

The University of Minnesota

TWENTY-SIXTH ANNUAL  
REPORT OF THE  
AGRICULTURAL EXPERIMENT STATION

JULY 1, 1917

TO JUNE 30, 1918



UNIVERSITY FARM, ST. PAUL

LETTERS OF TRANSMITTAL

MINNEAPOLIS, MINN., NOVEMBER 12, 1918

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, 1918.

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

UNIVERSITY OF MINNESOTA  
MINNEAPOLIS, MINN., NOVEMBER 12, 1918

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, 1918.

Respectfully,  
MARION L. BURTON,  
President of the University of Minnesota

UNIVERSITY FARM, ST. PAUL, MINN., NOVEMBER 12, 1918  
Marion L. Burton,  
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, 1918.

Respectfully,  
R. W. THATCHER,  
Director

THE BOARD OF REGENTS

- The Hon. FRED B. SNYDER, Minneapolis. President of the Board. . . . 1922
- MARION LEROY BURTON, Minneapolis. . . . . *Ex Officio*  
The President of the University
- The Hon. J. A. A. BURNQUIST, St. Paul. . . . . *Ex Officio*  
The Governor of the State
- The Hon. C. G. SCHULZ, St. Paul. . . . . *Ex Officio*  
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. PIERCE BUTLER
- The Hon. C. G. SCHULZ
- The Hon. C. L. SOMMERS
- The Hon. MILTON M. WILLIAMS
- The Hon. C. W. GLOTFELTER
- The Hon. JOHN G. WILLIAMS
- President MARION LEROY BURTON

STATION STAFF

ADMINISTRATIVE OFFICERS

- R. W. THATCHER, M.A., Director
- ANDREW BOSS, Vice-Director
- A. D. WILSON, B.S. in Agr., Director of Agricultural Extension and Farmers' Institutes
- C. G. SELVIG, M.A., Superintendent, Northwest Substation, Crookston
- M. J. THOMPSON, M.S., Superintendent, Northeast Substation, Duluth
- O. I. BERGH, B.S. Agr., Superintendent, North Central Substation, Grand Rapids
- P. E. MILLER, B.S. Agr., Superintendent, West Central Substation, Morris
- CHARLES HARALSON, Superintendent, Fruit-Breeding Farm, Zumbra Heights (P. O. Excelsior)
- W. H. KENETY, M.S., Superintendent, Forest Experiment Station, Cloquet
- W. P. KIRKWOOD, B.A., Editor
- ALICE McFEELY, Assistant Editor of Bulletins
- HARRIET W. SEWALL, B.A., Librarian
- T. J. HORTON, Photographer
- R. M. WEST, B.S., Secretary

DIVISION OF AGRICULTURAL BIOCHEMISTRY

ROSS AIKEN GORTNER, Ph.D., Agricultural Biochemist

*Section of Biochemical Research*

ROSS AIKEN GORTNER, Ph.D., Agricultural Biochemist, in Charge

*Section of Plant Chemistry*

J. J. WILLAMAN, M.A., Assistant Agricultural Biochemist  
CLARENCE A. MORROW, Ph.D., Assistant Agricultural Biochemist

*Section of Cereal Technology*

C. H. BAILEY, M.S., Associate Agricultural Biochemist, in Charge  
CORNELIA KENNEDY, M.S., Assistant Agricultural Biochemist  
A. M. GURJAR, M.S., Assistant in Agricultural Biochemistry

*Section of Agricultural Analysis*

R. A. DUTCHER, M.S., Assistant Agricultural Biochemist, in Charge  
\*S. D. WILKINS, Special Analyst

DIVISION OF AGRICULTURAL ENGINEERING

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

DIVISION OF AGRONOMY AND FARM MANAGEMENT

ANDREW BOSS, Agriculturist

*Section of Coöperative Seed Production and Distribution*

†C. P. BULL, B.S., Associate Agronomist, in Charge  
\*A. D. HAEDECKE, Assistant in Agronomy

*Section of Farm Crops*

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

*Section of Plant Breeding*

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

*Section of Cost Accounting*

F. W. PECK, B.S., Assistant Agriculturist, in Charge

*Section of Farm Organization*

ANDREW BOSS, Agriculturist, in Charge  
L. B. BASSETT, Assistant Agriculturist, Farm Equipment  
†A. H. BENTON, M.S., Assistant Agriculturist, Farm Surveys

\* Appointed during the year.  
† Absent on leave  
‡ Resigned at end of year.

