

The University of Minnesota

TWENTY-FOURTH ANNUAL
REPORT OF THE
AGRICULTURAL EXPERIMENT STATION

JULY 1, 1915
TO JUNE 30, 1916



UNIVERSITY FARM, ST. PAUL

FEBRUARY, 1917

LETTERS OF TRANSMITTAL

MINNEAPOLIS, MINN., October 10, 1916

To His Excellency, John A. A. Burnquist,
Governor of Minnesota.

SIR: I have the honor to transmit to you herewith the annual report of the Agricultural Experiment Station of the University of Minnesota for the fiscal year ending June 30, 1916.

Respectfully,
FRED B. SNYDER,
President Board of Regents

UNIVERSITY OF MINNESOTA

MINNEAPOLIS, MINN., October 10, 1916

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, 1916.

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

UNIVERSITY FARM, ST. PAUL, MINN., October 10, 1916

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, 1916.

Respectfully,
A. F. WOODS,
Director

THE BOARD OF REGENTS

The Hon. FRED B. SNYDER, Minneapolis, President of the Board	- - - - -	1922
GEORGE EDGAR VINCENT, Minneapolis	- - - - -	<i>Ex officio</i>
The President of the University		
The Hon. J. A. A. BURNQUIST, St. Paul	- - - - -	<i>Ex officio</i>
The Governor of the State		
The Hon. C. G. SCHULZ, St. Paul	- - - - -	<i>Ex officio</i>
The Superintendent of Education		
The Hon. W. J. MAYO, Rochester	- - - - -	1919
The Hon. MILTON M. WILLIAMS, Little Falls	- - - - -	1919
The Hon. JOHN G. WILLIAMS, Duluth	- - - - -	1920
The Hon. GEORGE H. PARTRIDGE, Minneapolis	- - - - -	1920
The Hon. A. E. RICE, Willmar	- - - - -	1921
The Hon. CHARLES L. SOMMERS, St. Paul	- - - - -	1921
The Hon. PIERCE BUTLER, St. Paul	- - - - -	1922
The Hon. C. W. GLOTFELTER, Waterville	- - - - -	1922

THE AGRICULTURAL COMMITTEE

The Hon. A. E. RICE, Chairman	The Hon. CHARLES L. SOMMERS
The Hon. PIERCE BUTLER	The Hon. MILTON M. WILLIAMS
The Hon. C. G. SCHULZ	The Hon. JOHN G. WILLIAMS
The Hon. C. W. GLOTFELTER	President GEORGE E. VINCENT

STATION STAFF

ADMINISTRATIVE OFFICERS

- A. F. WOODS, M.A., D.Agr., Director
- R. W. THATCHER, M.A., Assistant Director
- A. D. WILSON, B.S. in Agr., Director of Agricultural Extension and Farmers' Institutes
- C. G. SELVIG, M.A., Superintendent, Northwest Substation
- M. J. THOMPSON, M.S., Superintendent, Northeast Substation
- O. I. BERGH, B.S.Agr., Superintendent, North Central Substation
- E. C. HIGBIE, M.A., Superintendent, West Central Substation
- CHARLES HARALSON, Superintendent, Fruit-Breeding Farm, Excelsior
- W. H. KENETY, M.S., Superintendent, Forestry Experiment Station, Cloquet
- W. P. KIRKWOOD, B.A., Editor
- HARRIET W. SEWALL, B.A., Librarian
- T. J. HORTON, Photographer
- R. M. WEST, B.A., Secretary

DIVISION OF AGRICULTURAL BIOCHEMISTRY

R. W. THATCHER, M.A., Plant Chemist, Chief

Section of Plant Chemistry

R. W. THATCHER, M.A., Plant Chemist, in Charge
CORNELIA KENNEDY, M.S., Assistant Agricultural Chemist
D. O. SPRIESTERSBACH, M.S., Research Assistant

Section of Biochemical Research

....., Associate Agricultural Biochemist, in Charge

Section of Cereal Technology

*C. H. BAILEY, M.S., Cereal Technologist, in Charge

Section of Agricultural Analysis

J. J. WILLAMAN, M.A., Assistant Agricultural Chemist, in Charge
†R. M. WEST, B.A., Assistant Agricultural Chemist
‡R. A. THUMA, M.S., Special Analyst

DIVISION OF AGRICULTURAL ENGINEERING

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

DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Agronomist and Farm Management Investigator, Chief

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 Plant 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, Chief
L. V. FRANCE, M.S. in Agr., Assistant Apiculturist

* Absent on leave, June 1, 1916-June 1, 1917.
† Resigned during the year.
‡ Temporary appointment.

DIVISION OF DAIRY AND ANIMAL HUSBANDRY

T. L. HAECKER, Dairy and Animal Husbandman, Chairman

Section of Animal Husbandry

J. S. MONTGOMERY, B.S. in Agr., Assistant Animal Husbandman. Horses
T. G. PATERSON, B.S. in Agr., Assistant Animal Husbandman. Beef Cattle and Sheep
R. C. ASHBY, M.S., Assistant Animal Husbandman. Swine

Section of Dairy Husbandry

R. M. WASHBURN, M.S.A., Dairy Husbandman. Dairy Manufacture
GUSTAV W. GEHRAND, Ph.B., Assistant Dairy Husbandman. Dairy Stock and Production
E. O. HANSON, Assistant in Dairy Laboratory

Section of Poultry Husbandry

A. C. SMITH, B.S., Poultry Husbandman
D. J. LANE, Assistant in Poultry Husbandry

Section of 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 ECONOMIC ZOOLOGY

F. L. WASHBURN, M.A., Entomologist, Chairman

Section of Economic Vertebrate Zoology

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

Section of Economic Entomology

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

Section of Parasitology

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

Section of Research in Economic Zoology

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

DIVISION OF HORTICULTURE

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

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., Associate Horticulturist, in Charge
W. D. VALLEAU, B.S., Assistant in Horticulture

Section of Fruit and Vegetable Investigations

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

Section of Fruit Handling and Utilization

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

DIVISION OF PLANT PATHOLOGY AND BOTANY

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

Section of Plant Pathology

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

Section of Seed Laboratory

W. L. OSWALD, Assistant Agricultural Botanist, in Charge
 ROBERT C. DAHLBERG, B.S., Seed Analyst
 R. P. INGRAM, B.S., Seed Inspector

DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

E. DANA DURAND, Ph.D., Agricultural Economist, Chief
 O. B. JESNESS, B.S. in Agr., Assistant in Agricultural Economics

DIVISION OF SOILS

F. J. ALWAY, Ph.D., Soils Chemist, Chief
 R. A. GORTNER, Ph.D., Associate Soils Chemist
 C. O. ROST, M.A., Assistant Soils Chemist
 P. R. McMILLER, M.S., Assistant Chemist in Soils

DIVISION OF VETERINARY SCIENCE

M. H. REYNOLDS, Veterinarian, Chairman

Section of Veterinary Biochemical Products

*H. P. HOSKINS, V.M.D., Assistant Veterinarian, in Charge
 *J. T. E. DINWOODIE, V.M.D., Assistant Veterinarian
 H. C. H. KERNKAMP, D.V.M., Assistant Veterinarian

Section of Veterinary Medicine and Pathology

W. L. BOYD, D.V.S., Assistant Veterinarian, in Charge

Section of Veterinary Physiology

C. C. PALMER, D.V.M., Assistant Veterinarian, in Charge

Section of Veterinary Sanitation

M. H. REYNOLDS, D.V.M., Veterinarian, in Charge

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., Superintendent, Cloquet Station
 G. H. WIGGIN, B.S. in For., Assistant Forester at Cloquet.

* Resigned during the year.

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FINANCIAL STATEMENT

THE MINNESOTA AGRICULTURAL EXPERIMENT STATION IN ACCOUNT WITH THE UNITED STATES APPROPRIATIONS 1915-1916

Dr.

To receipts from the Treasurer of the United States in accordance with the appropriation for the fiscal year ending June 30, 1916, under Act of Congress approved March 2, 1887..... \$15,000.00

Cr.

By Salaries \$9,300.00
Labor 5,700.00

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, 1916, under Act of Congress approved March 16, 1906..... \$15,000.00

Cr.

By Salaries \$14,550.00
Labor 450.00

Total Adams fund \$15,000.00 \$15,000.00

FEDERAL FUNDS 1915-1916

	Morrill	Nelson	Hatch	Adams	Smith-Leyer	Total
Agricultural Chemistry		\$3,000	\$500	\$2,400		\$5,900.00
Agricultural Education		1,100				1,100.00
Agricultural Engineering		6,900				6,900.00
Agronomy and Farm Management	\$1,100	2,450	4,120			7,670.00
Dairy and Animal Husbandry	1,700	3,000	2,780	7,400		14,880.00
Economic Zoology	1,200	1,400	2,000			4,600.00
Horticulture		1,800	900	1,650		4,350.00
Plant Pathology and Botany	1,000	1,000		1,350		3,350.00
Soils	1,000	500	300	2,200		4,000.00
Veterinary Science		1,000	1,400			2,400.00
School and College		2,850				2,850.00
Experiment Station			3,000			3,000.00
Agricultural Extension					\$24,898.99	24,898.99
Total	\$6,000	\$25,000	\$15,000	\$15,000	\$24,898.99	\$85,898.99

CLASSIFIED STATEMENT OF DISBURSEMENTS OF DEPARTMENT OF AGRICULTURE
1915-1916

	Substations	University Farm	Total
Salaries	\$52,066.43	\$293,818.89	\$345,885.32
Labor	30,707.26	93,697.65	124,404.91
Publications	465.66	8,333.32	8,798.98
Postage and stationery	3,688.26	10,580.85	14,269.11
Freight and express	2,312.98	2,164.56	4,477.54
Heat, light, water, and power	11,942.74	32,771.05	44,713.79
Chemicals and laboratory supplies	186.31	3,686.64	3,872.95
Seeds, plants, and sundry supplies	4,307.86	9,325.19	13,633.05
Fertilizers		182.27	182.27
Feeding stuffs	10,828.77	22,594.46	33,423.23
Library	1,453.63	3,401.33	4,854.96
Tools, machinery, and appliances	3,424.78	4,891.89	8,316.67
Furniture and fixtures	1,398.71	5,714.32	7,113.03
Scientific apparatus	327.65	3,510.58	3,838.23
Livestock (including hogs for hog cholera work, \$6,115.92)	4,934.94	10,871.19	15,806.13
Traveling expenses	2,979.50	21,159.14	24,138.64
Contingent expenses	64.11	2,242.35	2,306.46
Buildings and lands (exclusive of special appropriations)	4,875.73	10,893.49	15,769.22
Total	\$135,965.32	\$539,839.17	\$675,804.49

GENERAL SUMMARY OF DISBURSEMENTS FOR THE FISCAL YEAR 1915-1916

	General Support	Special	Federal	Total
Agricultural Chemistry	\$5,760.30	\$3,338.84	\$5,900.00	\$14,999.14
Agricultural Education	10,445.86		1,100.00	11,545.86
Agricultural Engineering	14,880.90	1,055.31	6,900.00	22,836.21
Agronomy and Farm Management	17,109.41	13,069.26	7,670.00	37,848.67
Bee-Keeping	2,071.24	3,353.13		5,424.37
Dairy and Animal Husbandry	38,846.79	22,061.54	14,880.00	75,788.33
Economic Zoology	3,916.65	3,492.04	4,600.00	12,008.69
Home Economics	30,668.41		1,150.00	31,818.41
Horticulture	8,863.95	9,088.27	4,350.00	22,302.22
Plant Pathology and Botany	9,183.93	10,612.70	3,350.00	23,146.63
Research in Agricultural Economics	2,758.50	2,936.54		5,695.04
Soils	8,996.17	2,022.04	4,000.00	15,018.21
Veterinary Science	7,213.85	18,105.85	2,400.00	27,719.70
Forestry Investigations	3,600.00	16,322.72		19,922.72
Agricultural Extension		28,728.21	24,898.99	53,627.20
Library	1,699.36	8,550.84		10,250.20
Repairs to buildings	10,514.13	18,470.58		28,984.71
Campus maintenance		3,350.46		3,350.46
General School and College	56,928.80		1,700.00	58,628.80
General Station	25,469.87		3,000.00	28,469.87
Coal	30,453.73			30,453.73
Totals	\$289,381.85	\$164,558.33	\$85,898.99	\$539,839.17

DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1915-1916

	Fund	Total	School and College	Experiment Station	Extension
Administration	Support	\$21,440.03	\$16,080.02	\$5,360.01	
	Hatch	3,000.00		3,000.00	
Summer School	Support	4,492.69	4,492.69		
Short Courses	Support	4,733.74	4,733.74		
General service	Support	3,587.93	1,793.96	1,793.97	
Farm maintenance	Support	6,648.56		6,648.56	
Registrar	Support	5,806.38	5,806.38		
Custodial	Support	14,437.59	10,828.19	3,609.40	
Hospital	Support	700.00	700.00		
Dormitories	Support	394.98	394.98		
General School	Support	9,991.81	9,991.81		
Publications	Support	6,022.21	140.55	5,881.66	
English	Support	4,142.75	4,142.75		
	Nelson	1,700.00	1,700.00		
Agricultural Chemistry ..	Grain laboratory	2,155.10		2,155.10	
	Sorghum sirup	1,183.74		1,183.74	
	Nelson	3,000.00	3,000.00		
	Hatch	500.00		500.00	
	Adams	2,400.00		2,400.00	
Agricultural Education ..	Support	5,760.30	3,375.30	2,385.00	
	Nelson	1,100.00	1,100.00		
Agricultural Engineering ..	Support	10,445.86	10,445.86		
	Drainage	270.97		270.97	
	Engineering investigations ..	784.34		784.34	
	Nelson	6,900.00	6,900.00		
	Support	14,880.90	14,322.90	558.00	
Agronomy	Farm management	4,116.97		4,116.97	
	Field crops	8,412.45		8,412.45	
	Eradication of noxious weeds ..	539.84		539.84	
	Morrill	1,100.00	1,100.00		
	Nelson	2,450.00	2,450.00		
	Hatch	4,120.00		4,120.00	
	Support	17,109.41	10,367.41	6,742.00	

DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1915-1916—
Continued

	Fund	Total	School and College	Experiment Station	Extension
Bee-Keeping	Bee-culture investigation	3,353.13	2,514.84	838.29	
	Support	2,071.24	2,071.24		
Dairy and Animal Hus-	Dairy extension	3,411.25			\$3,411.25
bandry	Cow-testing	2,105.29			2,105.29
	Poultry investigation	6,312.76	6,312.76		
	Animal nutrition	5,025.21		5,025.21	
	Livestock	5,207.03	3,905.27	1,301.76	
	Morrill	1,700.00	1,700.00		
	Nelson	3,000.00	3,000.00		
	Hatch	2,780.00		2,780.00	
	Adams	7,400.00		7,400.00	
	Support	38,846.79	29,135.09	9,711.70	
Economic Zoology	Investigation of injurious insects	3,492.04		3,492.04	
	Morrill	1,200.00	1,200.00		
	Nelson	1,400.00	1,400.00		
	Hatch	2,000.00		2,000.00	
	Support	3,916.65	2,326.65	1,590.00	
Home Economics	Nelson	1,150.00	1,150.00		
	Support	30,668.41	30,668.41		
Horticulture	Fruit-breeding	3,816.45		3,816.45	
	Fruit-breeding farm	2,000.00		2,000.00	
	Horticultural crops	3,271.82		3,271.82	
	Nelson	1,800.00	1,800.00		
	Hatch	900.00		900.00	
	Adams	1,650.00		1,650.00	
	Support	8,863.95	6,165.95	2,698.00	
Plant Pathology and	Bacteriology	1,556.57		1,556.57	
Botany	Plant diseases	2,187.57		2,187.57	
	Seed inspection	5,064.22		5,064.22	
	Seed laboratory	1,804.34		1,804.34	
	Morrill	1,000.00	1,000.00		
	Nelson	1,000.00	1,000.00		

DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1915-1916—
Continued

	Fund	Total	School and College	Experiment Station	Extension
Research in Agricultural Economics	Adams Support	1,350.00		1,350.00	
Soils	Marketing investigation	9,183.93	4,078.93	5,105.00	
	Support	2,936.54		2,936.54	
	Soil investigation	2,758.50	2,463.50	295.00	
	Morrill	2,022.04	1,000.00	2,022.04	
	Nelson	1,000.00	500.00		
	Hatch	300.00		300.00	
Veterinary Science	Adams Support	2,200.00		2,200.00	
	Support	8,996.17	6,036.17	2,960.00	
	Hog cholera serum	18,105.85		18,105.85	
	Hatch	1,400.00		1,400.00	
	Nelson	1,000.00			
	Support	7,213.85		3,606.92	
Forestry	Forestry investigation	10,322.72	10,881.81	5,440.91	
Agricultural Extension	Support	3,600.00	2,400.00	1,200.00	
Library	Extension	28,728.21			\$28,728.21
	Smith-Lever	24,898.99			24,898.99
	Library special	8,550.84	4,275.42	4,275.42	
Repairs	Support	1,699.36	849.68	849.68	
Campus maintenance	Repairs special	18,470.58	13,852.94	4,617.64	
	Support	10,514.13	7,885.59	2,628.54	
	Coal	3,350.46	3,350.46		
		30,453.73	22,840.39	7,613.34	
Total University Farm		\$539,839.17	\$294,238.57	\$186,456.86	\$59,143.74

RECEIPTS AND DISBURSEMENTS OF THE DEPARTMENT OF AGRICULTURE FOR THE
FISCAL YEAR 1915-1916

University Farm			
Allotment for General Support budget	\$255,756.00		
Balance, General Support, August 1, 1915	8,191.12		
Receipts credited to Support budgets	8,932.36		
Total receipts, General Support		\$272,879.48	
Appropriation for Special funds budget	140,500.00		
Balance Special funds, August 1, 1915*	15,723.44		
Receipts from sales credited to Special funds	35,419.95		
Total receipts, Special funds		191,643.39	
Allotment for coal	30,453.73	30,453.73	
Receipts from Farm sales credited to General University	15,576.02		
Receipts from Fees, General University	26,581.69		
Total receipts to General University		42,157.71	
Receipts from United States Government	85,898.99	85,898.99	
Expenditures, General Support	\$258,928.12		
Expenditures, Special funds	104,558.33		
Expenditures, Coal	30,453.73		
Expenditures, Receipts to General University	42,157.71		
Expenditures, Federal funds	85,898.99		
Balance, August 1, 1916, General Support	\$581,996.88		\$581,996.88
Balance August 1, 1916, Special funds	13,951.36		
	27,085.06		
	\$623,033.30		\$623,033.30

* Of the August 1, 1915, balance \$651.83 was transferred to Zumbra and \$700.94 was cancelled by State Auditor.

