a portion of the grain needed by the livestock maintained at the Station.

## NORTH CENTRAL EXPERIMENT STATION, GRAND RAPIDS

Otto I. Bergh, Superintendent

### CROPS

Weather conditions for the growing season of 1914 were on the whole quite satisfactory. Spring opened a little earlier than usual with temperatures through May and June above normal and with ample rainfall. There were no killing frosts until September 25, giving time for the corn to mature sufficiently for excellent ensilage. The season was altogether favorable, with the exception of warm sultry weather in July which caused much damage from rust to the grain crops, and drought during August which severely taxed the newly seeded grasses and somewhat lessened the yield of fodder corn on areas of light soil.

The general average yield from all the fields, of the various crops grown, was as follows: oats, 30.2 bushels per acre on the upland and 17.8 bushels on muskeg-margin soil; wheat 6.1 bushels per acre of very inferior grade, badly damaged by rust; barley 18.6 bushels per acre of poor quality, also badly damaged by rust; potatoes 310.3 bushels per acre, of excellent quality; rutabagas 17.6 tons per acre; ensilage 9.6 tons per acre, a field of 4.88 acres giving the maximum yield of 12.8 tons per acre from the Minnesota No. 13 variety; clover and timothy, general average, first cutting, 2.86 tons per acre, the maximum yield in two cuttings being 4.36 tons per acre; millet 2.25 tons per acre.

All the crops on the farm are grown in a three-year rotation as follows: grain, clover and timothy for hay, followed by a cultivated crop. With the relatively small acreage of land under cultivation in this section of the state, this rotation gives best results as it gives the maximum amount of farm-produced feeds for the livestock and also allows for the production of marketable crops, such as potatoes, grass seed, and grains.

### NEW PROJECTS STARTED

Two projects were started in 1914 in coöperation with the Division of Soils of the Agricultural Experiment Station, at St. Paul. The first was an experiment with ground rock phosphate and acid phosphate applied separately on upland soil with and without manure and lime in a three-year rotation of grain, grass, and cultivated crops. This project covers six acres, divided into 108 plots. The second project, covering 1.33 acres, on peat soil ranging in depth from one to nineteen feet, is for the purpose of testing the effect of the various commercial fertilizers applied both singly and in combination, on peat soil, on such crops as potatoes, oats and clover, and timothy and redtop.

New projects begun this year are as follows:

1. Raw peat vs. stable manure as a fertilizer for upland soil
2. Fertilizers on muskeg for garden crops
3. Corn experiments:
   - Selection for local adaptations
   - Ear to row selections
   - Variety tests
   - Rate of planting
   - Influence of environment on growth and characteristics
4. Potato investigations:
   - Rate of planting
   - Size of seed
   - Mature vs. immature tubers for seed
   - Early vs. late planting
   - Selected vs. bin-run tubers for seed
   - Variety tests
5. Small grain investigations:
   - Wheat variety tests
   - Oat variety tests
   - Barley variety tests
   - Millet variety tests
   - Rolled vs. unrolled seed bed on upland soil
   - Treatment of seed barley for smut
6. Investigations with grasses:
   - Grass and clover variety tests
   - Alfalfa variety tests
   - Alfalfa inoculation tests
   - Nurse crop vs. no nurse crop for alfalfa
   - Alfalfa improvement by plant selection
   - Methods of seeding alfalfa
7. Garden crop investigations:
   - Variety tests
   - Fertilizers for garden crops on muskeg
   - Onion improvement
8. Peat for barn litter
9. Treating fence posts



### LIVESTOCK

The work with livestock is that of grading up a herd of common cows by the use of pedigreed Guernsey sires. The herd contains over one hundred head, of which over fifty are milkers. The signs of abortion which appeared three years ago have now entirely disappeared. Of more than fifty calves dropped, none was dropped before the time. The trouble with goitre among the calves still continues. A loss of approximately 12 per cent has been sustained from this cause. The production of milk and butter from the grade cows continues to show a marked advance above that from the common stock. The average production from the herd, exclusive of cows that have been barren for more than two years and young cows that have not yet completed a year's production, was 5,450.9 pounds of milk and 256.5 of butter fat. At the average price of butter fat received, 30 cents per pound, the average gross income from butter fat per cow was $76.95. The average cost of feed (hay at $10 per ton, ensilage at $2.50, and grain feeds at $30) amounted to $36.76 per cow, giving a net return for butter fat of $40.19 per cow.