DIVISION OF ANIMAL HUSBANDRY

CARL W. GAY, B.S.A., D.V.M., Animal Husbandman

*Section of Horse Husbandry*

J. S. MONTGOMERY, B.S. in Agr., Assistant Animal Husbandman, in Charge

*Section of Beef Cattle and Sheep Husbandry*

T. G. PATERSON, B.S. in Agr., Assistant Animal Husbandman, in Charge

*Section of Swine Husbandry*

R. C. ASHBY, M.S., Assistant Animal Husbandman, in Charge

DIVISION OF ANIMAL NUTRITION

T. L. HAECKER, Animal Nutrition Investigator  
AGNES ERICSON, Assistant Chemist in Animal Nutrition  
VERNE C. CROWL, Analyst

DIVISION OF BEE CULTURE

\*FRANCIS JAGER, Apiculturist  
L. V. FRANCE, M.S. in Agr., Assistant Apiculturist

DIVISION OF DAIRY HUSBANDRY

H. H. KILDEE, M.S.A., Dairy Husbandman  
R. M. WASHBURN, M.S.A., Dairy Husbandman, Dairy Manufacture  
....., Assistant Dairy Husbandman, Dairy Stock and Production  
E. O. HANSON, Assistant Dairy Husbandman, Testing Laboratory

DIVISION OF ENTOMOLOGY AND ECONOMIC ZOOLOGY

W. A. RILEY, Ph.D., Entomologist and Parasitologist

*Section of Economic Vertebrate Zoology*

F. L. WASHBURN, M.A., Economic Zoologist, in Charge

*Section of Economic Entomology*

A. G. RUGGLES, M.A., Associate Entomologist, in Charge  
†R. N. CHAPMAN, Ph. D., Assistant Entomologist  
WARREN WILLIAMSON, M.A., Assistant in Entomology

*Section of Parasitology*

W. A. RILEY, Ph.D., Parasitologist, in Charge

*Section of Insecticidal Investigations*

WILLIAM MOORE, B.A., Associate Entomologist, in Charge  
S. A. GRAHAM, M.F., Assistant in Entomology  
ANNA WENTZ, M.S., Assistant in Entomology

DIVISION OF FORESTRY

E. G. CHEYNEY, B.A., Forester  
J. P. WENTLING, M.A., Associate Forester

\* Absent on leave.  
† Appointed during the year.

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

DIVISION OF HORTICULTURE

W. G. BRIERLEY, M.S. in Hort., Associate 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, Ph.D., Assistant in Horticulture

†JOHN N. BUSHNELL, 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

*Section of Plant Pathology*

\*E. C. STAKMAN, Ph.D., Associate Plant Pathologist, in Charge

F. JEAN MCINNES, B.S., Mycologist

G. R. BISBY, M.A., Assistant Plant Pathologist

\*F. J. PIEMEISEL, M.S., Research Assistant in Plant Pathology

G. R. HOERNER, B.S., Assistant in Plant Pathology

A. G. NEWHALL, B.S., Assistant in Plant Pathology

*Section of Seed Laboratory*

ROBERT C. DAHLBERG, B.S., Seed Analyst, Acting in Charge

RUBY URE, Assistant Seed Analyst

DIVISION OF POULTRY HUSBANDRY

A. C. SMITH, B.S., Poultry Husbandman

DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

\*W. W. CUMBERLAND, Ph.D., Assistant Agricultural Economist

†C. E. ROBBINS, Ph.D., Acting Assistant Agricultural Economist

FRANK ROBOTKA, A.B., Assistant in Marketing Investigations

DIVISION OF SOILS

F. J. ALWAY, Ph.D., Soils Chemist

C. O. ROST, M.A., Assistant Soils Chemist

P. R. McMILLER, M.S., Assistant Chemist in Soils

\*G. R. MCDOLE, M.A., Assistant in Soils

WM. SHAW, M.S., Assistant in Soils

\* Absent on leave.