RECEIPTS AND DISBURSEMENTS OF SUBSTATIONS FOR YEAR 1915-1916

Crockston			
Appropriation for Maintenance.....		\$45,400.00	
Balance Aug. 1, 1915.....		1,698.62	
Receipts from Farm sales.....		9,754.82	
Receipts from fees.....		2,341.12	
Expenditures, Maintenance	\$58,015.49		
Balance Aug. 1, 1916.....	1,179.07		
	\$59,194.56	\$59,194.56	
Morris			
Appropriation for Maintenance.....		\$34,500.00	
Balance Aug. 1, 1915.....		840.91	
Receipts from Farm sales.....		4,655.63	
Receipts from School fees.....		2,238.52	
Expenditures, Maintenance	\$39,302.90		
Balance, Aug. 1, 1916.....	2,932.16		
	\$42,235.06	\$42,235.06	
Grand Rapids			
Appropriation for Maintenance.....		\$10,000.00	
Balance, Aug. 1, 1915.....		558.11	
Receipts from Farm sales.....		6,847.00	
Expenditures, Maintenance	\$16,632.09		
Balance, Aug. 1, 1916.....	773.02		
	\$17,405.11	\$17,405.11	
Duluth			
Appropriation for Maintenance.....		\$7,600.00	
Balance, Aug. 1, 1915.....		2,856.38	
Receipts from Farm sales.....		2,141.59	
Expenditures	\$9,274.10		
Balance, Aug. 1, 1916.....	3,323.87		
	\$12,597.97	\$12,597.97	
Waseca			
Appropriation for Maintenance.....		\$4,400.00	
Balance, Aug. 1, 1915.....		2,802.21	
Receipts from Farm sales.....		1,696.67	
Expenditures	\$8,314.19		
Balance, Aug. 1, 1916.....	584.69		
	\$8,898.88	\$8,898.88	
Zumbra			
Appropriation for Maintenance.....		\$4,000.00	
Balance, Aug. 1, 1915.....		651.83	
Receipts from Farm sales.....		1,496.49	
Expenditures	\$4,426.55		
Balance, Aug. 1, 1916.....	1,721.77		
	\$6,148.32	\$6,148.32	

SPECIAL STATE APPROPRIATIONS

DISBURSEMENTS FOR MAINTENANCE 1915-1916

Grain laboratory	\$2,155.10	
Sorghum sirup	1,183.74	
Total, Agricultural Chemistry.....		\$3,338.84
Drainage problems	270.97	
Engineering investigations	784.34	
Total, Agricultural Engineering.....		1,055.31
Farm management	4,116.97	
Field crops	8,412.45	
Eradication of noxious weeds.....	539.84	
Total, Agronomy and Farm Management.....		13,069.26
Bee culture	3,353.13	3,353.13
Dairy extension	3,411.25	
Dairy cow testing.....	2,105.29	
Poultry investigation	6,312.76	
Animal nutrition	5,025.21	
Livestock	5,207.03	
Total, Dairy and Animal Husbandry.....		22,061.54
Investigation of injurious insects.....	3,492.04	
Total, Economic Zoology		3,492.04
Campus maintenance	3,350.46	
Fruit-breeding	3,816.45	
Fruit-breeding farm	2,000.00	
Horticultural crops	3,271.82	
Total, Horticulture		12,438.73
Bacteriology investigation	1,556.57	
Plant diseases	2,187.57	
Seed inspection	5,064.22	
Seed laboratory	1,804.34	
Total, Plant Pathology and Botany.....		10,612.70
Marketing investigations	2,936.54	
Total, Research in Agricultural Economics.....		2,936.54
Soil investigations	2,022.04	2,022.04
Hog cholera	18,105.85	
Total, Veterinary Science		18,105.85
Forestry	16,322.72	16,322.72
Agricultural Extension	28,728.21	28,728.21
Library	8,550.84	8,550.84
Repairs	18,470.58	18,470.58
Grand total	\$164,558.33	\$164,558.33

DETAILED STATEMENT OF SPECIAL STATE APPROPRIATIONS FOR THE YEAR 1915-1916

	Appropriation	Balance Aug. 1, 1915	Receipts	Total credits	Disbursements	Balance Aug. 1, 1916
Grain laboratory.....	\$2,500.00	\$68.24	\$24.59	\$2,592.83	\$2,155.10	\$437.73
Sorghum sirup.....	1,000.00	183.74	.....	1,183.74	1,183.74	.....
Total, Agricultural Chemistry.....	3,500.00	251.98	24.59	3,776.57	3,338.84	437.73
Drainage problems.....	.....	271.89	.....	271.89	270.97	0.92
Engineering investigations.....	500.00	532.03	.....	1,032.03	784.34	247.69
Total, Agricultural Engineering.....	500.00	803.92	.....	1,303.92	1,055.31	248.61
Farm management.....	4,500.00	0.14	.....	4,500.14	4,116.97	383.17
Field crops.....	6,500.00	1,543.23	1,411.06	9,454.29	8,412.45	1,041.84
Eradication of noxious weeds.....	.....	716.44	.....	716.44	539.84	176.60
Total, Agronomy and Farm Management	11,000.00	2,259.81	1,411.06	14,670.87	13,069.26	1,601.61
Bee-Keeping.....	3,000.00	330.93	361.20	3,692.13	3,353.13	339.00
Animal nutrition.....	3,500.00	1,175.82	548.29	5,224.11	5,025.21	198.90
Dairy extension.....	3,100.00	418.60	.....	3,518.60	3,411.25	107.35
Dairy extension cow testing.....	.....	.....	2,319.95	2,319.95	2,105.29	214.66
Livestock.....	2,000.00	535.07	5,366.07	7,901.14	5,207.03	2,694.11
Poultry investigation.....	5,000.00	325.53	1,497.27	6,822.80	6,312.76	510.04
Total, Dairy and Animal Husbandry....	13,600.00	2,455.02	9,731.58	25,786.60	22,061.54	3,725.06
Investigation of injurious insects.....	3,500.00	0.44	.....	3,500.44	3,492.04	8.40
Total, Economic Zoology.....	3,500.00	0.44	.....	3,500.44	3,492.04	8.40

DETAILED STATEMENT OF SPECIAL STATE APPROPRIATIONS FOR THE YEAR 1915-1916—Continued

	Appropriation	Balance Aug. 1, 1915	Receipts	Total credits	Disbursements	Balance Aug. 1, 1916
Campus maintenance.....	3,500.00	11.52	15.38	3,526.90	3,350.46	176.44
Fruit-breeding.....	3,500.00	410.60	.....	3,910.60	3,816.45	94.15
Fruit-breeding farm.....	2,000.00	.....	.....	2,000.00	2,000.00	.....
Horticultural crops.....	2,500.00	270.00	757.77	3,527.77	3,271.82	255.95
Total, Horticulture.....	11,500.00	692.12	773.15	12,965.27	12,438.73	526.54
Bacteriology investigation.....	1,500.00	77.81	.....	1,577.81	1,556.57	21.24
Plant diseases.....	2,000.00	179.17	8.40	2,187.57	2,187.57	.....
Seed inspection.....	5,000.00	82.46	.....	5,082.46	5,064.22	18.24
Seed laboratory.....	1,500.00	.....	369.85	1,869.85	1,804.34	65.51
Total, Plant Pathology and Botany.....	10,000.00	339.44	378.25	10,717.69	10,612.70	104.99
Marketing investigation.....	3,000.00	270.63	.....	3,270.63	2,936.54	334.09
Total, Research in Agricultural Economics	3,000.00	270.63	.....	3,270.63	2,936.54	334.09
Soil investigations.....	2,000.00	18.17	9.00	2,027.17	2,022.04	5.13
Hog cholera serum.....	10,000.00	5,982.95	15,427.01	31,409.96	18,065.63	13,344.33
Hog cholera investigations.....	.....	40.22	.....	40.22	40.22	.....
Total, Veterinary Science.....	10,000.00	6,023.17	15,427.01	31,450.18	18,105.85	13,344.33
Forestry investigations.....	15,500.00	675.26	628.30	16,803.56	16,322.72	480.84
Agricultural Extension.....	26,900.00	33.74	1,817.09	28,750.83	28,728.21	22.62
Library.....	9,000.00	345.37	37.38	9,382.75	8,550.84	831.91
Repairs.....	17,500.00	1,223.44	4,821.34	23,544.78	18,470.58	5,074.20
Total.....	\$140,500.00	\$15,723.44	\$35,419.95	\$191,643.39	\$164,558.33	\$27,085.06

SPECIAL APPROPRIATIONS FOR BUILDINGS AND IMPROVEMENTS FOR BIENNIUM
1915-1917

Enlarging Home Economics building and equipment..	\$45,300.00	
Enlarging Power House and equipment.....	30,000.00	
Special improvements	8,750.00	
Total, University Farm.....		\$84,050.00
General repairs, betterments, and alterations.....	7,500.00	
Special improvements	9,500.00	
Total, Crookston		17,000.00
General repairs, betterments, and alterations.....	1,000.00	
Special improvements	6,000.00	
Total, Grand Rapids		7,000.00
Repairs, betterments, and alterations.....	9,000.00	
Special improvements	16,500.00	
Additional lands	2,500.00	
Farm Engineering Building.....	25,000.00	
Livestock	5,000.00	
Farm cottage	15,000.00	
Total, Morris		73,000.00
Institute Hall and equipment.....	7,000.00	
Clearing land	3,000.00	
Total, Duluth		10,000.00
Alterations, betterments, and repairs.....	1,375.00	
Total, Waseca		1,375.00
Special improvements	7,600.00	
Total, Zumbra		7,600.00
Grand total, University Farm and Substations..		\$200,025.00

REVOLVING FUNDS FOR UNIVERSITY FARM AND SUBSTATIONS, FOR THE
FISCAL YEAR, 1915-1916

	Univ. Farm Din. Hall	Univ. Farm Book Store	Univ. Farm Photo Lab.	Univ. Farm Gym.	Univ. Farm Hospital
Pay rolls.....	\$13,182.02	\$1,995.21	\$1,022.25	\$687.53	\$1,238.80
Photo supplies.....		38.59	942.34		
Postage and stationery	406.38	3,429.05	8.50	53.10	16.20
Freight and express.....	172.05	128.45	2.00	1.48	
Fuel, light, and water	3,719.43				
Drugs and sundries..	459.90	3,823.35	9.08	41.74	160.68
Confectionery		1,647.03			
Feeding stuffs.....	408.17				
Provisions	36,175.99				
Text books.....		5,932.08			
Tools and machinery	228.11	28.55			
Furniture	1,956.67	353.46	48.38		
Gymnasium supplies..				510.91	
Traveling expense... ..	10.91		12.28		12.00
Laundry	4,218.41			359.51	
Repairs	642.07			5.42	
Land rental.....	300.00				
Refunds	1,841.78	24.41		5.79	1.12
Livestock	365.00				
Total.....	\$64,086.89	\$17,400.18	\$2,044.83	\$1,665.48	\$1,428.80

REVOLVING FUNDS FOR UNIVERSITY FARM AND SUBSTATIONS, FOR THE
FISCAL YEAR, 1915-1916—Continued

	Univ. Farm seed cases	Univ. Farm Farmhouse	Univ. Farm Cold Stor.	Crookston Din. Hall	Morris Din. Hall
Pay rolls.....	\$626.25	\$145.00	\$152.90	\$3,588.91	\$4,140.39
Photo supplies.....	90.17				
Postage and stationery	30.05		14.60	13.40	
Freight and express..	0.60		2.75	160.27	61.73
Fuel, light, and water				2,556.44	2,541.89
Drugs and sundries..	481.03		167.17	85.42	113.57
Confectionery					
Feeding stuffs.....					
Provisions			12,368.51	9,672.65	6,465.61
Text books.....					
Tools and machinery	24.73		110.79	81.72	271.33
Furniture	68.00			633.13	175.39
Gymnasium supplies..					
Traveling expenses..				2.00	10.44
Laundry				290.93	732.13
Repairs	118.80			73.46	10.35
Land rental.....					
Refunds		2.90			50.59
Livestock					
Total.....	\$1,439.63	\$147.90	\$12,816.72	\$17,158.33	\$14,573.42
Credits—Dining Hall, University Farm.....				\$65,787.54	
Book Store, University Farm.....				19,449.76	
Photo Laboratory, University Farm...				3,283.96	
Gymnasium, University Farm.....				1,732.12	
Hospital, University Farm.....				1,395.77	
Seed cases, University Farm.....				2,961.29	
Farmhouse maintenance.....				247.50	
Cold storage.....				10,933.58	
Crookston Dining Hall.....				18,792.64	
Morris Dining Hall.....				14,229.80	
Total credits.....				\$138,813.96	
Expenditures				132,762.18	
Balance August 1, 1916.....				\$6,051.78	

REPORT OF THE DIRECTOR

CHANGES IN ORGANIZATION

Considerable progress was made during the year in organizing the work of the Experiment Station. With increasing Government coöperation and more stringent regulations governing the expenditure of money appropriated to this work by the Federal Government, it has become necessary to maintain a much closer administrative touch with it. In order to accomplish this, R. W. Thatcher, formerly secretary of the Station staff, has been made Assistant Director.

The old Division of Entomology was reorganized on the sectional basis. The name was changed to Division of Economic Zoology to conform to the larger field covered by the investigations. The following sections were established: (1) Economic Vertebrate Zoology; (2) Economic Entomology; (3) Parasitology; (4) Research in Economic Zoology.

A slight change was also made in the Division of Horticulture, by making the chairman appointive instead of elective.

The name of the Division of Agricultural Chemistry was changed to Agricultural Biochemistry.

Plans were perfected for bringing into much closer relation the various divisions dealing with Animal Industry. The first step in this direction was taken in 1911 by bringing together dairy and animal husbandry, poultry, and animal nutrition. In addition to these, Veterinary Science is now included. The Animal Industry Group, of which Carl W. Gay will be chairman, will consist of the Division of Animal Husbandry, Professor Gay, chairman and animal husbandman; Dairy Husbandry, H. H. Kildee, chairman and dairy husbandman; Animal Nutrition, T. L. Haecker, chairman and nutrition investigator; Veterinary Science, M. H. Reynolds, chairman and veterinarian; Poultry Husbandry, A. C. Smith, chairman and poultryman. No other change has been made in the sections of these divisions.

Only a few changes have been made in the Station staff. H. P. Hoskins, who was in charge of the hog cholera serum manufacture, has accepted a position as pathologist with the Parke-Davis Co. and will be located at Detroit, Michigan. Dr. J. T. E. Dinwoodie, who assisted him, has accepted a position in the extension service of the South Dakota Agricultural College, at Brookings. Neither of these positions has yet been filled.

In connection with the reorganization of the animal husbandry work, Carl W. Gay, of the University of Pennsylvania, was appointed chairman of the Division of Animal Husbandry and also of the Animal Industry Group. H. H. Kildee of Ames, Iowa, was appointed chairman of the Division of Dairy Husbandry. Frank Robotka was appointed Assistant in Accounting in the Division of Research in Agricultural Economics, in cooperation with the Office of Markets of the National Department of Agriculture. L. G. Hood was appointed Assistant Editor, and G. R. Bisby, Assistant in Pathology. R. M. West was made secretary of the Station staff February first, and resigned as Assistant Chemist.

It was planned to secure an expert to head the work of investigation in animal diseases. The laboratories for the work were completed late last year with special reference to work in contagious abortion in cattle, shipping fever, and other contagious diseases. The appointment could not be made on account of reduced funds available for Station investigations. It is highly important that provision should be made for this at the next session of the legislature. The loss by contagious abortion alone is not less than ten million dollars annually in Minnesota. All of the time and money available have been devoted to this work and some progress has been made in the study of cause and treatment, but the subject is too urgent and important to handle in so small a way.

During the hog cholera epidemic, every available man and every cent of available money had to be devoted to the manufacture and distribution of serum. Little work was possible, therefore, in attempting to get more light on the cause and nature of this dread disease. While the legislature provided a revolving fund for the manufacture and distribution of serum at cost, no special provision was made for investigation. Hog cholera is a very obscure disease and little is known regarding its cause. Much work should be done if we hope ever to save the farmers and the state from the enormous losses caused by it. There is no economy in stopping work of this kind. Similar projects on crop diseases, such as wheat rusts and smuts, potato diseases, and fruit diseases, are causing immense loss. Years of study are frequently required to work out some of these obscure troubles and to find practical methods of control. Unfortunately, new diseases and pests are continually appearing, as powdery scab of potatoes and blister rust of white pine. Both of these diseases have been found in the state during the last year. So far they have not spread much and every effort is being made to eradicate them.

With the rapid development of agriculture in the state many soil problems are arising and the Station is expected to solve them. Many of these can be determined only after several years of experimental

laboratory and field work. For example the best methods of handling the different classes of peat soils and certain types of sandy and gravelly soils must be worked out experimentally. A soil survey is also essential to enable us to determine the best types of agricultural practice to advise in given localities in the newer parts of the state. Provision should be made to start such a survey as soon as possible in cooperation with the Bureau of Soils of the United States Department of Agriculture.

There is much to be done in the study of marketing conditions, farm finance, and agricultural organization. We are cooperating with the United States Department of Agriculture in this work.

Increasing demands are made on the milling and baking laboratory which should be met.

More intensive methods of agriculture are requiring more study and assistance from our Division of Agronomy and Farm Management.

The increasing importance of Minnesota as a fruit-growing state is making new demands on our horticultural workers. The same is true with every branch of the Station work. The cost of such work is exceedingly small compared to the benefit secured. Estimates made by the National Congress showed the cost to be less than one-tenth of one per cent of the cash returns per year.

PUBLICATIONS

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

EXPERIMENT STATION SERIES

Bulletin 151. Quack Grass Eradication; Part I. Experimental Evidence and Conclusions; Part II. Tabulated Statement of Operations on the Fields Under Rotation, by A. C. Arny, Division of Agronomy and Farm Management. 82 pp. 10,000 edition.

152. Farmers' Elevators in Minnesota, by L. D. H. Weld, Division of Research in Agricultural Economics. 24 pp. 8,000 edition.

153. Fruit and Vegetable Diseases and Their Control, by E. C. Stakman and A. G. Tolaas, Division of Plant Pathology and Botany. 68 pp. 15,000 edition.

154. The Cost of Producing Sugar Beets, by F. W. Peck, Division of Agronomy and Farm Management. 36 pp. 5,000 edition.

155. Investigation in Animal Nutrition, Beef Production, by T. L. Haecker, Division of Dairy and Animal Husbandry. 32 pp. 10,000 edition.

156. Coöperative Livestock Shipping Associations in Minnesota, by E. Dana Durand, Division of Research in Agricultural Economics. 30 pp. 10,000 edition.

157. Labor Requirements of Crop Production, by T. P. Cooper, F. W. Peck, and Andrew Boss, Division of Agronomy and Farm Management. 56 pp. 8,000 edition.

158. Potato Diseases and their Control, by E. C. Stakman and A. G. Tolaas, Division of Plant Pathology and Botany. 48 pp. 15,000 edition.

159. Second Annual Seed Laboratory Report, by W. L. Oswald, Division of Plant Pathology and Botany. 16 pp. 7,500 edition.

Bulletin 129, Minnesota Weeds, Series I, by W. L. Oswald, Division of Plant Pathology and Botany, and Andrew Boss, Division of Agronomy and Farm Management, was reprinted. 80 pp. 10,000 edition.