During the winter of 1914-1915 a comparative test was made between middlings and bran as feed for dairy cows when fed in connection with clover and timothy hay and corn silage. Thirty-two cows

were included in this test, and the test covered a period of 18 weeks. The results indicate that middlings will return a larger profit on the money invested than bran when used as a concentrate with hay and ensilage. A complete report on this work will be included in the next annual report of this Station.

A comparative test of three common breeds of poultry, Plymouth Rock, White Orpington, and Single Comb White Leghorns, is being carried on.

The spring of 1915 opened early after a mild winter with very little snow, the ground being bare most of the time. Work in the field began April 15. The last half of April was very mild so that by the middle of May the deciduous trees were green and the fruit trees were in blossom. The warm weather and low precipitation made conditions ideal for the preparation of the fields and planting. All grains were in by the middle of May. At this date corn-planting was also begun and many of the potatoes, as well as early garden vegetables, were planted. The last of May, however, was quite the reverse. The weather was cold and wet. A snowstorm occurred May 17, which was followed by a heavy frost. The crops that had been planted have made very little headway up to date, June 1. Pastures are doing nicely. The herds were turned on them May 18.

Daily weather records are kept, and water levels, soil temperatures, and other data are being taken in connection with muskeg experiments.

Since August, 1914, about five acres of upland and muskeg have been cleared and prepared for crops.

## THE NORTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION, DULUTH

M. J. THOMPSON, Superintendent

### EXPERIMENTAL WORK

The Experimental work at this Substation, on account of the newness of the institution, has been confined to the following projects:

*Land-clearing.*—Of the twenty acres under investigation, ten acres are now in crop, five more are in experimental pasture, and on the remaining five the stumps are being piled, so that most of it will be cropped to rye this fall. An additional area of ten acres has been cut off and sown to clover and grass and data secured on brushing, burning, and logging. The forest products have been used, thus materially lessening the cost of clearing.

*Feeding value of cut-over land.*—Five acres of cut-over land have been seeded at the rate of six pounds of grass and clover seed per acre. It is now supporting two heifers and three cows full time. Returns



will be measured in terms of number of days pasturage, butter-fat returns, and increased weight for the young stock. Last year's clearing of ten acres will be used in the extension of this work in 1916.

*Bees in northern systems of farming.*—The work with bees was started with five hives in May, 1915, the stock being Yellow Italian and owned by the Division of Bee Culture of the Central Station at St. Paul. The stock has already increased about sixty per cent. The object of this work is to learn whether or not bees may become a source of income to the farmer before the land is cleared, and be an adjunct to the dairy during that time.

*Potato investigations.*—The study of mature vs. immature seed, small vs. large seed, degenerate vs. normal stock, and tests of pure lines, is coöperative with the Division of Horticulture of the Station at St. Paul.

*Northern orchard management.*—A coöperative fertilizer and culture test of apple varieties covers an area of three acres. Five hundred trees have been set out and are making a splendid growth. The interspaces are occupied by variety tests of potatoes, rutabagas, and other vegetables. Some check varieties of corn were also included.

*Variety tests of farm grains.*—Seventeen varieties of corn, five of oats, and two of barley are being grown coöperatively with the Division of Agronomy and Farm Management in order to determine which are best adapted to local conditions.

### FARM DEVELOPMENT

During the year eleven acres have been added to the land under plow, five acres of new pasture land are now in use, the first picking of stones has been made over an area of forty acres and the first breaking has been done on the farm. Roads have been built through the farm which have greatly facilitated the drainage. Land that yielded about two tons of hay per acre last season is this year being worked into a rotation. Over ten acres were brushed and logged last October and about seven acres additional have been brushed and the entire area sown to grass. The orchard, consisting of over five hundred trees, was set out in May, together with an additional acre of small fruit. The outside fencing is now nearly complete around the farm, and the paddock, poultry, hog, and sheep fences are being placed. The grading of the farmstead, preparatory to landscape work is progressing satisfactorily. The Station water system has been installed on the main campus and connections made to all the buildings. The preliminary drainage survey has been completed.

The poultry department was started August 1, 1914. The work is limited to White Leghorns and Barred Plymouth Rocks. With the hatch of the present season it is planned to have the poultry house

full next winter. The farm caters to a special poultry trade. The dairy herd of Guernseys has increased to twenty, which includes the mucelus of a pure-bred herd. The swine work has developed very favorably; registered Yorkshires only being fed. The problem with hogs in this district is one of cost of feed, hence work is under way at this Station to try to determine a cheap maintenance ration. An interesting phase of this work has been the demand from the farmers of northeastern Minnesota for breeding-stock, poultry, swine, and grade Guernsey calves. Several new projects are soon to be started, including a test of sheep and goats in clearing land, meterological observations, feeding tests with swine, and subprojects in land-clearing.