SPECIAL SERIES

No. 3. Minnesota Boys' and Girls' Clubs; The Bread-Making Contest, by T. A. Erickson, State Leader, and Mrs. Margaret B. Baker, Assistant. 12 pp. 10,000 edition.

No. 4. Woodworking Exercises for the Agricultural School Shop, by H. B. White, Division of Agricultural Engineering. Reprint of Experiment Station Bulletin 135. 34 pp. 10,000 edition.

No. 5. Standard Potato Varieties for Minnesota, by C. E. Brown, Division of Agricultural Extension, and Richard Wellington, Division of Horticulture. 8 pp. 15,000 edition.

No. 6. Outline for Club Work; Child Welfare, Personal and Home Hygiene, and Home Care of the Sick, by Bess M. Rowe, Juniata L. Shepperd, and Mary L. Bull, Division of Agricultural Extension. 8 pp. 10,000 edition.

No. 7. Quack Grass Eradication, by A. C. Army, Division of Agronomy and Farm Management. Popular edition of Experiment Station Bulletin 151. 16 pp. 10,000 edition.

No. 8. Some Insect Enemies of Corn, by Warren Williamson, Division of Economic Zoology. Also State Entomologist's Circular No. 39. 16 pp. 10,000 edition.

AGRICULTURAL EXTENSION SERIES

MINNESOTA FARMERS' LIBRARY

No. 57. More and Better Acres of Corn for Minnesota, by A. C. Army, Division of Agronomy and Farm Management. 12 pp. 75,000 edition.

No. 58. Lighting Farm Buildings, by J. L. Mowry, Division of Agricultural Engineering. 8 pp. 65,000 edition.

No. 59. Cost of Producing Field Crops, 1908-1912, by F. W. Peck, Division of Agronomy and Farm Management. Popular edition of Experiment Station Bulletin 145. 8 pp. 75,000 edition.

No. 60. House Heating, by J. L. Mowry, Division of Agricultural Engineering. 16 pp. 75,000 edition.

ARTICLES PUBLISHED IN SCIENTIFIC JOURNALS BY MEMBERS OF STATION STAFF

The following articles, reporting results of research work at this Station, were published in scientific journals during the last year:

10 "The Effect of Different Methods of Inoculation on the Yield and Protein Content of Alfalfa and Sweet Clover," by A. C. Army and R. W. Thatcher. In *Journal of the American Society of Agronomy*, Vol. VII, No. 4 (July-August, 1915), pp. 172-185.

A report of the results of extensive studies of the effect of various methods of inoculation of the soil at time of seeding on the yield and protein content of the hay crops harvested in the second and third years after seeding, and of the effect of inoculation on the proportion of tops to roots and the percentage of plant-food constituents taken from the soil by inoculated and uninoculated plants.

11 "Relations Between *Puccinia Graminis* and Plants Highly Resistant to Its Attack," by E. C. Stakman. In *Journal of Agricultural Research*, Vol. IV, No. 3 (June 15, 1915), pp. 193-200. pl. 1.

A report of investigations which establish the fact that immune plants are in reality hypersensitive to the action of the parasite, so that the fungus, after having killed the host cells near the point of entrance, is unable to develop further.

12 "Some Recent Applications of Biochemistry in Agricultural Science," by R. W. Thatcher. In *Proceedings of Thirty-sixth Annual Meeting of the Society for the Promotion of Agricultural Science*, held at Berkeley, California, August 9 and 10, 1915, pp. 57-66.

A discussion of the general field of chemistry in experiment station work, and of the application of recent methods of biochemical investigation to the solution of problems in agricultural science, with a brief review of progress on certain projects in this field at this and other stations.

13 "Enzymes of Apples and Their Relation to the Ripening Process," by R. W. Thatcher. In *Journal of Agricultural Research*, Vol. V, No. 3 (October 18, 1915), pp. 103-116.

A report of a systematic study of the enzymes which are present in the flesh and in the seeds of the apple, with a discussion of the relation of these to the chemical changes involved in the ripening of the fruit.

14 "Infection Experiments With Timothy Rust," by E. C. Stakman and Louise Jensen. In *Journal of Agricultural Research*, Vol. V, No. 5 (November 1, 1915), pp. 211-216.

A report of results of inoculations of cereals and grasses with the urediniospores of timothy rust, with conclusions with reference to the possibilities of bridging hosts, and notes on the morphology of the spores of timothy rust in comparison with those of stem rust of oats.

- 15 "Concerning the Identity of the Proteins Extracted from Wheat Flour by the Usual Solvents," by C. H. Bailey and M. J. Blish. In *Journal of Biological Chemistry*, Vol. XXIII, No. 1 (November, 1915), pp. 345-357.

A report of critical investigations of the character of the protein material which is extracted from wheat flour by alcohol of varying strengths and by various solutions of salts, using the percentage of ammonia nitrogen in the hydrolyzed extract as the indicator of the nature of the protein obtained; and recommending extraction with a 5 per cent solution of potassium sulfate for the determination of non-gluten proteins, and of extraction with 50 per cent alcohol for 3 hours at from 83 to 84 degrees for the determination of gliadin.

- 16 "A Review of Recent Progress in Hog Cholera Investigations," by H. Preston Hoskins. In *Proceedings of Minnesota State Veterinary Medical Association*, 1915, pp. 1-16.

A review of the investigations of hog cholera and methods for its control in progress at several of the state experiment stations and in the Bureau of Animal Industry of the United States Department of Agriculture.

- 17 "The Progressive Development of the Wheat Kernel—II," by R. W. Thatcher. In *Journal of the American Society of Agronomy*, Vol. VII, No. 6 (November-December, 1915), pp. 273-282.

A report of the second year's study, with a summary of the results of two seasons' investigations, of the changes in chemical composition of the wheat kernel through progressive stages of development, including observations on the relation between chemical composition and specific gravity of the kernels and studies of the character of the nitrogen-containing compounds of wheat at successive stages of growth.

- 18 "Varietal Resistance of Plums to Brown-Rot," by W. D. Valleau. In *Journal of Agricultural Research*, Vol. V, No. 9 (November 29, 1915), pp. 365-398. pl. 3.

A critical review of the literature concerning the taxonomy and physiology of the brown-rot fungus, and a report of the results of a thoro study of the nature of parasitism of the fungus and of the varietal resistance of plums to the disease; including studies of the mode of infection, and of the morphology and chemical composition of different varieties as related to their resistance to infection.

- 19 "The Determination of Moisture in Sirups by the Calcium Carbide Method," by R. M. West. In *Journal of Industrial and Engineering Chemistry*, Vol. VIII, No. 1 (January, 1916), pp. 31-35.

A description of a new apparatus by means of which the moisture in sirups may be rapidly and accurately determined by measuring the volume of gas liberated by the action of calcium carbide on the water which it contains.

- 26 "A Method for the Determination of the Strength and Baking Qualities of Wheat Flour," by C. H. Bailey. In *Journal of Industrial*

and *Engineering Chemistry*, Vol. VIII, No. 1 (January, 1916), pp. 53-57.

A description of a baking test method in which an aliquot of the dough is allowed to expand in an "expansimeter." This automatically measures and records the maximum volume which the dough occupies. The other portion of the dough is allowed to raise to a fixed volume and baked, the bread thus produced being used in judging color, texture, odor, flavor, and other factors of quality.

- 21 "Fumigation of Animals to Destroy Their External Parasites," by William Moore. In *Journal of Economic Entomology*, Vol. IX, No. 1 (February, 1916), pp. 71-80.

A brief report of the results of fumigation of animals with nitrobenzene for the destruction of ticks, lice, fleas, and other insects, with notes on the toxicity of this and similar chemicals toward several different host animals and their parasites.

- 29 "Manufactures in Minnesota," by E. Dana Durand. In *Journal of Geography*, Vol. XIV (February, 1916), pp. 218-222.

This paper shows the character and distribution of Minnesota manufactures, the addition which they make to the value of the raw product, and the relation which the manufacture of agricultural products bears to other manufactures in the state.

- 22 "On the Chemical Constitution of the Proteins of Wheat Flour and Its Relation to Baking Strength," by M. J. Blish. In *Journal of Industrial and Engineering Chemistry*, Vol. VIII, No. 2 (February, 1916), pp. 138-143.

A review of the various opinions which have been held concerning the cause for "strength" in flour, and a report of the results of an investigation of the composition of the proteins in flours of varying baking strength, by means of a study of their products of hydrolysis; showing that it is possible to accurately determine the proportion of the several proteins present in any given sample of flour by this new method, and that flours of varying baking strength exhibit wide variations in percentages of albumin and globulin and great uniformity in their gliadin-glutenin ratio.

- 23 "Nitrogen Content of the Humus of Arid Soils,"¹ by F. J. Alway and E. S. Bishop. In *Journal of Agricultural Research*, Vol. 5, No. 20 (February 14, 1916), pp. 909-916.

A critical review of previous work on the subject together with the laboratory investigation of 16 arid soils from California, showing that a high content of nitrogen in the humus of arid soils, long recognized as one of their most marked characteristics, is of such rare occurrence that the percentage of nitrogen in the humus can not be relied on as a means of identification of arid soils.

"The Loess Soils of the Nebraska Portion of the Transition Region."¹

¹ Reports of work done at Nebraska Experiment Station while the authors were connected with that Station, results prepared for publication in 1915-16.

I. "Hygroscopicity, Nitrogen and Organic Carbon," by F. J. Alway and G. R. McDole. In *Soil Science*, Vol. I, No. 3 (March, 1916), pp. 197-238.

II. "Humus, Humus-nitrogen and Color," by F. J. Alway and M. J. Blish. In *Soil Science*, Vol. I, No. 3 (March, 1916), pp. 239-258.

III. "Potash, Soda and Phosphoric Acid," by F. J. Alway and R. M. Isham. In *Soil Science*, Vol. I, No. 4 (April, 1916), pp. 299-316.

IV. "Mechanical Composition and Inorganic Constituents," by F. J. Alway and C. O. Rost. In *Soil Science*, Vol. I, No. 5 (May, 1916), pp. 405-436.

A detailed study of the chemical composition and physical properties of certain aeolian soils in relation to the climate and the region in which they have developed, together with a comparison of those soils with the Chernozem soils of Russia and the arid soils of the United States.

24 "The Relation of Certain Physical Characteristics of the Wheat Kernel to Milling Quality," by C. H. Bailey. In *Journal of Agricultural Science*, Vol. VII, Pt. IV (April, 1916), pp. 432-442.

This paper reports the results of a series of investigations of the relation between kernel volume and percentage of endosperm, of specific gravity to kernel volume, and of these properties to yield of flour and to nitrogen content of the grain; describes a new method for the determination of specific gravity of the grain; and discusses the influence of various factors on the specific gravity of the kernel.

25 "Some Limitation on the Cultivation of Peat Lands in Minnesota," by F. J. Alway. In *Journal of the American Peat Society*, Vol. IX, No. 2 (April, 1916), pp. 65-73.

A paper read before the annual meeting of the Society held at Detroit, Michigan, in September, 1915, discussing the relation of the economy of reclaiming peat lands to the depth of the peat, to the cost of labor, to the amounts and relative cost of the commercial fertilizers and lime required, and lastly to the liability of the various bogs to summer frosts, the occurrence of which on many peat tracts is in sharp contrast to their absence on the adjacent ordinary soils, as is illustrated by the observations in 1914 on the Grand Rapids Substation farm.

26 "The Chemical Composition of Some Minnesota Peat Soils," by DeForest Hungerford. In *Journal of the American Peat Society*, Vol. IX, No. 2 (April, 1916), pp. 74-80.

A report on the chemical composition of 28 samples of peat soil taken from different localities in Minnesota, representing both muskegs and grass bogs, showing the percentage of volatile matter, ash, nitrogen, phosphoric acid, potash, and lime, as well as the relative acidity of 17 of the samples.

27 "The Effect of Climatic Factors on the Hydrocyanic-Acid Content of Sorghum," by J. J. Willaman and R. M. West. In *Journal of Agricultural Research*, Vol. VI, No. 7 (May 15, 1916), pp. 261-272.

A report of the second season's study of the factors which influence the percentage of cyanogenetic glucoside present in sorghum; showing the effect

of various factors in influencing the rate of growth and thereby indirectly affecting the percentage of dhurrin in the plant, and discussing various theories concerning the probable function of this glucoside in the plant's growth.

28 "A Rapid Method for the Estimation of Calcium Oxide in Peat Soils," by R. A. Gortner. In *Soil Science*, Vol. I, No. 5 (May, 1916), pp. 505-508.

Describes a rapid method of determining the percentage of calcium oxide in an acid extract of the ash from peat soils, without removing iron and aluminum compounds. The method works well with peat soils which contain a high percentage of volatile matter, but is not applicable to mineral soils.

DIVISION OF AGRICULTURAL BIOCHEMISTRY

R. W. THATCHER, Chief

In order to more clearly define the field of work of this division, as well as to indicate more accurately its major lines of research, the name was changed during the year from Division of Agricultural Chemistry (as reported in former years) to Division of Agricultural Biochemistry. It is planned that the major part of the research work of the division in the future shall be in the field of plant chemistry, including the chemistry of physiological and pathological processes in plants, the relation of chemical composition of farm crops to their utilization in manufactures and their value as food, and similar investigations.

The following organization of the division into sections was authorized early in the year:

Section of Plant Chemistry, in charge of the chief of the division;

Section of Biochemical Research, in charge of an associate chemist;

Section of Cereal Technology, in charge of a cereal technologist;

Section of Agricultural Analysis, in charge of an assistant chemist.

Several changes in the staff of the division occurred during the year, and certain changes in rank and title were made to conform to the new sectional organization. It is believed that these changes will materially aid in the efficiency of administration of the affairs of the division.

Gratifying progress was made on nearly all of the research projects. Work on two of the general projects was completed, and several subprojects were brought to definite conclusion. Nine articles giving the results of these investigations were published in various scientific journals and several others have been accepted for publication. Two new projects were added during the year.

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

Cereal and flour investigations.—The control work for various state boards and institutions, which was one of the original purposes of these investigations, has now become largely a matter of routine tests and has therefore been transferred to the project known as *Analytical service*. (See below.) Work on the only remaining subproject of these investigations, the one entitled *Wheat storage investigations*, was necessarily discontinued when market conditions became such as to make it impossible to keep the grain continuously in store long enough to permit the necessary observations of its changes in temperature and enzymic activities, but will be resumed as soon as economic conditions permit.

Coöperative wheat investigations.—Two subprojects have been organized.

Subproject: *Influence of environment on the composition and milling quality of wheat.*—The grain from the test plots of Fife, Blue-stem, Velvet Chaff, and Marquis wheat, at Morris, Crookston, and University Farm (12 samples); the wheats grown on the rotation and continuous-culture plots in Fields C and T and the variety test plots of the Section of Field Crops (66 samples); and grain sent in by farmers (6 samples) were all milled and tested in the usual way. Meteorological data to accompany these samples were collected and filed. A monograph embodying the results of five years' study of this subject has been prepared and is on file ready for publication when opportunity can be found.

Subproject: *The progressive development of the wheat kernel.*—The investigations of the progressive changes in chemical composition of the wheat kernel as it develops were completed in 1914-15, and the results were compiled and published in 1915-16. Additional data showing the progressive changes in the structure of the kernel and in the percentages of endosperm to envelope, as affecting the probable yield of flour, were accumulated and are being prepared for publication.

The "strength" of wheat flour.—A new method for measuring the expansive power of dough, called the "expansimeter test" as an indication of flour strength, including the construction of a special expansion chamber and self-recording devices, was perfected early in the year and has been in use in all control baking tests since that time. A description of the apparatus and method was published.

The sorghum sirup industry in Minnesota.—It was planned at the beginning of this year to complete the investigations on the sorghum sirup industry during the year. This plan was carried out, with one exception: An early frost interrupted the final investigations of the effect of "topping" the canes on the composition of the juice. A general report of the application of the results of our three years' investigations to the sorghum sirup industry is in preparation. The special

phases of the investigations which were completed during the year are:

1. Further work on the polariscopic method of estimating the acids in plant juices; and a thoro study of the effect of climatic factors on the hydrocyanic acid content of sorghum. A report of the latter was published.

2. A study of the soluble non-sugars in sorghum juice. This has a direct bearing on the nature and possible utilization of the "scums" produced in sirup-making. The results are ready for publication.

Wild rice investigations.—An unfavorable season last year prevented much work in the investigation of wild rice. A trip to the wild rice fields in the northern part of the state was taken early in September, but the quantity of material available was so small that only a few samples were procured.

The cider- and vinegar-making quality of Minnesota apples.—Fourteen samples of cider and seventeen samples of vinegar resulting from the fermentation of these, by different processes, were analyzed during the year, and the data are on file for comparison with future results.

Investigation of proposed official methods of analysis.—The cereal technologist, acting as referee for the Association of Milling and Baking Technology, carried out a complete set of tests of proposed methods for experimental milling of wheat and analysis and testing of flour. His results were tabulated with those of all other collaborators and presented as a report at the annual meeting of the association.

The analytical work requested by the referee on insecticides and fungicides for the Association of Official Agricultural Chemists was carried out by one of the research assistants in this division, and the results were included in the report of the referee at the annual meeting.

The chemistry of resistance to disease in plants.—A new project was organized during the year, having as its object a comprehensive study of the principles and phenomena of a chemical-physiological nature which are concerned in the resistance to disease by plants, especially by those which are known to be immune or highly resistant to infection with particular diseases. A very comprehensive bibliography of the subject is being prepared and will be kept as complete and up-to-date as the facilities of our library will permit. The nature of the subprojects which have thus far been outlined and the progress of the work done on each during the last year may be briefly summarized as follows:

Subproject: *The biochemistry of resistance to cereal rust (Puccinia graminis).*—Wheat plants which were badly infected with rust and a check lot of the same variety of wheat which was practically rust-free were procured last summer from the plant-disease nursery

and kept during the winter in the cold storage plant. At intervals, samples were drawn out for preliminary studies of methods of detecting chemical differences in the rust-infected and rust-free material. Only a beginning has been made, but the work is in active progress.

Subproject: *Photosynthesis and translocation in different parts of normal and rust-infected wheat plants.*—A very complete study of the effect on sugar and starch formation and accumulation in the leaves, in the different nodes of the stem, and in the chaff and grain of the heads, with normal plants and with plants from which part or all of the leaves had been removed, was carried out and the results are being prepared for publication. The facts ascertained pave the way for a study of the effect of rust infection on the different functions of the plant.

Analytical service.—The volume of analytical work done for other divisions or substations, or for various state departments, having grown rapidly during recent years, it seemed desirable to outline a definite project which would clearly indicate the purpose and function of this division with reference to work of this kind. Accordingly, this new project was organized early in the year and the following work on several of its subprojects was carried out.

Subproject 1: *Analyses and tests of flour for State Board of Control.*—Tests of 110 samples of flour sent in by manufacturers and by bakers at the several institutions were made and reported to the board and used by them as a basis for awarding contracts and paying for flour purchases.

Subproject 2: *Tests of wheat for State Board of Grain Appeals.*—Sixteen samples of wheat were milled and the flour analyzed and tested for the State Board of Grain Appeals, the results being used by the board as a basis for affirming or rejecting the grading assigned to the samples by the official inspectors.