### PUBLIC SERVICE

The institution has served the people of northeastern Minnesota in several ways. During the autumn months several one-day farm practice short courses were held, the plan being to do only simple daily routine work. In March, the Second Annual Short Course and Continuation School of Agriculture was held, out of which grew the organization of the Tri-County Crop Improvement Association, which now has members in five counties; and the reorganization of the Grade Guernsey Production Registry, both of which have headquarters at this Station. At the same time, the County Federation of Farmers Clubs was enlarged by the addition of four clubs. Considerable extension work was done directly from the institution and services, such as testing milk and locating seed and livestock, were rendered individuals. The Station has distributed, at a reasonable price among farmers of the district, a number of registered Yorkshire swine of both sexes, also grade and pure-bred Guernsey calves, in addition to supplying farmers in five counties with pure-bred seed. A summer Institute and Picnic was held July 22 at the Station under the auspices of the Northeastern Minnesota Horticultural Society, the Farmers' Clubs, and the Station.

## SOUTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION, WASECA

ANDREW BOSS, in Charge

The demonstration tract of two hundred acres at Waseca, has been still further developed during the year. Some additional land was prepared for tiling and a farm house, modeled after the first-prize plan of the State Art Society, was erected, also a combination horse and dairy barn. A well was drilled, and a windbreak planted. The new farmstead is ready for occupancy.

The major five-year rotation was followed in the cropping system.



In coöperation with the Division of Soils, seventy-two tenth-acre plots have been established for fertilizer investigations. Tests of varieties of crop plants adapted to southeastern Minnesota are also being conducted coöperatively with the Central Station.

Fruit trees, small fruits, and berries have been set out with a view to establishing trial gardens, and additional experimental work is being introduced as rapidly as the ground can be brought into shape to handle it.

During the winter twenty-six two-year-old steers were fattened. Thirteen of these were fed on silage as the roughage part of the ration. The other thirteen were fed on bundle-corn. Both lots received adequate rations of grain in addition and made very good gains. The steers fed on silage made gains at slightly less cost than those fed on bundle-corn and returned slightly greater profits on the feed.

## STATE FRUIT-BREEDING STATION

CHARLES HARALSON, Superintendent

The fall of 1914 was exceptionally good for ripening wood and fruit buds. All fruit trees and small fruits were in good condition. All the fruits except apples bore good crops. The apple trees blossomed profusely in the spring of 1914 but set very little fruit. Whether this was because of unfavorable weather or of a weakened condition of the trees, I do not know. Not over 300 apple seedlings, out of about 9,000 trees of bearing age, bore any fruit, and these only a few specimens. The same was true with the named varieties of apples.

A block of about 4½ acres of Wolf and DeSoto plum seedlings, containing about 5,000 trees, was grubbed out and burned, scions from a few selected trees having been saved for grafting. The clearing of this block was necessary to make room for apple seedlings.

Last summer blight did considerable damage in one of the top-worked orchards. It started on Gould crab seedlings used as stock for top-working, and spread very rapidly to Patten's Greening and Hibernal. Very little blight was apparent in the other orchards or in the seedling plantations.

### PLANT-BREEDING

Plant-breeding was continued with apples, plums, pears, peaches, apricots, gooseberries, grapes, and everbearing strawberries. This work was largly done under glass during the latter part of the winter and in the early spring. A great deal of seed was saved from the different combinations to be planted next spring. Pollen of hardy pears was secured from C. G. Patten, of Charles City, Iowa, for crossing with several varieties grown in tubs for this purpose.

Several seedlings, the results of crossing the Compass cherry with apricot and peach are growing, and look promising; also over fifty seedlings of Compass cherry and native plums crossed with *Prunus pissardi.* These seedlings have proved hardy so far and will make fine ornamental shrubs or trees, on account of their dark purple foliage. They resemble the *Prunus pissardi.* They are good growers and sometimes make a growth of from five to six feet the first year in the nursery row.

Last spring 250 hybrid plum seedlings of many different combinations were planted; 1,100 apple seedlings (some crosses, and others from seed of top-worked winter apples), 200 grape seedlings (Beta X Delaware and vice versa), 600 Columbus gooseberry seedlings, 500 currant seedlings, 200 Rosa Rugosa seedlings (double varieties), 125 raspberry seedlings, and between four and five thousand everbearing strawberry seedlings.