Subproject 3: *Nitrogen content of legumes as affected by different methods of inoculation.*—Four hundred and forty samples of alfalfa and sweet clover were analyzed to show the proportion of nitrogen in the dry matter; and 15 samples of sweet clover roots and tops were analyzed for their plant food percentages. A report of the work on the first year's samples was published, and a similar report on the second year's studies is in preparation.

Subproject 4: *Chemical composition of silage crops.*—Forty-four samples of corn and 14 of soy beans, grown by the Division of Agronomy and Farm Management, in a study of their value for silage-making, were submitted to complete feeding-stuffs analyses, and the results were reported to that division.

Subproject 5: *Chemical composition of root crops.*—Three samples of carrots, 8 of rutabagas, 3 of turnips, and 10 of mangels, grown

at the Crookston Substation, were analyzed to show their probable feeding value, and the results were reported to the superintendent of that Substation.

Subproject 6: *Dry matter determinations of forage crops.*—A total of 998 samples of the various forage crops grown by the Division of Agronomy and Farm Management were received and the percentage of dry matter in each was determined and reported to that division for their use in calculating yields per acre.

Subproject 7: *Dry matter determinations of ear corn.*—The dry matter content of about 300 samples of ear corn, grown by participants in the Boy's Corn-Growing Contest, was determined for the Division of Agricultural Extension.

Subproject 8: *Tests of quality of strains of wheat from plant-breeding nursery.*—Twenty-seven samples of wheat from the plant-breeding nursery were milled and the flour analyzed and baked. The results were reported to the Section of Plant-Breeding of the Division of Agronomy and Farm Management.

Subproject 10: *Tests of quality of disease-resistant hybrid wheats.*—Forty-four samples of the wheats used or produced by the Division of Plant Pathology and Botany in their experiments in breeding disease-resistant strains were milled and tested.

Subproject 12: *Analyses of corn for the selection of high-protein and low-protein strains.*—The percentage of nitrogen in the dry matter in each of 132 samples of corn was determined and reported to the Section of Plant-Breeding of the Division of Agronomy and Farm Management.

A considerable number of miscellaneous samples of water, feeding stuffs, insecticides, and fungicides, which were sent in by farmers or others were analyzed, but analyses of this sort usually have such slight value, even to the parties who request them, that a constant effort is made to limit the volume of work of this kind to the lowest possible amount, and to confine the analytical work of the division to samples which have a direct connection with some regularly approved projects of investigation.

DIVISION OF AGRICULTURAL ENGINEERING

J. T. STEWART, Chief

Throughout the year the division has furnished information by correspondence and personal visits in all the various activities included under the head of agricultural engineering. More or less information has been given on farm buildings and equipment, power machinery, drainage, and sanitation. Tile drains amounting to 60,380 feet were constructed at the several substations and elsewhere, under the super-

vision of the division. Information in regard to drainage and cultivation of peat lands has been collected and compiled. Assistance has been given in carrying on coöperative tests to determine the effects of alkali on cement tile and in the preparation of standard specifications for drain tile of all classes.

Manuscripts were prepared on Mechanical Drawing for the Farm and Agricultural School; The Silo on Minnesota Farms; and Cement and Its Use on the Farm. Data have also been collected on design and construction of poultry and hog houses.

The introduction into the School of Agriculture of a special course in automobiles and gas engines further increased the necessity for the study of power machinery suitable for the farm, and considerable attention was given to this work.

DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Chief

There was no change in the organization of the division staff during the year. Progress was made on most of the projects.

SECTION OF COÖPERATIVE SEED-PRODUCTION AND DISTRIBUTION

Seed-production and distribution.—Pedigreed seeds have been disposed of as in the past. A total of 691 bushels of cereals and other farm crop seeds was sold to farmers for approximately one thousand dollars. In addition, 279 pounds of grains were distributed to farmers as a foundation stock for home selection and improvement.

Coöperative work is in progress with farmers for the testing of varieties best adapted to particular localities. A few farmers are making selections for pedigreed seed plots. Seeds of various sorts have been furnished the several substations to be tested in comparison with those already in use.

Corn-breeding and testing.—The corn trial stations are continued with supervision from this office. A few coöperators have asked for inspection of seed offered for sale.

Continued interest is manifested in sweet-corn breeding in coöperation with the canning companies. Through the Minnesota Crop Improvement Association a standardization of varieties of corn was secured whereby certain varieties were regarded as standard, others as tolerated, and others as rejected for use in any part of the state. Nearly three bushels of selected seed was furnished to eighty-one farmers for pure-seed plots.

Tobacco-growing investigations.—The tobacco investigations were brought to a close during the fiscal year, owing to the discontinuance of the appropriation. Additional data on the cost of growing were gathered. The cost was \$36.53 per acre as against \$24.25 previously

reported. The increase was chiefly due to adverse weather conditions, which made extra hand labor necessary. The crops averaged 1,280.51 pounds per acre and sold at an average price of 7.5 cents per pound, the range of price being from 2 to 10 cents. It is classed as filler. The quality is equal to Wisconsin tobacco. The farmers interested in tobacco-growing are in and about Sherburn County and the south-eastern counties bordering on the Mississippi river.

Sorghum sirup industry in Minnesota.—In coöperation with the Division of Agricultural Chemistry, varietal plots were planted, but owing to adverse weather conditions the plants made no development worthy of consideration and were, therefore, cut for forage.

Wild rice investigations.—High water seriously reduced the crop of wild rice. An extended trip to rice fields in the northern part of the state was planned, but owing to heavy and continued rains and the fact that the rice harvest is a short-time enterprise, the trip was abandoned. Details of the Indian's methods of harvesting and treating the crop were obtained in one locality.

Sugar beet seed-production.—Coöperation in sugar beet seed-production with the Minnesota Sugar Company has been continued. A small tract of land was set out to roots which had been stored in pits the previous fall. A rather large percentage of these was non-producing, but those which formed seed stalks were heavily seeded. Thirty-seven pounds of excellent seed were harvested, threshed, and cleaned. At University Farm several selections of "mother" types were planted and harvested separately. Visible differences were noted. A total of 105 pounds of seed was harvested. In 1916 the seed is all being grown at Chaska, where the work is continued.

SECTION OF FARM CROPS

Investigations with small grains.—The investigations with small grains have been continued. The work on the value of different grades of seed oats shows, with the Sixty Day variety, an advantage for the two-year period in favor of the heavy seed. The results with the medium maturing variety, Improved Ligowa, have not been consistent in either direction. The three-year average results of the experiment on methods of preparation of seed bed and rate of seeding wheat indicate that fall and early spring plowing give practically equal yields; double disking did not give sufficient increase in yield to pay for the cost of the operation. Studies of the rate of seeding of wheat will be continued. Studies of individual kernels of wheat show an advantage in favor of the large kernels for seed purposes. The three-year average yields of grains grown alone and in mixtures show Manchuria barley to be the highest yielder in pounds per acre. Mixtures of Manchuria barley and Sixty Day oats are second and third in yield,

Improved Ligowa oats is fourth and Sixty Day oats fifth in yield.

The usual variety trials of wheat, oats, barley, flax, and other crops were made. Minnesota No. 184 barley was increased for distribution.

Forage crop investigations.—The comparison of different methods of planting field corn for silage, stage of maturity at which to cut for silage of best quality, and varieties of corn for silage production, was carried out as outlined.

The work with alfalfa indicates that if the land is in fair condition and comparatively free from weeds, seedings made with nurse crops may be expected to produce yields practically equal to those made without nurse crops. When alfalfa is to stand for a long period of years, seeding without a nurse crop is advisable. Inoculation for alfalfa should be practiced and lime should be used if the soil is acid.

Work with Sudan grass has shown that it may be used to advantage as an annual forage crop. Seedings from May 15 to June 15 gave an average yield of 4.5 tons of hay on a 15 per cent moisture basis, and 850 pounds of seed per acre.

The work with the white- and yellow-flowered biennial sweet clovers indicates that they may be used to good advantage as green manure crops and as hay crops where alfalfa does not thrive. On fields where inoculated sweet clover or alfalfa has not been grown before, supplying bacteria has been found necessary for good results with sweet clover.

Eradication of noxious weeds.—The results of the investigations in the eradication of quack grass have been published. Work on methods of eradication of Canada thistles was carried out at Buffalo, Wright county, during the year. This work can not be carried further at the present time on account of lack of funds.

Crop rotation.—The regular plan of cropping was followed on Field C with the exception that cultivated crops were grown on the continuous wheat plots which had become badly infested with weeds.

The results for the first six years on Field T have been prepared for publication. An increase in yield of 13.7 per cent for corn, 14.95 per cent for oats, and 30.98 per cent for wheat, was secured in a four-year rotation consisting of oats, wheat, clover hay, corn, as compared with growing the same crops continuously. In the same rotation the increases in net gains per acre as compared with growing the same crops continuously were, corn, 21.4 per cent and wheat, 72.3 per cent.

No consistent increases in yields were secured from the use of commercial fertilizers, alone or in combination, in the three-year rotation, oats, clover, corn.

The yields of corn on ground plowed in the fall and in early spring were practically equal.

The growing of oats and the securing of a stand of clover and timothy on spring-plowed ground did not prove as satisfactory as on fall-plowed ground or on double-disked corn ground.

SECTION OF PLANT-BREEDING

Investigations in cereal-breeding.—Preliminary studies obtained by the use of centgener plots, rod rows, and 1/110-acre field plots in coöperation with the Section of Farm Crops, have shown the necessity for a change in methods for the cereal-breeding work. The following plan has been adopted: Use centgener plots, which give an opportunity for individual plant study, for the first year of selection and for crop-breeding until purity is obtained. Make a preliminary test by the use of replicated rod rows for three years, at the end of which time the strain will be either discarded or further tested in duplicated 1/40-acre field plots in comparison with a few standard sorts. Further studies are being made to determine the value of guard rows and the number of replications necessary to give reliable results.

Winter wheat.—Twenty-five winter wheat crosses and selections which seem to be more hardy than Turkey Red have been grown in replicated rod rows at Duluth, Grand Rapids, and Waseca in coöperation with the Section of Coöperative Seed-Production and Distribution. This test should be of special value for the determination of winter injury. The data at hand show the value of crossing for the production of hardy winter wheat. Accordingly numerous crosses were made in 1915 between parental types which had proved most promising for winter hardiness.

Spring wheat.—The crosses of spring wheat made several years ago have been examined for purity and the promising strains put in the rod-row test. Several winter-spring crosses seem especially promising. The more promising spring wheat strains are being tested at Crookston, Waseca, and Morris in coöperation with the Section of Coöperative Seed-Production and Distribution.

Oats.—Forty selections of oats have been put in the preliminary rod-row test for the determination of their economic value. Special study is being made of the relation of certain characters to lodging.

Barley.—Definite coöperative arrangements for barley-breeding have been made with the Bureau of Plant Industry, United States Department of Agriculture.

Corn-breeding investigations.—Altho the season was a very unfavorable one for corn, some progress was made. The study of the relation of certain score-card points to yield is nearly completed. The study of the value of first-generation crosses is being continued. The results in 1915 were very favorable for the crosses. The studies of inheritance are giving results of considerable scientific interest.

Breeding of miscellaneous field crops.—Progress has been made in the breeding work with alfalfa, flax, millets, and timothy. The 1915 field test of the millet selections showed the superiority of several of these as compared with commercial sorts.

Genetics of rust resistance.—The study of the genetics of rust resistance is carried on in cooperation with the Division of Plant Pathology and Botany and the Office of Cereal Investigations, United States Department of Agriculture. Definite plans have been made for a study of the genetics of rust resistance, and the respective resistant and non-resistant varieties were selected and planted for the purpose of obtaining considerable crossed seed.

SECTION OF COST ACCOUNTING

Cost of producing farm products.—The state investigations in the cost of producing farm products were continued as usual at Halstad, Norman County, and Cokato, Wright County. This is the fourteenth year at Halstad, and the third at Cokato. The data are affording valuable material for farm planning and reorganization.

The United States Department of Agriculture and state cooperative cost accounting investigations have been continued, closing the third year with ten cooperators and entering the fourth with eleven. This work is giving an excellent opportunity for a comparison of cost-accounting methods and accurate data on such items as costs of buildings and equipment for livestock.

During the summer of 1915, a cost-accounting survey was made of the production of sugar beets and sweet corn. The data on sugar beets have been published and those on sweet corn have been tabulated, but not yet published.

The cooperative project of the Division of Forestry and of Agronomy and Farm Management, entitled "*An experience survey of Northern Minnesota*," was carried through its first year with records from sixty settlers. The blanks have been revised and new records are being received. This work gives promise of obtaining many valuable facts about the north country, especially regarding successful practices, types of farming, need of credit, and others.

The subproject on the "*Cost of producing gains on cattle and hogs*," was discontinued for one year, owing to unfavorable crop and market conditions. The present plan is to resume the investigations in the fall of 1916.

SECTION OF FARM ORGANIZATION

The studies of eradication of noxious weeds and of crop rotation, reported for this section last year, have been included in the report of

the Section of Farm Crops, as the field work is now being done by that section.

Farm management surveys.—No additional data on farm management have been secured during the year. The records from Rice county have been completed and the data tabulated.

Farm equipment.—Some progress was made in the classification and tabulation of material gathered under the farm equipment project. The work was handicapped considerably by lack of clerical help and because the leader was obliged to give his attention largely to teaching.

Comparison of fence posts.—Results thus far seem to indicate that the American Steel posts are superior to any of the others used for holding the fence tight and in line. A continuation of this project for several years is necessary before final conclusions can be reached.

DIVISION OF BEE CULTURE

FRANCIS JAGER, Chief

The Division of Bee Culture during the last year has continued all projects under consideration and begun two other series of investigations.

In the study of artificial fertilization, tests were made with 22 queens. Nine tests resulted negatively, that is, eggs laid by these artificially fertilized queens hatched but produced drones or male bees only. The rest of the queens laid no eggs. Information concerning methods of procedure for the coming season has been obtained.

Over five hundred breeding queens were reared and sold to Minnesota bee-keepers for improvement of their stock. This required drawing on the apiary quite extensively for brood and bees for queen-rearing operations during the entire season, weakening many colonies for winter. In this weakened condition, however, only 8 per cent winter loss in dead colonies was sustained. A low food supply caused very low building up in strength in March, 1916, for the 72 colonies which remained alive.

Necessary equipment for the enlargement of the apiary and the extension of queen-rearing operations was obtained.

A few studies were made in cooperation with the Section of Economic Entomology, Division of Economic Zoology, during December, January, February, and March, of the repellent effects of small percentages of various substances in a mixture of honey and water to gain an idea of their possible value in spray mixtures as a repellent for bees.

The new investigations begun this year were a Survey of Bee-keeping Conditions in Minnesota and studies in the Consumption of

Food in the Wintering of Bees. They will be in progress during the coming season.

Much time and effort have been given to general and individual aid to bee-keepers of the state and requests for aid and information are continually received.

Diseased bees have been found that may prove to be affected with *Nosema apis*, a disease of adult bees.

It is essential that in the future additional funds become available, if the division is to conduct successfully additional general work, with investigations concerning artificial fertilization of queens, survey work, honey-production, and bee diseases.

DIVISION OF DAIRY AND ANIMAL HUSBANDRY

T. L. HAECKER, Chief

Experimental and research work during the last year has been confined almost exclusively to projects bearing on beef- and pork-production. Satisfactory progress has been made both in the amount of work accomplished and in the character of data obtained.

SECTION OF ANIMAL HUSBANDRY

Definite progress is being made in the Section of Animal Husbandry, but lack of equipment has been a constant handicap. The present hog barn contains but sixteen pens and was planned only for the breeding herd. It is not adapted to other use and contains no provision for feed storage. The greater part of the experimental feeding has been carried on outside with no feeding-floors, with only A houses for shelter, and without a windbreak. Drifting snow in winter and mud in spring and fall interfere seriously. The temporary feeding-yards require constant repairing and a consequent unnecessary amount of labor. Lack of pasture permits the consideration of very few phases of these problems or compels the employment of an insufficient number of hogs in each group, thus entailing heavy expense for fencing and labor. A total of 9½ acres of pasture is available for the breeding herd and for experimental work.

Additional barn room, an inexpensive shed for experimental feeding in dry lot, grain storage facilities, and a root cellar are urgently needed. Increased pasture would both facilitate experimental work and increase its value.

The progress of the work in the *Swine-feeding experiments* is briefly summarized:

Subproject A: *Comparison of spring and fall pigs.*—A complete record of one group of fall pigs from farrowing to market was kept in 1915-16. (In 1914-15 a record was kept on fall pigs from

weaning to an average weight of 100 pounds.) They proved both practicable and profitable.

Subproject B: *Fall and winter feeding of brood sows.*—Owing to limited yard space and lack of help, only preliminary work was done.

Subproject C: *Rations and systems of feeding to fatten swine.*—One hundred hogs have been fed experimentally in 10 lots, including 6 self-feeder tests with a total of 57 hogs. No skimmilk, buttermilk, or roots being obtainable, grain rations only have been used. These included:

1. Shelled corn, shorts, tankage.
2. Shelled corn, ground barley, shorts, tankage.
3. Ground barley, shorts, tankage.
4. Shelled corn, shorts, oilmeal.
5. Shelled corn, shorts.

In every case the self-fed hogs made larger daily gains than those fed twice daily by hand. This year self-fed gains were more economical, last year they were slightly less so.

Subproject D: *Pasture and forage crops for pork-production.*—Two, 3, and 4 per cent shelled corn rations with rape pasture gave average daily gains per pig of 0.61 pounds, 0.81 pounds, and 0.93 pounds. With corn at 75 cents a bushel, and pasture at \$10 an acre the actual feed cost of 100 pounds gain was \$4.60, \$4.46, and \$4.81 respectively. This work is being continued on a broader plan.

Subproject E: *Pasture crops for dry brood sows.*—The summer of 1915 completed the fourth consecutive test with rape pasture and also with oats, peas, and rape. Single year tests have been made with alfalfa, bluegrass, sorghum, oats, and corn pastures. Results are being prepared for publication.

Subproject F: *Feeding tests with fall pigs.*—During the last winter 53 fall pigs were divided into five lots and fed as follows: Lots 1 and 2 were self-fed; lots 3, 4, and 5 were hand-fed. All lots have shown excellent thrift and have made rapid and satisfactory gains. No pigs were lost from any cause, after weaning.

Subproject G: *Self-balanced rations as taken by individual pigs.*—During the summer of 1915 ten pigs were fed individually from self-feeders containing separately, shelled corn, shorts, and tankage. A report is being prepared for publication. Four pigs were similarly fed last winter.

Subproject H: *Digestion tests and metabolism studies.*—Nutrition crates are only now being completed. Actual work will begin this fall or next spring.

Subproject I: *Hogging-off grain crops.*—A plot of rye, seeded to red clover in the spring, was hogged-off in August by 50-pound shoats. The results were negative.

SECTION OF DAIRY HUSBANDRY

Creamery management investigation (Formerly *Creamery overrun*).—The creamery management investigation is being carried on with the coöperation of the state creamery at Albert Lea. Up to date the evidence points strongly to the necessity for an adjustment of the test or method of reading the fat in milk if it is to check with the usually accepted method for cream. The quantity of fat received or present, as indicated by a test of each lot of milk, checks well with the amount indicated by the total milk and the drip sample composite test, but not with the amount shown from the weight of cream and its test, nor yet by the amount of butter and its fat content. Mechanical losses were carefully determined. More work is necessary before conclusions can be drawn.

Cold storage of butter.—Butter was made, 96 packages in all, in July and August, 1915. Scores were determined and chemical and biological analyses were made at that time and again in November, 113 days later. The tests will be repeated about June, 1916.

Information is being secured on the question of salt effect on keeping quality, relation of bacterial growth to score, and the effect on score of overworking the butter; but the major point, viz., the effect of delayed refrigeration on the keeping quality, will probably not be settled by this preliminary test.

SECTION OF ANIMAL NUTRITION

During the year very satisfactory progress was made in the studies with beef-bred steers, their composition at various stages of growth and fattening, and the relation of food to body substance stored. Two steers were slaughtered for analysis, one weighing 1,300 pounds and one 1,191 pounds, and complete analyses of eleven steers were completed and reported for final record. Recompilations of the records of eight steers were made to check errors found in earlier work. Compilations have been completed on the daily average of feed stuffs, dry matter nutrients consumed per week during the lifetime of all steers on exclusive stall feeding of Groups III to VII inclusive, and of those turned to pasture of Groups V and VII.

For the purpose of studying methods, the composition of the bodies of four pigs has been determined and reported for final record.

The data secured concerning feed consumed in the various stages of growth and fattening of steers have been tabulated and a bulletin issued showing the amount required by each group for each period named, the average amount used by the five groups, and the return made in body weight and finish; also the cost of feed for production during the various periods, and the average for all the groups from the weight of 100 pounds to the steer weighing 1,200 pounds, finished for market.

DIVISION OF ECONOMIC ZOOLOGY

F. L. WASHBURN, Chairman

SECTION OF VERTEBRATE ZOOLOGY

Nursery and orchard inspection.—The state entomologist has inspected 117 nurseries, issuing certificates to each, and to 8 dealers. An enormous amount of foreign stock has been inspected. In inspecting the larger nurseries in the state a force of from three to five men spent three or four days at each place, thus insuring thoro work. A large number of permits were issued to persons wishing to ship a small amount of nursery stock.

Field mice and other rodents.—Experiments with field mice were continued and valuable data obtained as to their breeding habits and the distribution and abundance of different species in Minnesota. Observations have been made on two species in captivity.

Hymenoptera in Minnesota.—Work has been continued in bibliography and many species of Hymenoptera have been identified.

Zoological museum.—Some work was done in labeling mammals, but no funds were available for additions to the museum.

Live fish for farmers.—Acting on the suggestion of the United States Bureau of Commerce, applications for fish fry have been sought and obtained from Minnesota farmers owning lakes or ponds. Blanks from the United States Bureau of Fisheries, filled out by the applicants, were scrutinized and those deemed most worthy of consideration were forwarded to Washington with the approval of the Director of the Experiment Station.

SECTION OF ECONOMIC ENTOMOLOGY

Insect collection.—The insect collection was enlarged materially and two groups of insects were satisfactorily arranged.

Spraying of injurious insects.—Owing to freezing weather in the spring of 1915, no results were obtained in orchard spraying. Several spraying demonstrations were given and much interest is being taken by orchardists in up-to-date methods.

Honey bees and insecticides.—As bee-keepers often object to the ordinary spraying operations, experiments were conducted under greenhouse conditions to determine whether materials could be found which, when put in food in very small quantities would prevent its use by the bees. The experiment has not progressed far enough to warrant publication of the results.

Oak twig girdler.—The fact that the oak twig girdler, which did so much damage to oak twigs in 1914, has a two-year life cycle was established.

Weed insects.—Twenty-five insects, from 17 kinds of weeds, were reared. The life history of many of these has never been known. As some of these may at any time change their food habits and attack crops of economic importance, the value of this study is apparent.

The strawberry weevil.—Many new phases of the habits of the strawberry weevil have been discovered, and after another season's work very definite recommendations will probably have been worked out to circumvent its ravages. Four parasites were reared, two of which are absolutely new to science.

The wheat stem maggot.—Some points in the breeding habits of the wheat stem maggot are proving very elusive. One species of parasite was reared from the larva.

SECTION OF PARASITOLOGY

The work of the Section of Parasitology is now limited to parasitology and medical entomology.

Blackhead of turkey.—Study of the morphology and life history of the causative organism of blackhead in turkeys, as well as the pathology of the disease has been continued. Field observations have been checked up by observations on birds kept in confinement. The disease has been successfully transmitted to full-grown poults by feeding large numbers of *Coccidial oospores* from the droppings of diseased birds. It was impossible to infect white rats, guinea pigs, and sparrows with these oospores, these results being contrary to those of other workers, who claim that rodents and sparrows will act as carriers of the disease.

House fly.—Further observations have been made on the manner in which the house fly hibernates. In Minnesota it is apparently unable to live through the winter in any stage, except that a few adults survive under special conditions where the temperature is high enough and the supply of food is abundant. All stages seem to be extremely sensitive to low temperatures, a temperature of even 40 degrees being fatal if continued longer than seven or eight days.

Horse fly (Tabanidea).—Field work on the horse fly was continued. The connection of horse flies with the transmission of infectious anemia of horses was studied in cooperation with the United States Bureau of Animal Industry. As *Tabanus* is not known to transmit any disease organisms biologically, the mechanical method of transmission was tested. A total of 71 flies belonging to the species *Tabanus lasiophthalmus* and *Tabanus affinis* were fed on an infected and a healthy horse with an interval of only about five seconds between bitings. Results were negative.

Biting stable fly (Stomoxys calcitrans).—Work with the biting stable fly was continued. Studies of breeding habits and methods of control were carried out.

Chigger mites.—The complete life history of one of the mites which is suspected of being the adult form of chigger mites has been completed. It does not seem, however, to be the one sought.

Larvae of the Schizophora.—Much material has been procured for the study of this group of flies, most of it being bred in the laboratory.

Artificial fertilization of queen bees.—The artificial fertilization of queen bees was carried on in cooperation with the Division of Beekeeping. Twenty-two queen bees were used in the experiment. The work of the season consisted in an attempt to ascertain if the age of the queen at the time of artificial fertilization was of any importance. The interval between emergence of the queen and fertilization varied from 3 to 38 days. Of these queens, nine produced eggs, but all of the resulting brood were drones. The other queens were refused by the bees, or for some other reason died.

SECTION OF RESEARCH IN ECONOMIC ZOOLOGY

Fumigation with hydrocyanic acid gas.—On the major project, fumigation with hydrocyanic acid gas, progress was made in the study of the influence of moisture and heat and light on successful fumigation. In the subproject, the "Influence of hydrocyanic acid gas on the oxidation of the plant," considerable work was done without definite results.

Progress on the project entitled "Insecticide investigation" was very satisfactory and resulted in the discovery of nitro-benzene as a successful fumigant for destroying external parasites on animals without injury to the animals.

The cabbage and onion maggot.—Work with the cabbage and onion maggot has demonstrated that sweetened poison spray can be used to considerable advantage in destroying the adult fly.

INSECTARY WORK

Considerable work was completed in the Insectary, and the filing system started two years ago was finished. Routine work was done with white grubs, and the cages containing the grubs will be kept another year.

DIVISION OF HORTICULTURE

W. G. BRIERLEY, Chairman

SECTION OF FRUIT-BREEDING

Sterility in fruits.—The studies in sterility were carried forward during the last season primarily with the strawberry and the plum. Some attention has been given to the maple for purposes of comparison. The results with the strawberry indicate that where good pollen

is produced in the cultivated varieties the plants are self-fertile. A study is being made of the formation of pollen and of aborted pollen in *Fragaria Virginiana* and *F. Americana* and the cultivated varieties. The relation of aborted pollen to hybridity is being investigated. A study of "nubbins" is being made from the standpoint of frost injury, pollination, and sterility.

The extent of the occurrence of aborted pollen in Burbank × Wolf and Abundance × Wolf hybrid plums has been studied. The results of tests under tent and in the greenhouse show that Burbank × Wolf Nos. 6, 10, 12, and 21, the sand cherry, the Burbank, and the Compass Cherry are self-sterile. The intercrossing tests showed further that some of these hybrids were inter-sterile and that Burbank × Wolf No. 10, pollinated with No. 21, sets fruit. The sterility studies show that self-sterility can not be ascribed to aborted pollen or defective nuclei.

Studies of flower types of the maple have been made in five species, namely, *Acer saccharum*, *A. saccharinum*, *A. platinoides*, *A. rubrum*, and *A. spicatum*. It has been found that in general there are two types of plants, namely, those bearing a large number of pistillate flowers, with a few perfect flowers, and those bearing for the most part only staminate flowers with a few perfect flowers. The pollen of the partially suppressed anthers of the functionally pistillate flowers has been found to be normal in all five species, but the flowers are self-sterile because dehiscence does not take place in this type of anther.

Inheritance of fruit characters.—No fruit was available for studies of plum hybrids last season. Data taken the previous year on the pit, fruit, and leaf were worked up in final form, the flower descriptions were checked up, and further records were made of twig characters. The general question of clonal improvement was given a careful survey. Sex inheritance in the grape was given some attention and crosses were made to check further the points in this study. Material was collected and sectioned for a cytological study of the intermediate type of grape flower. The inheritance of types of flower in the strawberry was studied.

Breeding fruits for hardiness.—Observations on the hardy seedlings at the Fruit-Breeding Farm were continued. The indications at present are that the Minnesota No. 4 raspberry is of value because of its hardiness. This hybrid has sustained no winter injury at the Fruit Farm in the last four seasons. At Deerwood it was not injured by a temperature of 49 degrees below zero when left uncovered.

The twigs of four varieties of apple have been collected at intervals during the year and their water content determined to ascertain if there is a loss during the time that the ground is frozen.

Studies were begun during the year of the relationship between structure and hardiness and recovery from winter injury. The winter of 1915-16 was such that the most tender varieties of plums were killed, the hardier plums uninjured, and those more or less intermediate between these two extremes showed injury in varying degrees. The winter was sufficiently differential that the various species and inter-specific hybrids of the plum can be classified with respect to their hardiness.

SECTION OF FRUIT HANDLING AND UTILIZATION

Cider- and vinegar-making qualities of Minnesota apples.—Fifty pressings of ten varieties of apples were made during the season. Further comparisons were made between the "barrel" or "drum" type of hand press and the "press cloth" type, the results being uniformly in favor of the latter. Records of the yields of the varieties pressed are on file for further comparison. Preliminary time-of-production runs indicate that a sufficient quantity of cider can be extracted in a given time to make the work profitable. Analyses made by the Division of Agricultural Chemistry show that the sugar content of Minnesota apples is relatively low, ranging from 9.25 per cent to 7.17 per cent. This fact indicates that care is necessary in fermentation if a marketable grade of vinegar is to be obtained. However, the studies made during the year have shown that vinegar of standard grade can be obtained within five months from pressing if kept in reasonably warm quarters. Owing to the lack of proper quarters early in the season and the necessity of transferring the ciders during midwinter from cold to warmer quarters, the results of the fermentation studies show no uniformity. The project will be continued in order to obtain additional data under the favorable conditions which can now be provided.

Pruning the apple and plum.—The portion of the project in which the best methods of pruning the apple were studied is considered complete. The results are definite and closely parallel to the results obtained elsewhere in experimental or commercial enterprises.

The study of the most desirable time of year for pruning has been continued. In previous years the work was done in the general seasons designated as "late fall," "winter," and "spring." Last year pruning was done in each month from November to March and will be continued until June. Results of this work so far indicate that success depends more on careful work than on the season in which the work is done. All trees will be observed throughout the season to note any effects which may be apparent. The study of this part of the project will be continued for at least one more year.

Work with the plum has been discontinued, at least for the present. The trees available are miscellaneous seedlings which do not respond uniformly to the treatment given, so this part of the project will be discontinued until named varieties can be obtained for pruning studies.

SECTION OF FRUIT AND VEGETABLE INVESTIGATIONS

Coöperative orchard management.—The planting of the apple orchard at the State Hospital for Inebriates, at Willmar, was completed and a very satisfactory growth was made. The orchard at the Northeast Experiment Farm, Duluth, made a good growth, considering the condition of the ground, but during the winter about 20 per cent of the trees were winter-killed. J. P. West's orchard, at Rockford, was badly injured during the winter by the severe cold and by rabbits, altho the trees were well protected by wood veneering and by mounding. The injury in Mr. West's orchard, however, is only temporary, as the trees are young and healthy and will soon develop new heads. The coöperative work in the orchard at the Rochester State Hospital was abandoned, owing to the shortage of labor to keep the orchard in proper condition.

Potato investigations.—The potato investigations were seriously hampered by adverse conditions, such as floods at Crookston, early frosts at Duluth and Grand Rapids, and the prevalence of late blight and other diseases. Hill-selection was carried on extensively, but owing, mainly, to the severe attack of curly-dwarf, the isolation of high yielding strains proved futile. The results of the work, however, show conclusively that the improvement of seed by any kind of selection, is an impossibility when the seed has been affected with this type of disease. Since all the seed stock grown for one year on the plots used by the Division of Horticulture becomes diseased, it is evident that selection work must either be discontinued or carried on under different soil conditions.

Coöperative tests of seed stock of several varieties which had been produced on the Station grounds and outside of the state were started with the Northeast Experiment Farm, Duluth, the North Central Experiment Station, Grand Rapids, and the Northwest Experiment Farm, Crookston. The harvested crop from Duluth and Grand Rapids was stored at University Farm so that all variations that might occur from storage would be eliminated and the stock could be described and differences noted. In the spring a part of the stock of each variety was returned and part sent to the other Stations and farms for trial. Experiments, such as growing potatoes under a cheesecloth tent, with a layer of straw mulch, with a heavy coating of Bordeaux mixture, and with the use of various methods of cultivation

were made; and temperature readings were taken above and below the surface of the ground in order to discover, if possible, what conditions were responsible for the degeneration, or running out, of varieties. Late blight and accidental destruction by cattle reduced the amount of available experimental stock and the work will have to be repeated. In addition to these experiments, tests were made of seedlings and varieties and in all cases the new stock proved to be superior in productiveness and vigor to the old stock grown for one or more years in the Station grounds.

Breeding and selection of vegetables.—Selection of pure lines of the Refugee bean and Alaska pea was continued and marked differences in yield, as well as minor characteristics were noted. The results of the cucumber work were largely negative, owing to a disease which killed the vines before the seed was mature. The new types of melon produced by the New York Agricultural Experiment Station were tested and seed obtained. Selfed seed, gathered from a few different types of the Big Boston lettuce was grown and a Mendelian splitting of the red color on the foliage was noted, as well as a marked difference in the time of maturity. Onion breeding and selection was continued and one pure line of the Red Globe, owing to its good keeping quality, gives promise of being a valuable acquisition. Selfed seed from many Hubbard squash plants, the fruit varying greatly in size, shape, thickness of flesh, hardness and wartiness of shell, was procured. The results indicate the possibility of isolating and fixing a desirable commercial type of the Hubbard. The tomato experiment, which dealt with the influence of crossing and the isolation of strains in varieties, has been practically completed and the results are nearly ready for publication. Marked increases in yield were obtained from some of the crosses and a few of the combinations will undoubtedly prove valuable for commercial purposes, owing to their earliness, smoothness, and productiveness.

Variety tests of fruit.—Promising varieties and seedlings of fruit were tested as during the previous year. Technical descriptions were made of about one hundred and fifty strawberry varieties and seedlings and phenological data on apples, plums, and strawberries were collected. A few of the more promising varieties were propagated and some stock was sent to the Northeast Experiment Farm, Duluth, for testing. The freeze on May 18 destroyed practically all of the apples, currants, and gooseberries and most of the plums, and consequently no data on these fruits were obtainable.

SECTION OF LANDSCAPE GARDENING AND FLORICULTURE

University Farm campus.—The enlargement of the campus and location of new buildings has necessitated making new plantings and

changing old ones. Part of these new plantings were finished this year, others will be put in, in 1916 and 1917. Some of the newer shrubs, trees, and perennials for different purposes, are being tried.

Ornamental plants and shrubs and their uses.—The work already started with ornamental plants was continued. A few new hedges were set out and careful observations of the old plantings were made. Apparently the best plants for clipped hedges are buckthorn, *Cotoneaster acutifolia*, and Alpine currant. Hackberry and *Viburnum lantana* have been used with good results under some conditions. A start has been made in testing and developing some of the perennials. Some exceptionally fine aquilegia and delphinium have been grown. About four hundred seedling peonies have flowered and the best of these have been taken for further trials. About seventy-five varieties of annuals were tested in the gardens and on the campus, both as bedding plants and for cut-flower purposes. A few dahlias were tried, and during 1916 a much larger number will be tried in coöperation with the National Dahlia Society, fifteen or sixteen growers throughout the United States having agreed to send plants. Several importations of the Bureau of Plant Industry are being tried in the trial plots. A test of chrysanthemums was made in the greenhouse in the autumn.

DIVISION OF PLANT PATHOLOGY AND BOTANY

E. M. FREEMAN, Chief

SECTION OF PLANT PATHOLOGY

Disease survey.—The disease survey work progressed favorably during the last year. More accurate information than was ever before available was obtained on the prevalence and destructiveness, as well as the contributing factors, of the diseases of economic importance in the state. Several serious diseases appeared in the state for the first time. A survey to determine their extent and seriousness was immediately made, and proper measures for controlling them, or possibly eradicating them, were taken. The number of specimens in the pathological herbarium has been increased materially during the year.

Rusts of cereals.—The work in developing disease-resistant wheat progressed favorably. Promising hybrids were obtained and tested. The results, altho not final, are very encouraging. Further studies of the nature of the resistance to rust and the factors influencing it have been made. The effect of various natural and commercial fertilizers on the severity of rust attacks has been investigated and the results confirm the work done in previous years.

Work on grass rusts, including a study of the biologic forms and their plasticity, was pursued vigorously and definite results were obtained. Preliminary evidence on the effect of grass rusts on the epi-

demology of cereal rusts was obtained. The work has shown quite conclusively that the biologic forms of grass rusts are fairly sharply fixed. This fact is of considerable significance in the problem of developing rust-resistant wheats.

Cereal and forage-crop diseases.—Work on corn smut was continued, special attention being given to a study of the vitality and viability of the spores. It was shown that the spores do not remain viable after having been in a silo for a few weeks. This is important in controlling the disease.

Work on wilt- and rust-resistant flax varieties was continued. Further selections were made and give indications of a possible method of developing wilt-resistance.

The study of the imperfect fungi on cereal and root crops has progressed favorably. The pathogenicity of some of the forms isolated has been established and specific differences in symptomology have been noted. A study of wheat scab was begun during the year.

Further work was done in attempting to devise simpler methods for preventing the loose smuts of wheat and barley. The results are not yet conclusive, but indicate the possible success of the attempts. Definite results were obtained in the experiments made to determine the best methods for controlling rye smut.