### GRAFTING AND BUDDING

Standard varieties of winter apples have been top-grafted and top-budded the last three or four years on hardy stock, such as Hibernal, Patten's Greening, Duchess, and Gould and Virginia crab, with several purposes in view: (1) to supply material for plant-breeding; (2) to determine which varieties of apples will do best top-worked; (3) what stock is best to top-work on. Among varieties which seem to do fairly well are, Colorado Orange, Grimes Golden, Stayman Winesap, Windsor Chief, English Russet, Perry Russet, Golden Russet, Gilbert Winesap, Jonathan, McIntosh, Bayard, Hubbardston Nonsuch, Black Annette, and Fameuse. These have been out three winters and always come out in fairly good shape in spring. Other varieties have done very well, but have been out only one and two winters, which is too short a time in which to reach any conclusion. As to stock, we consider Hibernal the best; it will make a good union with almost any variety grafted on it.

One hundred and four named varieties of apples are top-worked up to date and growing, as follows: Arctic, Alexander, American Blush, Akin, Allens Choice, America, Blue Pearmain, Baldwin, Black Annette, Boiken, Black Ben, Bellflower, Bottle Green, Ben Davis, Brilliant, Ben Hur, Bayard, Bailey Sweet, Bethel, Benoni, Century, Colorado, Orange, Delicious, Evelyn, English Russet, Eastman, Fallawater, Fameuse, Fall Sweet, Grimes' Golden, Gano, Grundy, Gilbert Winesap, Golden Russet, Goodhue, Giant, Geniton, Hutchings, Henry Clay, Hubbardston Nonsuch, Haas, Iowa Beauty, Iowa Blush, Jewell's Winter, Jewell's Sweet, Jonathan, Judson, King David, King, Lady, Lowland Raspberry, Lansingburg, Lowrie, Malinda, McIntosh, Milwaukee, McMahon, Maiden Blush, Minkler, Mann, Newton Pippin, Nodhead, Northwest Greening, Opalescent, Pearmain, Paragon, Perry Russet,



Primate, Pound Sweet, Rawle's Jenette, Rome Beauty, Radiant, Redwing, Red Canada, Roman Stem, Roxbury Russet, Red Romanite, Rhode Island Greening, Scott's Winter, Sugarloaf, Spitzenberg, Silas Wilson, Salome, Superb, St. Lawrence, Senator, Stayman Winesap, Shackleford, Summer Champion, Sandy Glass, Twenty Ounce, Wismer's Dessert, Winter Banana, Winesap, Wolf River, Wagoner, Wilson Red, Windsor Chief, White Pearmain, Winterstine, Winter Maiden Blush, Willow Twig, Walbridge, Wealthy.

### STRAWBERRIES

Everbearing strawberry No. 907, which is a cross between Autumn and Brandywine, and No. 1,017, a cross between Pan-American and Senator Dunlap, have proved very productive the last two years. These two varieties are the final selections from about 100 seedlings. On October 20 as many as 230 blossoms and berries were counted on a single plant; and nearly as many on other plants. Berries were picked from August 1 to November 6. The berries are of good size, perfect in form, and of good quality for a fall-bearing variety. It is also a good plant-maker. These two new varieties, when introduced, should prove of great value; they are just as hardy as any other variety, and the foliage has been free from rust or any other disease up to date.

Among the everbearing strawberries introduced in the last few years, the Progressive is the most satisfactory with us.

During the fruiting season we had nearly 800 varieties of strawberries bearing. Wherever we had sufficient mulching to protect them during winter they bore a good crop, but where there was little or no mulching, the plants were badly hurt and did not fruit so well as they would with better protection. About fifty seedlings were selected for further testing, some of which will be equal to any of the best varieties grown for commercial purposes. Among these is our No. 3. It is hardy, and has borne good crops for several years. I think it will be one of the leading varieties when fully tested.

### RASPBERRIES

The raspberries bore an exceptionally good crop last summer. Nos. 1, 2, 3, 4, 5, 6, and 7 have been sent to the trial stations in the state for testing. No. 4, I think, will prove to be one of the best. It has a good cane and healthy foliage, the berries are large, good color, firm enough to stand shipping, and of very good quality. Some of the others are nearly as good and may prove better when fully tried out.

A few numbers of black-cap seedlings have borne a good crop for several years and are very promising, but they are slow to propagate.

### GRAPES

The Beta grape seedlings bore a good crop again this year. Most of the vines were overloaded with fruit. Twenty-three vines have made a good record for the last three years. Many of these resemble the Beta in fruit, bunches, and quality. The vines have had no winter protection since they were planted, but have always come out in good condition in the spring. The fruit is not of high quality, like the Delaware, but will be valuable for planting where standard varieties are too tender. Two vines will be propagated as rapidly as possible. One is a red grape of fair quality, nearly the size of Moore's Early; the other is black when ripe, and the fruit is about the same size. Both are vigorous growers and hardy.