Potato and garden truck diseases.—In addition to obtaining facts of scientific interest on the factors contributing to the seriousness of many of the potato diseases, seed-plot methods have been further tried and it has been shown conclusively that a large number of the serious diseases can be almost entirely controlled in this way. Experiments to determine the financial value of spraying potatoes were made and the results furnish further evidence (by averaging results of experiments covering several years) that spraying is financially profitable under average Minnesota conditions.

Methods for controlling several diseases of vegetables have been extensively tried, and definite results obtained. This information is available in bulletin form.

Fruit diseases.—Results of experiments on the control of brown rot of plums make possible definite recommendations to fruit-growers. The results have been published.

A study of the diseases of bush fruits was begun and some definite results were obtained. Raspberry diseases, having become very serious, received considerable attention, and coöperative experiments on control measures were started.

Dendro-pathology.—The cause of the death of oaks has been further investigated. The results of a large number of inoculations made with different fungi, however, were all negative and further work must therefore be done.

The microflora of peat lands.—It has not been possible to work on this project during the last year.

SECTION OF SEED LABORATORY

Seed-testing.—During the year, 9,461 samples of seed were voluntarily sent to the seed laboratory for testing. Most of these were accompanied by requests for both purity and germination tests, although a few were tested for either purity or germination alone. This number of samples required, therefore, approximately fourteen thousand five hundred tests, a considerable increase over the number of tests made in 1914-15.

Inspection work was carried on as formerly, and over 100 samples were collected by the seed inspector and tested for germination and purity.

Considerable work was done in testing seed under varying light conditions, and it was found that many seeds germinate much better in the sunlight germinator.

Greenhouse testing for germination was discontinued, but will be carried on extensively as soon as funds are available.

Seed studies.—Work was started to determine the exact germination period of seeds of different *Agropyrons*. The desirability of this information is due to the fact that much of the hay sold on the open market contains considerable quack grass.

Notes have been taken on the square-rod plots of lawn grass planted last year, and it has been found that some of the mixtures developed into exceedingly poor lawns, while others made exceptionally fine ones. More lawn grass plots have been added this year, using red fescue seed as a basis. More perennial grasses have also been added to the perennial grass garden.

Weed seed cases.—Approximately eight hundred seed cases were distributed during the year; and many rural schools, agricultural high schools, and agricultural colleges are now using Minnesota weed seed cases in their classes. Ninety-six varieties of weed seeds are now included in the collection.

Weed investigations.—Many weeds and grasses were identified for residents of the state. Agricultural high school instructors, rural school teachers, county agents, and farmers are availing themselves of the opportunity of having weeds identified. An accurate record is kept as to the source of these weeds. In this way a weed survey of the state is being made. No new weed of a noxious character has been discovered during the year. The number of plants in the weed garden has gradually been increased. At the present time practically 200 different varieties are grown in this garden, which is used for

demonstrations and for the collection of herbarium specimens of plants and seeds.

DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

E. DANA DURAND, Chief

The work of the Division of Research in Agricultural Economics has been devoted to problems of marketing, cooperation, and rural credit.

Collection of statistics of cooperative organizations in Minnesota.—In compliance with state law, information and statistics have been obtained from cooperative organizations engaged in marketing farm products and in buying supplies for farmers. A detailed study of Farmers' Elevators, based on the returns for 1913-14, was published as Bulletin 152, entitled "Farmers' Elevators in Minnesota." Special studies of the several classes of cooperative organizations, based on the returns of 1914-15, have been made and submitted for publication. These cover cooperative creameries, cooperative stores, and farmers' elevators, respectively. These studies not only continue the statistics of Bulletins 146 and 152, but contain additional and more elaborate analyses of such statistics, and data on other aspects of the several subjects. It is proposed to continue this series of reports annually, not repeating the detailed analyses of any given aspect, but rather showing the growth of the movement, and taking up other aspects for special study.

Cooperative purchasing by farmers' clubs.—The investigation of cooperative purchasing by farmers' clubs is distinct from that mentioned above, in that the clubs are not "cooperative organizations" and are not required to report annually to this division. This special study was begun in June, 1915, agents being sent to visit personally most of the clubs which had reported that they bought goods for members. A report has been prepared and submitted for publication.

Rural credit in Minnesota.—The investigation of rural credit, undertaken in October, 1915, originally contemplated detailed studies, based on schedules and personal interviews, of credit conditions, in hope of finding an explanation of the differences in interest rates in different parts of the state. It soon became evident, however, that Congress was likely to create new rural credit facilities, and it seemed desirable to postpone detailed studies to await the working of the new system. Meantime a general survey was made of credit conditions and methods in this state, in other states, and in foreign countries. The chief of the division assisted committees of the All-Minnesota Development Association, the Northern Minnesota Development As-

sociation, and other bodies, in discussing and drafting plans for possible state legislation on rural credit.

Marketing farm products.—For the most part, work on marketing was held in abeyance during the year. The reports on the marketing of butter prepared in conjunction with the Office of Markets and Rural Organization, United States Department of Agriculture, and the State Dairy and Food Commission, were completed, so far as this division was concerned, early in the year, but their publication has been delayed pending agreement with the other offices concerned regarding the exact form and contents of the publication. Some study has been devoted to the marketing of livestock and of dairy products, through interviews and attendance at conventions.

DIVISION OF SOILS

F. J. ALWAY, Chief

The urgent need of immediate field studies and field experiments has had the effect of diverting more and more of the resources of the Division to such work, with the result that laboratory investigations are necessarily being more and more curtailed. The cramped laboratory accommodations, the insufficiency of greenhouse space, and the inadequacy of funds to provide supplies and common labor, are less serious than the lack of provision for field experiments on the prominent soil types occurring in the state. There has been no provision for field experiments on the peat soils, altho these probably occupy several million acres, while only a few of the important types, even on the mineral or ordinary soils, are as yet included in the field experiments.

Fertilizer experiments.—The experiments with commercial fertilizers at University Farm, Morris, Waseca, Crookston, and Grand Rapids, described in the preceding two reports have been continued. The applications of both rock phosphate and acid phosphate, in combination with stable manure as well as alone, during the two years that they have been in operation, have failed to produce such crop increases at any of the five experimental farms as to make their use appear economic. However, it should be again emphasized that the results up to the present are not to be considered as *proof* that phosphates may not be used with profit under various conditions in this state. They clearly show, however, that the Experiment Station is not justified in recommending the use of phosphates in general farming operations in this state, since on five widely scattered experimental farms, over two hundred one-tenth acre plots, fertilized with phosphates, and growing wheat, oats, corn, clover, and potatoes during the first two years' work, have failed to yield sufficient increase to

make the treatment profitable. Some of the most important and most extensively cultivated soil types in the state are not represented on our experimental farms, however, and these might show a very different response to commercial fertilizers. There is urgent need of the establishment of a considerable number of small experimental areas, at least one on each of the most important soil types.

Peat soils.—The laboratory and greenhouse investigations were continued with different types of peat soils from various parts of the state. In coöperation with the Grand Rapids Substation, fertilizer experiments were continued on a small field of peat soil at that Substation. Hay was gathered from the plots seeded to grasses and clovers in 1914 as well as from similar plots seeded without a nurse crop in 1915. Oats, also, were grown. The need of an application of lime continues to be the most marked characteristic of this particular peat soil.

Late in the summer, work was begun on the experimental area at Dibbell, about 50 miles northwest of Duluth, the Duluth, Missabe & Northern Railway Company having furnished a site and made an appropriation to provide for the cost of clearing and ditching the land, and for fertilizers and labor. The work was conducted under the supervision of this division in coöperation with the Division of Agricultural Engineering. This experimental tract is situated in the midst of a very large bog with uniformly deep peat which is naturally much better provided with lime than that of the bog on the Grand Rapids Substation farm. The work is to be continued through the season of 1916 with funds provided by the railroad company.

An experimental area in the midst of the large wire-grass marsh in Anoka County has been temporarily arranged for. A group of business men and farmers owning peat land in that marsh will provide a considerable part of the expense.

The carrying on of these two experimental areas with outside assistance emphasizes the urgent need of investigations on the different types of peat of state-supported experimental fields.

Soils of the different glacial drift sheets.—The laboratory study of the glacial drift sheets has been largely suspended, owing to the lack of funds to provide necessary assistance. Based upon the first year's work, which indicated the approximate limits of the uniformly non-calcareous areas, extensive liming experiments have been started on the Loess, the Old Gray Drift, and the eastern part of the Late Gray Drift, including over one hundred thirty fields selected on the basis of the high degree of acidity of the surface soils. These are located in Houston, Fillmore, and Mower counties. As alfalfa is to be regarded as more sensitive to a lack of lime than other ordinary farm crops, it was selected as the trial crop. This was seeded in 1915,

a portion of each field being left unlimed. An inspection late in the autumn revealed marked differences in the growth of the alfalfa on many of the fields. The relation of the need of liming to the acidity of the soil should be apparent from the growth of the alfalfa during the coming summer.

It is planned during the coming summer to carry out liming experiments with alfalfa on the Early Red Drift, the Late Red Drift, the outwash plains of the Late Gray Drift, and the least calcareous portions of the till plains of the Late Gray Drift.

This experimental work is carried on in coöperation with the Agricultural Extension Division, and in some localities with the instructor in Agriculture of the nearest high school.

Glacial soils on the Gray Drift.—The laboratory investigations of the glacial soils on the Gray Drift were continued.

Studies of the movement of water in soils.—The work on the movement of water in soils was resumed, field studies being conducted at University Farm.

Organic constituents of the soil.—The chief results to date of the study of the organic constituents of the soil may be summarized as follows:

1. The organic matter of the ammonia extract of soils seems to bear but little relationship to the amount of organic matter dissolved by sodium hydroxide. Hence the usual method of determination of "humus nitrogen" is without justification.
2. The black pigment of the soil has been isolated.
3. The ordinary "humus" solution which has been supposed to contain only *matiere noire*, contains approximately only 30 per cent of black pigment, the remainder consisting of relatively colorless compounds.
4. Very dark "humus" solutions can be obtained from vegetable materials (hay, leaves, etc.) which have never come in contact with the soil. These solutions contain, however, no soil pigment.
5. The only reliable distinction between the organic matter of soil and ordinary undecomposed vegetable materials is the presence of soil pigment.
6. The soil pigment contains relatively little nitrogen and the fact that the darker soils are, in general, the more fertile appears to be a coincidence.
7. "Humification," induced by mixing soil with organic material and exposing the mixture under moist conditions in a greenhouse, causes a decrease in both organic carbon and humus, or ammonia-soluble organic matter.

DIVISION OF VETERINARY SCIENCE

M. H. REYNOLDS, Chairman

Coöperative work with the Bureau of Animal Industry, United States Department of Agriculture, and the State Livestock Sanitary Board in the study of swamp fever, has continued during the year with emphasis as heretofore on the problem of accurate diagnosis, especially by laboratory methods and under the personal direction of Dr. C. F. Flocken, of the Federal Bureau of Animal Industry. Research work on the disease itself must necessarily be unsatisfactory until an accurate means of diagnosis can be established. Brief reports of progress have been published from time to time in annual reports of the Bureau of Animal Industry but nothing has been published by this Station.

SECTION OF VETERINARY SANITATION

The work of the Section of Veterinary Sanitation consisted largely of active service for the State Livestock Sanitary Board and the Stallion Registration Board.

State accredited herds.—During the year, a plan was put into operation for state recognition of tuberculosis-free purebred herds, the purpose of which is to secure, if possible, total eradication of tuberculosis from purebred cattle and to give the owner valuable advertising privileges and the freest possible movement of his stock within the state and into other states. It is believed that this plan will serve as very useful advertising for Minnesota purebred cattle and tend to give Minnesota the best possible reputation for sound breeding-stock.

Minnesota stallion board.—The head of the section spent considerable time in the examination of stallions concerning which there is disagreement among veterinarians, or regarding which there is reason to suspect incorrect veterinary report as to soundness.

University herds were taken under closer personal supervision, especially with reference to the prevalence, importation, and dissemination of tuberculosis and other infectious diseases. This work showed that University herds were all in excellent condition during the year, excepting the herd at Crookston, where an infection with tuberculosis resulted from the introduction of an infected animal which had failed to react to the tuberculin test. This experience shows the necessity for investigations of possible methods of detection of tuberculosis other than the tuberculin temperature test. It has been found that this test is not always reliable, in cases where animals have been frequently tested or are so seriously affected with the disease that the injection of an additional amount of tuberculin does not produce the characteristic rise in temperature.

SECTION OF VETERINARY BIOCHEMICAL PRODUCTS

The law under which the state serum plant is now operating went into effect very early in the year. During the first year of operation under the new law no serious defects have been found in it.

A very marked decrease in the demand for the double treatment for hog cholera was noticeable throughout the summer and fall of 1915, owing, no doubt, to one or more of the following reasons: (1) The decrease in the prevalence of the disease; (2) The penalty imposed by the new law for the use of virus without proper authorization; (3) The refusal of the State Livestock Sanitary Board to issue any virus permits to local veterinarians; (4) The results obtained in the Renville County experiments with the single treatment exclusively; (5) The wide advocacy of the use of the single treatment by the men in charge of the state serum plant and by the State Livestock Sanitary Board.

Considerably less hog cholera existed in Minnesota in 1915 than in 1914, a very noticeable decrease having been apparent since the fall of 1913. This is in line with the history of previous bad outbreaks.

Only two serious outbreaks, as far as known, occurred during 1915. One of these was in the northwestern part of the state, in Polk County, and the other in the southwestern part, in Jackson County. In both cases very gratifying results were obtained with the single treatment, both in saving hogs in infected herds and in protecting hogs in exposed herds.

For fear of a heavy demand for serum late in the summer and fall of 1915, serum was produced to the limit of the capacity of the plant until about the first of August. Since August, 1915, the only serum produced has been that incident to testing serum; some experimental work; and the inoculation of small lots of pigs, from time to time, for the purpose of resuscitating our strain of virus.

SERUM PRODUCTION AND DISTRIBUTION

Month	1915	
	Production cc.	Distribution cc.
April	384,460	61,125
May	510,480	90,200
June	613,010	108,515
July	573,210	147,700
August	704,420	203,440
September	97,430	219,260
October	6,310	60,975
November	750	37,355
December	23,220	22,660

1916

January	16,040	5,255
February	27,795	2,965
March	30,660	12,480
Totals	2,987,785	971,930

Considerable work of a research and experimental nature has been planned, but lack of sufficient laboratory facilities and housing space for experimental animals has greatly handicapped this work, which has been divided into the following subprojects:

1. Laboratory diagnosis of hog cholera;
2. Histopathological studies of the lesions found in hog cholera;
3. The attenuation of hog cholera virus to produce a vaccine;
4. The isolation and cultivation of the causative organism of hog cholera;
5. Bacteriological examination of serum;
6. Standardization of hog cholera serum.

Attempts to perfect a method for the laboratory diagnosis of hog cholera have been along the line of complement fixation, using various materials as antigens. Considerable time has been spent in perfecting certain details of technique, and this work will be pushed as soon as the new experimental laboratories are completed.

Several hundred sections of tissue from organs of cholera pigs have been selected and mounted for histopathological study. The microscopical studies which are under way deal with the exact nature of the petechial haemorrhages in certain organs, with their correlation to other conditions, especially the presence of organisms belonging to the class of secondary infections.

The work of attenuating hog cholera virus, for the purpose of obtaining a vaccine, has been pursued with irregular results. This irregularity is in accord with the results obtained by others, using various methods. Our method has been to obtain the vaccine by bleeding hyperimmune hogs at various intervals after the injection of hog cholera virus, believing that a short residence of the virus in a highly immune hog might result in sufficient attenuation to make it safe to use as a vaccine. The extreme variations in immunity and susceptibility of various hogs has undoubtedly been an important factor in the irregular results obtained.

Attempts to isolate and cultivate the causative organism of hog cholera have failed. This work, however, has been greatly handicapped by lack of suitable facilities for quarantining susceptible pigs or for housing experimental animals. Until such quarters are provided, the work will be discontinued.

A large number of bacteriological examinations of serum have been made. Samples have been kept of over thirty different batches of serum, some of them being almost eighteen months old. Bacterial counts have varied between wide limits, age appearing to have little or no effect. Some tests are under way, comparing the value of phenol as a preservative, with and without glycerine. A considerable number of tests were made to determine the effects of freezing serum, both upon its potency and on the bacterial flora.

A little work was done with the globulins in hog cholera serum, principally in comparing normal hog serum, immune hog serum, and hyperimmune hog serum. A great deal of time has been spent preparing apparatus and perfecting technique.

SECTION OF PATHOLOGY AND VETERINARY MEDICINE

Infectious abortion.—The survey work with infectious abortion has been continued as in other years, and a fairly accurate idea of the manner of dissemination, the extent, and the seriousness of the malady has been obtained.

A considerable amount of work in the field has been done and new work is now under way in an attempt to immunize young heifers by injecting them with a series of vaccines containing the killed organisms of abortion. Virgin heifers, as well as heifers in the early stages of gestation, are being used. The results so far obtained are promising and the work will be vigorously pursued during the coming year. Two herds in which abortion appeared were vaccinated with a vaccine prepared from organisms isolated from aborted fetuses of the respective herds. The results obtained were encouraging but not satisfactory. Twelve different strains of the *Bacillus abortus* have been isolated in various sections of the state. The pathogenicity of these strains will be studied during the coming year. The study of the pathological changes which occur in the aborted foetus has been continued and it was found that a dropsical condition of either the chest or abdominal cavities or both, is not uncommon. In many instances the spleen appeared congested, and the stomach contents were found to vary from brown to a brownish-yellow in color. Oedema of the umbilical cord was not of frequent occurrence.

The investigation of sterility, or barrenness, one of the phenomena of abortion, has been continued. Many animals were examined clinically and it was shown that cystic degeneration of the ovaries and persistent *corpora lutea* were of common occurrence. Metritis and pyometra were also shown to be present in a large number of cases examined.

The massaging of the uterus and ovaries of non-breeding cows, together with draining and irrigating of the uterus in cases of pyo-

metra has been practiced during the year. More work of this nature will be necessary before definite results can be obtained.

Laboratory specimens.—As in past years, a considerable number of trips were made for the State Livestock Sanitary Board, for the purpose of establishing diagnoses, and the collection of material for bacteriological and pathological study. Numerous outbreaks of haemorrhagic septicaemia were investigated. It was found that the majority of the outbreaks were of a sporadic nature, altho in some instances the infection was probably introduced by buying animals (feeders and stockers) which had passed through stockyards. The pathological changes (macroscopic) were found to consist mainly of haemorrhages which were confined chiefly to serous and mucous membranes, the lesions occurring in the mucous membranes being in the minority. Pneumonic lesions, such as haemorrhages (petechial) and areas of active inflammation were observed in several autopsies.

There has been considerable increase in the number of specimens received for laboratory diagnosis. This section is glad to offer this kind of service to veterinarians and others who desire it.

The large number of specimens of avian tuberculosis received during the last year indicates that the disease is on the increase among poultry, especially chickens.

SECTION OF VETERINARY PHYSIOLOGY

Research work in veterinary physiology has been continued as outlined in last year's report. Considerable progress in the study of normal hog's blood has been made. Complete examinations have been made of the blood of twenty-five young pigs, ranging from two to forty-two days old. These results have been tabulated and are available for publication. Considerable progress has been made in the study of the blood of hogs weighing approximately one hundred pounds.

Simultaneously with the work on normal hog's blood, studies have been made of the effects of muscular exercise on the blood and body temperature. After examining the blood of a normal hog, the animal is exercised for a given time and any changes in the blood or body temperature are noted. It was found that moderate exercise for as short a period as from five to fifteen minutes, depending on weather conditions, produced marked changes in the blood and body temperature and several hours were required for normal conditions to return. It has also been found that confining pigs in a sunshiny pen on warm days will cause marked changes in the blood and body temperature. This work, together with the studies on normal blood, will be completed during the coming year.

Studies of the role of the thyroid gland in the pig have also been carried out. The methods of study included extirpation of the thyroid gland in young animals, followed by careful observations of the clinical symptoms, and finally macroscopic and microscopic post mortem examinations. Several pigs in the same litter were used as controls. Altho the number of animals used in this experiment was small, results were so uniform that we believe we are justified in drawing several conclusions. Thyroidectomy in this animal does not induce symptoms of cretinism because of a compensatory hypertrophy of the accessory thyroid structures, but removal of the main structure (the thyroid gland) does render the body less resistant to disease and probably plays an important part in fertility and in nutrition of the foetus. Additional work in connection with this problem will include a study of the amount of accessory thyroid tissue present in normal pigs.

A study was made of the internal secretion of the pancreas of the dog and the ability of the internal secretion of the pancreas of the cat to prevent glycosuria when artificially introduced into the blood stream of a pancrëatctomied dog. This project will be continued.

FORESTRY INVESTIGATIONS

E. G. CHEYNEY, Chief

PROGRESS OF EXPERIMENTAL WORK

The experimental work carried on at the Forest Experiment Station, Cloquet, is now producing some conclusive results, especially with reference to methods of nursery practice and forest planting.

The development of improved methods of lifting, packing, and transplanting have shown that it is possible to cut the cost of producing transplant stock in half. This should enable the nurseries to produce transplanted stock for forest planting at a price within the reach of every one.

There has always been considerable question as to the classes of planting stock that should be used in different situations, such as open sand without ground cover, heavy brush, clay soil, and a thin stand of timber. It is now definitely determined where two-year-old seedlings can be used and where transplanted stock is needed. These experiments have also determined the best planting tools and the best methods of planting for each situation. It was found that these factors sometimes make a difference of 50 per cent in the cost of planting.

A careful study of the different soils has quite definitely developed a standard for determining the species best adapted to different types.

A method has also been worked out for determining the loss and gain of water from the first foot of soil in the different forest types.

This is of great importance in determining the probable success or failure of small seedlings.

Experiments in the collection and extraction of white and Norway pine seed have been completed. Definite instructions for this work can now be confidently given. Additional work is necessary with the other species.

Definite information is needed by the paper industry on the growth and yield of white spruce. Large areas of this species must be planted if the paper mills are to be maintained on their present basis, but this can not be done intelligently unless the returns from such planting can be pretty definitely predicted. The same is true to a lesser degree of popple (*P. tremuloides*). In order to answer these questions, a preliminary study covering most of the northern part of the state was made in coöperation with the Minnesota Forest Service. This must be followed by a more intensive study.

FUTURE PLANS

Heavy losses from damping-off diseases, sometimes amounting to 50 per cent, are suffered in every nursery where pine seedlings are raised. This problem has never been exhaustively studied. An investigation of methods for control of the diseases has been started this year, in coöperation with the Division of Plant Pathology and Botany.

Many of the experiments now under way must necessarily be continued for several years before any definite results can be obtained. These continuation experiments include work in sowing and planting, nursery practice, seed studies, management, and mensuration.

Coöperative work with the Water Department of the City of St. Paul is in progress. The city has adopted a definite policy under which planting will be carried on regularly every spring for several years on a quite extensive scale. The planting of the last three years has been very successful. It is hoped that this may lead to further planting by other city departments.

NEEDS OF THE DIVISION

The most keenly felt need of the division at present is a wood technology laboratory for the study of the structure and uses of different species of wood. The increased competition and the more highly developed methods of lumber salesmanship have created a great demand for this information and inquiries are constantly received that we can not answer. The manufacture of wood plays an important part in the industry of this state, and always will, and the fundamental data on which it must be based should be worked out.

The interest in all branches of forestry, as indicated by the inquiries which come to this office, is greater than ever before.

THE SUBSTATIONS

The Substations at Crookston, Morris, and Duluth each begin this year the publication of a separate annual report of progress of their experimental work, for distribution throughout the locality to which their special work is particularly adapted. On that account, only a brief review of the work in progress at these Substations is presented here. For full details of the progress on any of the Substation projects, the annual report of the particular Substation concerned may be consulted.

THE CROOKSTON SUBSTATION

C. G. SELVIG, Superintendent

At the Northwest Experiment Station, the year 1915 was marked by a noticeable improvement in the organization of the work, and the inclusion of a greater number of investigations than had been attempted before. The work now includes a study of the influence of tile and open drainage, coöperative work with farmers in the distribution of seeds and trees, and various phases of work in Agronomy, Horticulture, Dairy and Animal Husbandry, and Poultry.

Besides this, the Station corps are engaged in work with the farmers of the northwestern part of the state. Extension and demonstration work in treating seed potatoes and seed grain, spraying potatoes, feeding swine, improving poultry stock, eradicating weeds, and assisting in boys' and girls' contest work is carried on. Various organizations are affiliated with the Station, including the Red River Valley Livestock Breeders' Association, the Farm Crops Show Association, the Pure Seed Growers', Horticulturists', and Poultrymen's associations.

AGRONOMY SECTION

The 1915 field yields of barley and oats were the highest in the history of the Station. Barley, in the minor six-year rotation, yielded 41.9 bushels per acre; oats, 75.5 bushels; wheat, 17.4 bushels on a field that was flooded in June. Maximum yields per acre of the following crops were: potatoes, 124.9 bushels; mangels, 28 tons; carrots, 462.5 bushels; rutabagas, 650 bushels; turnips, 633 bushels; clover and timothy, general average small fields, 2.43 tons, the maximum yield in one cutting being 2.28 tons; and in two cuttings, 2.95 tons. The maximum yield of alfalfa was 4.09 tons per acre. Corn matured no seed on account of frost on August 26, and yielded a very light crop of inferior silage.

Cultural methods.—The range of yields in the rate-of-seeding tests of oats was from 80 to 98.7 bushels per acre, the highest yield

resulting from sowing 13 pecks per acre. In the average for five years, the yield from 14 pecks is highest. With wheat the range was from 16 to 24 bushels per acre, the highest resulting from both 3 pecks and 6 pecks per acre. In the five-year average, the 6-peck rate is the highest. The season of 1915 was very favorable for crop-production so that the rate of seeding made less difference than usual. There was a difference of only 2.5 bushels in favor of barley sown on April 29 as against May 20. Winter wheat was killed in the thaw of February, 1915. Alfalfa and clovers sown without a nurse crop in 1915 had a better stand than those sown with a nurse crop. The unusual growth of the nurse crop crowded out the grasses. Later trials must be made before conclusions are drawn. A slight advantage appeared in favor of tractor plowing and disking as compared to horse plowing and disking.

Varietal tests.—Variety tests were continued in 1915, this year completing the first five-year period for most of them. Marquis wheat yielded the highest, 40.6 bushels per acre. It also has the highest five-year average yield of any of the varieties of wheat. Minnesota No. 169 yielded 24.0 bushels in 1915 compared to 23.03 bushels, the average for five years; Minnesota No. 163, 30.9 bushels with an average of 23.03; Velvet Chaff in 1915, 35.5 bushels and an average of 28.30 bushels; Minnesota No. 951 (Margaroni) in 1915, 34.4 bushels, with an average of 27.95 bushels; Kubanka, in 1915, 38.0 bushels and the highest of the rust hybrids, 29.7 bushels. The lowest in 1915 was Rysting's Fife, 16.8 bushels, while the lowest in the five-year average is Preston's Fife, 18.33 bushels.

Russian barley yielded, in 1915, 58.2 bushels per acre, with an average yield during the five years of 45.9 bushels. Mährische No. 912, U. S. D. A., yielded 57.8 bushels per acre and Manchuria, 58.3 bushels. Gutekon gave the lowest yield, 24.1 bushels. Lincoln No. 340 oats yielded 96.6 bushels with a five-year average yield of 59.8 bushels; Alsaman 93.1 bushels, and an average of 64.35 bushels in a four-years' test. Early Champion gave the lowest yield, 42.9 bushels in 1915 and 45.2 bushels for the average in four years. The highest four-year average of oats was made by Canadian No. 429, 65.3 bushels; and the lowest by Sixty Day oats, 37.17 bushels. Millets yielded well in 1915, Southern German making 2.02 tons per acre and 2.67 tons in a three-year average. The variety grasses sown in 1915 were clipped in order to strengthen the stand. All came through the winter in good condition. The fiber flax plots were injured by the high water of 1915 and by flax wilt, so no returns were obtained. This project is being continued.

Rotations.—In the major six-year rotation fields east of the Northern Pacific Railway, barley yielded 41.9 bushels per acre, and

oats 75.5 bushels. The wheat field was flooded and the yield was greatly reduced as a consequence. Corn was cut for ensilage. The yield of clover and timothy hay was fair.

The grass stands in the fall of 1915 were 50 per cent in the continuous wheat with clover, and in the three-year rotation; 65 per cent in the five-year, and 90 per cent in the seven-year rotation. In the seven-year rotation, wheat yielded 32.46 bushels; in the five-year, 30.5 bushels; in the three-year, 31.8 bushels; in continuous wheat with clover, 25.9 bushels; and in continuous wheat, 29.7 bushels. The five-year average yield of wheat is a trifle above 25 bushels in each of these three rotations; 19.41 bushels in the continuous wheat plot; and 17.27 bushels in the continuous wheat grown with clover plowed under. Oats yielded 91.2 bushels in the seven-year rotation in 1915, and 63 bushels in the five-year series. The five-year average for oats in the seven-year rotation is 63.44 bushels, as compared to 50.0 bushels in the five-year series. Barley yielded 40.2 bushels in 1915 in the seven year rotation as compared to 41.05 bushels, the five-year average. Flax, 1915, 16.9 bushels; average for five years, 16.43 bushels. Corn froze in 1915, but the immature ears and fodder were weighed, giving the following yields: Seven-year rotation, 21.0 bushels; five-year, 8.3 bushels; three-year, 5.6 bushels; and continuous corn, 14.1 bushels. The highest five-year average yield of corn is that in the seven-year rotation, 42.58 bushels per acre. The clover and timothy in the five-year rotation made the highest yield, 5,910 pounds to the acre, as compared to 4,560 pounds in the three-year and 4,120 pounds in the seven-year rotation. The rotation project promises to give valuable information not only on yields but also on weed control.

Fertilizer tests.—The fertilizer tests conducted in coöperation with the Division of Soils, of the Experiment Station at University Farm, St. Paul, are reported by that division.

Corn-breeding.—The frost which occurred August 26 prevented the corn in different projects from maturing. Seed saved in 1914 was used this spring in continuing the work.

Weed eradication.—Various methods of eradicating quack grass besides the severe bare fallow followed by corn were begun in 1916, as a new phase of this project. They include sowing buckwheat and reseeding; sowing buckwheat and fallowing; sowing hemp; sowing millet followed by rye and repeat; planting corn in checks. Work with Canada and sow thistle is done coöperatively with neighboring farmers.

HORTICULTURAL SECTION

Tree and shrub investigations.—Trees and shrubs made a fair growth in 1915 in spite of the late spring and early fall frosts. The

seed of the leading windbreak trees was killed by the early summer frosts, hence the starting of the nursery seedlings had to be postponed until this spring. A good crop of seed had set on the ash, box elder, hackberry, basswood, and elm. The box elder aphid attacked the box elders, and woolly aphid the elm trees. Kerosene emulsion and home-made tobacco spray proved most effective in controlling the aphid on the young box elder trees. The winter of 1915-16 caused very little damage, owing, no doubt, to the heavy covering of snow. Several mountain ash trees were injured by sunscald and the new growth of several vines of Engelmann's ivy winter-killed to the ground. Considerable mechanical injury was inflicted by the strong wind of early summer. The cambium miner killed two of the large paper birch trees in the windbreak. Approximately forty-two hundred trees and shrubs were set out in the spring of 1916, and 7,500 willow cuttings. Many of them were taken from the woods along the Red Lake river. Diameter measurements of trees indicate that the greatest wood growth per acre is made by the white willow. The greatest growth in height was made by the cottonwood. The willow, box elder, and birch made about equal growth in height. The paper birch is making a satisfactory record.

Tree- and small-fruit investigations.—Tree and bush fruits given protection wintered well. Minnesota raspberries Nos. 3, 4, 5, and 7 fruited in 1916, as did the Carrie gooseberry, producing berries of good quality and size. The Long Bunch Holland and Perfection currants fruited this year, bearing good crops. Minnesota No. 3 strawberry fruited, giving every promise of being a very desirable standard berry. In 1915, the Virginia, Florence, and Early Strawberry crab-apples set a light crop of fruit for the first time. Plums and grapes are nearing the time when crops may be expected. A considerable number of fruit trees and plants were set out. Each year marks definite progress in this work.

Garden crop investigations.—Seventy-four varieties of garden vegetables produced crops in 1915. Squashes, melons, and cucumbers were all destroyed by early frosts. Late frosts ruined field beans. The following varieties produced maximum yields per acre: Early Egyptian beets, 466 bushels; Early Surehead cabbage, 15 tons; Chantenay and Oxheart carrots, each 500 bushels; Early Fordhook corn, 87.5 bushels; Extra Early Red Flat onions, 378 bushels; Hollow Crown parsnips, 300 bushels; Prosperity peas, 58.3 bushels; Long White Vienna radishes, 6,428 bunches; American Purple Top rutabagas, 486.5 bushels; Spark's Earliana tomatoes, 8,333 pounds. In 1916, 125 varieties of vegetables were planted. The canning project is being continued.

Root crop investigations.—Twenty-four varieties of rutabagas, mangels, carrots, and stock turnips were tested. A chemical analysis of their content was made by the Division of Agricultural Chemistry, at St. Paul. The maximum yields per acre were: Giant Sugar Feeding White mangels, 281 bushels; Carter's Hardy Swede and Sweet Russian rutabagas, each 650 bushels; Cowhorn turnip, 633 bushels; and Victoria carrots, 462.5 bushels. One hundred pounds of each variety wintered perfectly when pitted in the field, covered with layers of straw, dirt, and manure.

Potato investigations.—The work in variety testing of potatoes was continued and a new project in coöperation with the Division of Horticulture, at University Farm, St. Paul, was begun. A cold spring and excessive rainfall during early summer greatly reduced the yields. The Irish Cobbler yielded the best in a field test, 70.6 bushels per acre. The Green Mountain variety was highest, 100.5 bushels per acre, in the coöperative plot test. Work was continued in the tuber- and leaf-disease plots, as well as with methods of planting, including using different sizes of seed pieces and different rates of seeding. Two new subprojects, testing fungicides and insectides, were begun in 1916. The seed-selection plots again demonstrated the superiority of hill selected seed, in both yield and uniformity of type.

Fertilizer tests with potatoes are reported by the Division of soils.

A new subproject will be begun in 1916, in coöperation with the Section of Agronomy, namely, planting potatoes in rotation as the cultivated crop.

DAIRY AND ANIMAL HUSBANDRY SECTION

The project of comparing flax and tankage as protein feeds for pigs was completed. The result indicates that flax can not be successfully used as the only source of protein to balance a ration for pigs, using corn, oats, and barley as carbohydrate feeds. Whether a small quantity of flax fed in connection with tankage or some other protein feed is beneficial or harmful was not apparent.

In the herd-maintenance project, fall pigs were raised to determine whether the practice is feasible and profitable in Northern Minnesota. The hogs averaged 255 pounds in weight when eight months old. They required 5.42 pounds of feed per hundred pounds of live weight. The experiment seemed to indicate that fall pigs can be successfully grown in Northern Minnesota. Tankage was used as the protein feed to balance the ration. Water was warmed and mixed with ground feeds and fed as slop.

Work on the project of determining the influence of over-feeding with protein is being continued. A new project, using the self-feeder in pig-feeding, was begun this year. Alfalfa and rape are used suc-

cessfully as summer pastures for hogs. Hot-house lamb-raising has proved very profitable.

POULTRY SECTION

The investigation of artificial versus natural incubation of chicks is being continued with results more marked each year in favor of the natural method. The results in the experiment with poultry house construction were the same as last year excepting that the sixty Barred Plymouth Rock hens in the frame house produced 20 more eggs during the year than did the sixty in the concrete house, reversing last year's record. Experiments with chick- and hen-feeding are being continued. Steps have been taken to enlarge the output of breeding stock.

The program for 1916 includes additional projects in the sections of Agronomy and Horticulture and an increased amount of work in direct coöperation with the farmers of the Red River Valley.

MORRIS SUBSTATION

E. C. HIGBIE, Superintendent

Experimental work at Morris during 1915 was confined to crop rotations, fertilizers, and variety and seeding trials with the farm crops commonly grown in Western Minnesota. Plans were perfected for beginning, in 1916, swine-feeding experiments to test the value of alfalfa pasture as compared with dry-lot feeding, and the use of the self-feeder as compared with hand feeding for pork production; and an extensive trial of trees, shrubs, and ornamentals for planting on the prairies of Western Minnesota.

The progress of the experimental work in Agronomy during the year may be briefly summarized as follows:

Experiments with fertilizers.—The experiments with fertilizers are carried on in coöperation with the Division of Soils of the Central Station. Seventy-two plots, of 1/10 acre each, have been set aside for a continuous fertilizer experiment. A four-year rotation of corn, wheat, oats, and clover is used, with 18 plots in each of these crops each year. These plots are given six different treatments in triplicate, including no fertilizer, rock phosphate alone, acid phosphate alone, manure alone, rock phosphate with manure, and acid phosphate with manure. The experiments were begun in 1913, and the two seasons' crops which have been harvested thus far have not shown sufficient increase in crops on the treated plots as compared with those on the untreated check plots to pay for the additional cost of applying the fertilizer.

Experiments with alfalfa.—Twenty-one different strains and varieties of alfalfa are being tested in nursery rows, and a series of plots

has been set aside for tests in triplicate of dates and methods of seeding alfalfa. Results thus far indicate that the true Grimm, Baltic, and imported Turkestan varieties are sufficiently hardy to withstand the winters of Western Minnesota.

Experiments with clover.—Clover has been grown successfully in general field rotations each year since the Station was established, in 1910. Experiments are now under way in seeding and the use of different nurse crops, and in the utilization of clover as a green manure. Alsike clover has proved a very satisfactory crop for wet lands.