### PLUMS

The plum hybrids probably gave us the best results of all the fruits we attempted to improve. Several varieties were overloaded with large fruit. Nearly all of them bore a fair crop, and have for the last three or four years. Among the most promising are Burbank crossed with Wolf, Nos. 6, 12, 21, 9, 10, 25, and 1; Abundance crossed with Wolf, Nos. 35, 15, 8, and 27. Some of these varieties have fruit up to 1¾ inches in diameter, of good quality.

Results of plant-breeding to date are two varieties of everbearing strawberries, several June-bearing varieties, seven varities of grapes, seven of raspberries, two of gooseberries, and sixteen of plums. These varieties are all worthy of trial, whether for commercial purposes or for private use. Some of these new fruits have been distributed to the trial stations in the state, others will be sent later.

## REPORT OF LEGISLATIVE COMMITTEE APPOINTED TO EXAMINE THE STATE FRUIT-BREEDING STATION

"It was the pleasure of the writer along with Senator J. T. Elwell and Mr. S. P. Crosby to look over the Fruit Breeding Station, August 21 last. To say that we enjoyed the hospitality of Superintendent Haralson and were very much gratified with the work he has accomplished in so short a time would be putting it mildly.

"There were practically no apples fruiting, but the many seedlings and varieties on trial showed good promise and were in excellent condition. As the trees are just getting to a bearing age, indications are that another season will show some progress along that line, as it has in small fruits and plums.

"Raspberries were past their season, but from among the several thousand seedlings they have selected a few that are especially thrifty and desirable, particularly Numbers 4, and 1, 2, 3, and 5. Everbearing strawberries and plums, however, were in their prime, and particularly



worthy of mention and dissemination are strawberries Nos. 3 (June bearing) and 1017 (everbearing). Compared with the Progressive (which I consider the best of the named sorts), No. 1017 is fully as large, firm, and productive, but more vigorous and a better plant-maker. As they have a fairly good stock of this variety, no doubt it will be offered to the public the coming season.

"Superintendent Haralson has good reason to be proud of his productions along the plum line, more so, even, than those fruits already mentioned. The medium-season varieties were ripe at the time of our visit, these being mainly crosses between Wolf and Burbank or Abundance. Nos. 6 and 12, Wolf crossed with Burbank, and No. 35, Wolf crossed with Abundance, are perhaps the most promising, being all very large and attractive fruits of exceptional quality. No. 6 is an early clingstone variety. No. 12 is a freestone, a very heavy annual bearer, peels freely and hence bids fair to be the "peach" for the Northwest. No. 35 is also a freestone variety of upright growth but possibly not as hardy or productive. Other sorts of exceptional merit are Nos. 1, 4, 5, 10, and 17, any of which have our present list of native plums discounted for size, quality, and attractiveness (with the possible exception of the Surprise, which, where it yields satisfactorily, we could not very well dispense with. These should be generally tried throughout the state and Northwest as fast as possible, as the hardiest of them will revolutionize the plum industry and displace the present list of varieties. To our minds there is no better or quicker way of getting the desired information as to their behavior than by distribution through the Society, as has been practiced the last two seasons.

"If these are merely a few of the first fruits of the Minnesota Fruit-Breeding Station, what may we not expect under continued right management and proper encouragement. Four thousand dollars, I believe, was the amount received this year for operating the Station, of which something over one thousand dollars was used by the University for scientific research. On a place of this size and character, under existing conditions, the balance on hand shows judicious conservation and expenditure—considering the excellent condition in which everything appeared. In fact, I do not see how Superintendent Haralson could keep his expense within that limit.

"The grounds are getting pretty well covered at the present time, and unless additional land can be rented to advantage, eventually it will be necessary to purchase more, and the sooner this is acquired the better for the state, as in all probability it will not decrease in value.

"The most urgent need, however, is a larger available fund for general running expenses, a good assistant, another greenhouse, about the size of the present one, a water system, and another living-house for

teamsters and a boarding-house. Fifteen thousand dollars would, no doubt, cover these improvements to the present equipment and (with five thousand dollars annual appropriation for upkeep) give us a plant equipped to advantage for years to come."

GEORGE W. STRAND.

December, 1914.

Note: The recommendations in the last paragraph, were provided for, in part, by the legislature of 1915.