Experiments with corn.—Nine varieties of corn were tested in 1915, but the season was so short that none of the varieties matured. The tests will be repeated. Bulk plot selection of early-maturing and high-yielding strains of Silver King and Minnesota No. 13, was planned, but was prevented by early fall frosts. It will be continued in the future.

Experiments with wheat.—Seven varieties of spring wheat, five of them being the sorts commonly grown in Western Minnesota and two rust-resistant hybrids from the Central Station, were tested for yield and disease resistance, in 1915. Conditions were such that rust was not very prevalent last year and the tests will be repeated.

Experiments with oats.—Seven varieties of oats were tested and yields varying from 64 to 100 bushels per acre were obtained. Improved Ligowa gave the highest yield with the greatest freedom from lodging. These tests will be repeated.

Experiments with barley.—Three varieties of barley were tested. Several severe storms interfered with the growth of the crop and the tests will be repeated.

Experiments with peas.—Marrowfat, a late variety, yielded 24.3 bushels of peas per acre, as compared with 9.5 bushels from Early Alaska, an early dwarf variety.

GRAND RAPIDS SUBSTATION

O. I. BERGH, Superintendent

WEATHER CONDITIONS

The winter of 1914-15 was unusually open. There was not enough snow for sleighing after February. March and April were exceptionally warm and dry; precipitation being 0.16 of an inch for March and 0.94 of an inch for April. Field work began April 16 under conditions very favorable for seeding small grains. Corn- and potato-planting began May 15 and were completed by the end of the month. The temperatures for May, June, July, and August were much below the normal for those months, with little sunshine and excessive rains, especially in June, the precipitation for that month

being 7.78 inches. Frost on June 9 froze the corn and potatoes to the ground. Another frost occurred August 18 which, in places, entirely destroyed them. However, tho the conditions were very unfavorable for corn, potatoes, millets, small fruits, and tender vegetables, they were quite favorable for small grains, grasses, and pastures.

CROP YIELDS

Oats averaged for all fields, 76.9 bushels per acre. The average of 13 varieties of oats was 91.7 bushels of very good quality, the Sixty Day making the highest yield, 110.6 bushels per acre. The lowest yield of oats was 79.6 bushels for the Swedish Select.

The wheat average on the large field was 26.9 bushels per acre. The average of 13 varieties in plots was 26.6 bushels, the highest yield being from the Prelude, 30.6 bushels, followed closely by the Marquis and Haynes Bluestem which yielded 30.5 and 30.3 bushels per acre, respectively. The lowest yield was from the Alaska, a Pollard variety, 20.8 bushels per acre.

The average yield of barley on the large fields was 42.6 bushels per acre, and the average for 10 varieties was 54.6 bushels; the largest yield being made by the O. A. C. No. 21 (a six-rowed variety), 63.9 bushels per acre. The smallest yield of a six-rowed variety was from the Oderbrucker, 54.6 bushels per acre. The highest yield from the two-rowed varieties was from the Champion of Vermont, 55.6 bushels, and the lowest, from the Swedish Chevalier, 36.2 bushels per acre.

The average yield of corn, green, in bundles for ensilage was 3.4 tons per acre. The average yield of potatoes for all fields was 136.6 bushels; for clover and timothy, first cutting, 2.42 tons per acre; for rutabagas, topped, 24.47 tons.

LIVESTOCK

Dairy herd.—The breeding up of a grade Guernsey herd from common cows by the use of registered Guernsey sires continues to show a marked increase in production, as indicated by the table below, covering a period of five years from 1911 to 1915 inclusive. It should be noted that not only has the herd made an increase in the amount of milk produced but it has also increased the average percentage of butterfat in the milk from 4.27 per cent to 4.9. It should be kept in mind, however, that the breeding up of the herd is not the only factor in increased production from year to year. The herd was stall fed for a much longer period in 1913 and 1915 than in the other three years, and on pasture a much shorter time. The quality of ensilage was exceptionally good in 1914, as the corn crop was almost mature when harvested.

	1911	1912	1913	1914	1915
Average number of cows milking.....	30	44	47	34	41
Average number of weeks milking per cow..	43	45	48	47	45
Average pounds of milk per cow.....	5,300.9	5,370.6	5,312.5	5,518.7	5,721.2
Average percentage of butterfat.....	4.27	4.39	4.4	4.7	4.9
Average pounds of butterfat per cow.....	226.6	235.8	236.6	259.0	279.8
Average value of butterfat per cow.....	\$67.98	\$70.74	\$70.98	\$77.70	\$83.95
Average pounds of grain per cow, and value	{ 1,189 { \$14.86	{ 1,183 { \$14.79	{ 1,674 { \$20.92	{ 1,416 { \$17.70	{ 1,949 { \$24.36
Average pounds of roughage per cow, and value	{ 1,962 { \$9.86	{ 2,192 { \$10.96	{ 2,217 { \$11.08	{ 2,094 { \$10.47	{ 2,978 { \$14.89
Average pounds of fodder corn per cow....			{ 686 { \$1.71		
Average pounds of succulence per cow, and cost	{ 6,596 { \$8.25	{ 5,549 { \$6.93	{ 5,741 { \$7.18	{ 4,827 { \$6.03	{ 4,861 { \$6.08
Total cost of food per cow.....	\$32.97	\$32.68	\$40.89	\$34.20	\$45.33
Average value of butterfat above cost of feed	\$35.01	\$38.06	\$30.09	\$43.50	\$38.62
Date put into pasture.....	May 6	Apr. 28	May 18	May 17	May 14
Date taken from pasture.....	Nov. 5	Nov. 4	Oct. 12	Nov. 9	Oct. 4
Number of days stall fed.....	182	176	218	189	224
Number of days part stall fed and part pastured	15	34	14	21	16
Number of days pastured only.....	168	156	133	155	125

Swine.—The swine department has been continued as in the past, growing pork for profit. The breed kept is the Improved Large White Yorkshire. Nine registered brood sows were wintered.

Poultry.—The Rhode Island Red has been added to our poultry department, making four breeds under a comparative test, as follows: Plymouth Rock, White Orpington, Rhode Island Red, and White Leghorn.

EXPERIMENTAL PROJECTS

The experimental work at this Station has been carried on during the last year as outlined under "New Projects" in our 1914 report. It is yet too early to draw any conclusions from the results of the most of these projects, however from several projects definite results may be given.

Potato investigations.—In our potato investigations results clearly show that home-grown seed is in most cases superior to seed imported from outside districts. In some instances the home-grown seed yields 4 or 5 times as much as imported stock.

Raw peat vs. stable manure as a fertilizer for upland soil.—Raw peat applied on upland soil with a manure spreader and well worked into the soil by the use of a disk, shows marked beneficial results on corn and potatoes.

Peat for barn litter.—Dried peat is excellent stable bedding for cattle. The cheapest way of preparing this peat for bedding is to pulverize it on the open bog with a disk and cultivator. When dry, it can be hauled under cover in double wagon-boxes, being quickly and easily handled with a large scoop-shovel or ensilage fork.

Fertilizers on muskeg for garden crops.—Applications of lime in the form of ground rock on peat land at this Station, show marked beneficial effects on nearly all crops, and especially on clovers.

Investigations with grasses.—Meadow fescue or English bluegrass shows promise as a grass crop on muskeg for either hay or pasture, without treatment.

The inoculation of alfalfa is advisable and economical on lands where this crop is planted for the first time. Inoculation with soil from an old alfalfa bed gives better results than inoculation with bacteria solution.

NEW PROJECTS

1. Variety test of winter grains, including rod-row test of 150 different strains and varieties of winter wheat, and plot tests of 30 varieties; besides two varieties of winter rye. The majority of those wintered exceptionally well.

2. Time of seeding winter rye, to determine the effect on yield of this grain due to the date of seeding.

3. Variety test of field peas, soy beans, vetch, and serredella.

4. The starting of a new orchard of 350 trees, including 14 varieties of apples and crabs, Compass Cherry and 19 other varieties of plums.

5. Variety test of small fruits including: grapes, 11 varieties; raspberries, 15 varieties; blackberries, 15 varieties; dewberries, 2 varieties; gooseberries, 10 varieties; currants, 10 varieties; strawberries, 12 varieties; and high-bush cranberries.

6. Windbreak plantation, including several kinds of conifer trees.

7. Reforestation. Fifty acres in our present wood-lot have been set aside for this work with the approval of the Board of Regents.

NEW PROJECTS ON MUSKEG LAND

1. Rate of application of commercial fertilizer on muskeg.

2. Influence of a heavy application of limestone and quick-lime on muskeg land in its native state, to note the effect of such applications on the native vegetation.

DULUTH SUBSTATION

M. J. THOMPSON, Superintendent.

WEATHER RECORDS

The station maintains an equipment for taking maximum and minimum temperatures and rainfall and snowfall. In checking up with the Government station at Duluth, seven miles distant, it is found that, owing to peculiar local conditions of topography and geography,

there is a wide variation in weather records, the Station readings corresponding more closely to those of the ranges or of the Cloquet Station. The ranges are about seventy-five miles distant and Cloquet is about twenty miles.

COOPERATIVE ORCHARD EXPERIMENT

The young apple orchard passed through its first winter in 1915-16. Okabena and Duchess made the best showing for hardiness. The others followed in this order: Patten's Greening, Anisin, Wealthy, Hiberna. Results of blasting holes are not yet particularly in evidence except that all trees set in blasted holes show an exceptionally thrifty condition. Of the small fruits, strawberries have done exceptionally well. Varieties produced fruit in the following order: Staples, Parker's Early, Kansas, Bederwood, Prolific. Carrie gooseberries have exceeded other varieties in production.

BEE CULTURE IN CUT-OVER COUNTRY

The apiary work has been transferred from the poultry unit to the farm proper. The work was established late last season, so that only two colonies were obtained by increase. This season the five original colonies have yielded an increase of eight colonies and the policy for the rest of the season is to increase production rather than to increase the stock. A start has been made for more extensive work next summer.

LIVESTOCK

Investigations in swine-growing in northern latitudes.—The investigation of pork-production from farm-grown feeds is not sufficiently advanced for conclusive data. It will be continued. Self-feeding tests with Yorkshire pigs promise to be very important. Records of feed consumed are made and weights of pigs recorded at regular intervals. It is too early to draw conclusions. Sufficient to say that pigs fed from self-feeders are more thrifty than others of the same age.

POULTRY MANAGEMENT

A study of the comparative values of glass and muslin screening in poultry-house construction, covering three months, shows that the average temperature was lower for the muslin front than for the glass front at 7:00 a.m., 1:00 p.m., and 7:00 p.m. Data were taken from January 12 to March 31, inclusive. See the table.

AVERAGE TEMPERATURE

MONTH	7:00 a.m.		1:00 p.m.		7:00 p.m.	
	Glass	Muslin	Glass	Muslin	Glass	Muslin
January (22 days)	32.3	30.9	40.4	37.0	37.0	34.69
February (29 days) ..	32.96	31.44	44.1	39.6	38.8	36.48
March (31 days)	36.59	35.93	47.49	44.4	42.7	42.19

A study has been made of the comparative value of barley and milk versus corn and meat scrap, the former being produced on the farm and the latter purchased. A few peas were mixed with the barley. The appended table gives the results of the test.

NUMBER OF EGGS LAID

MONTH	Pen I Corn and meat scrap	Pen II Barley, milk, and peas
January (22 days)	102	87
February (29 days)	234	215
March (31 days)	140	197
Total	476	499

EXPERIMENTAL PROJECTS

Potato investigations.—A study of powdery scab of potatoes under various systems of management is being made in cooperation with the Division of Plant Pathology and Botany at University Farm. Tests with acid phosphate, wood ashes, manure, seed treatment with formaldehyde and corrosive sublimate, together with checking plots, make up the major part of the work. Another test was for the purpose of determining the action of the disease under different soils assembled in one place. Soils were sent in from Moorhead (Red River Valley type), Bemidji (sandy loam), Cloquet (Jack pine soil), Two Harbors (stiff red clay), University Farm (sandy loam). Only Moorhead and University Farm sent enough for a satisfactory test, but the poor quality of the seed, combined with the wet weather, caused the seed to decay and replanting was necessary.

Cost and efficiency of various methods of clearing land.—A bulletin has been submitted for publication covering the first part of the land-clearing investigations. The work of the current season will consist of gathering additional data on the value of returns from lands cleared under various systems as compared to those from stump land;

the value of forest byproducts as a credit against cost of clearing; and the comparative cost of contract and day labor.

The value of stump-land pasture in terms of beef and butterfat is being studied. This project is now broadened to cover three tracts: Tract I, five acres, cut off in October, 1913, now in the second year of test and maintaining four head of cattle; day pasture since June 1. Tract II, ten acres, cut off in October, 1914, and maintaining twelve head of cattle since June 10 on night pasture. Tract III, cut off in fall of 1914 and 1915, maintaining ten head of young stock. The data show gains of flesh and increased growth for the season made entirely from pasture grass.

Tile drainage.—A part of the drainage project has been completed and the data on cost will be complete as soon as the rest of the ditches are covered.

Phosphate fertilizer tests.—A tract of three series of eighteen plots, planned according to the outline followed at other stations where the Division of Soils is making these tests, is involved in the phosphate fertilizer tests. This is the first season. The work is only being started. The raw rock and acid fertilizers have been applied, but not the lime. Two of the series have been started in accordance with the rotation plan and the third will be started next spring. The lime will be applied this fall.

Variety tests of small grains and grasses.—Twenty-two varieties of corn, 6 of oats, 4 of barley, 4 of peas, 2 of flax, 3 one-hundred-rod rows of winter wheat, and 1 variety of rye are being tested. Work has been started with 2 varieties of bromus, and 3 varieties of rutabagas are under observation.

Reforestation.—An area of three acres, in detached portions, has been set with white pine and white spruce. This is a coöperative test to ascertain, some time in the future, the comparative value of the Station lands for forestry and farming purposes.

SOUTHEAST DEMONSTRATION FARM AND EXPERIMENT
STATION, WASECA

ANDREW BOSS, in Charge

THE FARM

The two-hundred-acre farm unit has undergone further development through the year. A little over a mile of tile drain was put in last year, part of it being laterals to the mains put in the year before, and part being a new main which drained the southwest corner of the farm. Additional tile is needed to drain the land completely and keep it under control so that crops may be raised on any part of the farm every year.

A good crop of oats was raised last year, also an excellent crop of hay, some of which was sold because of shortage of livestock to consume it on the farm. The corn crop froze last fall. No grain was harvested, but the entire crop was put in the silo and used as feed. Some spring wheat and flax were raised and a very good yield of potatoes was obtained.

During the fall and winter ten grade Shorthorn cows were purchased as a part of the foundation herd. It is the aim to add fifteen more as soon as they can be found, the object being to raise feeders which are to be fattened on farm-grown feeds. The cows will be milked by hand and the calves raised on skim milk. Two purebred Poland China brood sows were purchased, and have farrowed good litters. These will serve as the foundation for an increased herd of hogs. At present some grade Chester Whites are also kept, but these will be disposed of as soon as the Poland Chinas increase sufficiently in numbers.

The sheep have done well, yielding a good crop of wool and a considerable number of lambs. The present flock numbers 28 ewes.

The Central Station has generously contributed the use of a purebred Shorthorn sire and a purebred Shropshire ram. As soon as funds for the purpose are available, sires should be purchased which can be kept permanently at the Southeast farm.

THE EXPERIMENTAL UNIT

The only permanent work undertaken at the experimental unit consists of phosphate experiments conducted coöperatively with the Division of Soils at the Central Station. A good crop was harvested from most of these plots last fall and they have again been prepared and seeded as provided for in the rotation outline. Variety tests of the farm grains are also being conducted in coöperation with the Central Station. Some alfalfa has been grown and additional land is being seeded. Grimm seed was used, inoculation being secured through the pure culture obtained from the United States Department of Agriculture. The plot work on the experimental unit will be enlarged just as soon as the land can be brought under control and made comparable.

The apple trees set out last year seem thrifty and are growing well. Some small fruits and berries have also been planted and ornamental shrubs have been started. Owing to the loss of the corn crop last year no feeding experiments were undertaken. These will be resumed as soon as stock and feed supplies will permit.

COMMUNITY WORK

The people in the vicinity are learning to use the place. Numerous visitors are in evidence. The farmers' clubs from the surrounding

country meet at Institute Hall frequently and some large meetings have been held. Mr. Hoversten, the resident superintendent, is active in farmers' club work and contributes frequently to the programs of the clubs in the vicinity.

THE FRUIT-BREEDING FARM

CHARLES HARALSON, Superintendent

The Minnesota State Fruit-Breeding Farm was established principally for the purpose of breeding new varieties of fruit which are adapted to the climate and conditions in different parts of the state, and to obtain better commercial varieties of the various fruits grown in the state. Fruit-breeding is necessarily a long-time proposition, as it requires several years for many kinds of fruit to come into bearing so that the quality and yield of the fruit can be determined. Some of the earlier crosses are now beginning to show results, and several new varieties of small fruits have been produced which are being distributed for trial throughout the state. Since any judgment of the value of any of these new varieties must be based on several years' observations, it is difficult to give an exact review of the results of any single season's work, but the more general results of the season of 1915-16 may be briefly summarized as follows:

In general, it may be said that apples and plums yielded a very light crop. Grapes were injured by a late frost in May, and were a rather poor crop. Small fruits, such as strawberries and raspberries, gave a heavy yield of good fruit.

APPLES

A large amount of work is being done with apples in the hope of securing new varieties which will be well adapted to the needs of commercial orcharding in Minnesota. Seedlings have been planted by the thousand each year, for the purpose of selecting desirable varieties, or strains, from them when the trees come into full fruiting. Also, a large number of hybrids, or crosses, are made in the greenhouse each year, and a considerable number of these new cross-bred seedlings are planted. The final selections from these seedlings are to be based on both the hardiness of the trees, and the quality of the fruit which they produce. There is ample opportunity for selection of new varieties from so large a number of seedlings as are now on the place, but whether any new variety which is better than such standard sorts as the Wealthy will finally be found can only be determined by continued trials.

Some of the six thousand Malinda seedlings which were planted eight years ago have begun fruiting. The fruit shows a great varia-

tion in color, flavor, and keeping quality. There is also great variation in the date of ripening, some strains ripening as early as the Duchess, while others will keep until spring in good condition.

PLUMS

The hybridizing of our native plums, *Prunus Americana*, with *P. triflora*, has given good results, and several new strains resulting from this cross have been distributed to trial stations scattered over the state. It will take several years to obtain results from these trials for final conclusions as to the value of these new plums in different localities.

RASPBERRIES

Our London \times King No. 4 hybrid raspberry is proving to be one of the best commercial varieties for Minnesota. It is among the hardiest of varieties, produces the largest crops of berries of any of the sorts which are growing on the place, and the berries are very large, have a fine dark red color, and will stand shipping for long distances.

STRAWBERRIES

The Minnesota No. 3 strawberry is one of our additions to the list of small fruits which is being very extensively grown for commercial purposes in the berry-growing districts of the state. It is very hardy and productive and yields fruit of excellent quality.

OTHER FRUITS

Breeding work is being carried on with other fruits, including grapes, pears, cherries, peaches, apricots, gooseberries, and currants; but the results are not yet sufficiently definite to permit any other report at this time.