† Temporary appointment.

DIVISION OF VETERINARY MEDICINE

C. P. FITCH, D.V.M., Animal Pathologist and Bacteriologist

*Section of Animal Pathology and Bacteriology*

C. P. FITCH, D.V.M., Animal Pathologist and Bacteriologist, in Charge

\*W. A. BILLINGS, D.V.M., Assistant Pathologist

*Section of Veterinary Biological Products*

H. C. H. KERNKAMP, D.V.M., Assistant Veterinarian, in Charge

*Section of Veterinary Medicine and Pathology*

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

*Section of Veterinary Physiology*

..... Assistant Veterinarian, in Charge

*Section of Veterinary Sanitation*

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

\* Appointed during the year

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## TWENTY-SIXTH ANNUAL REPORT AGRICULTURAL EXPERIMENT STATION

### FINANCIAL STATEMENT

THE MINNESOTA AGRICULTURAL EXPERIMENT STATION  
IN ACCOUNT WITH THE UNITED STATES  
APPROPRIATIONS 1917-1918

Dr.		
To receipts from the Treasurer of the United States in accordance with the appropriation for the fiscal year ending June 30, 1918, under the Act of Congress approved March 2, 1887.....	\$15,000.00	
Cr.		
By Salaries.....	\$15,000.00	
		\$15,000.00
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, 1918, under the Act of Congress approved March 16, 1906.....	\$15,000.00	
Cr.		
By Salaries.....	\$15,000.00	
		\$15,000.00
Total Adams Fund.....	\$15,000.00	\$15,000.00

FEDERAL FUNDS 1917-1918

	Nelson	Adams	Hatch	Smith-Lever	Smith-Hughes	Total
Agricultural Biochemistry	\$2,000.00	\$2,541.67	\$2,500.00			\$7,041.67
Agricultural Education	1,100.00					1,100.00
Agricultural Engineering	4,966.66					4,966.66
Agronomy and Farm Management	\$1,100.00		4,379.92			7,929.92
Dairy and Animal Husbandry	2,900.00	5,200.00	780.00			14,180.00
Entomology and Economic Zoology	400.00	1,150.00	277.76			1,827.76
Horticulture	2,800.00	2,250.00	900.00			5,950.00
Plant Pathology and Botany	1,000.00	1,350.00				3,350.00
Soils	1,500.00	2,200.00	300.00			4,000.00
Veterinary Medicine	1,000.00	308.33	1,682.32			2,990.65
School and College	3,358.34					3,358.34
Experiment Station	125.00		4,180.00			4,305.00
Agricultural Extension				\$49,719.31	\$6,811.57	56,530.88
Total	\$25,000.00	\$15,000.00	\$15,000.00	\$49,719.31	\$6,811.57	\$117,530.88

CLASSIFIED STATEMENT OF DISBURSEMENTS OF DEPARTMENT OF AGRICULTURE 1917-1918

	Substations	University Farm	Total
Salaries	\$54,207.77	\$340,887.56	\$395,095.33
Labor	44,025.33	94,928.57	138,953.90
Publications	1,130.15	7,405.04	8,535.19
Postage and stationery	3,758.27	18,751.60	22,509.87
Freight and express	1,547.23	2,767.11	4,314.34
Heat, light, water, and power	18,888.06	41,017.94	59,906.00
Chemicals and laboratory supplies	215.02	4,665.98	4,881.00
Seeds, plants, and sundries	2,971.17	11,942.44	14,913.61
Fertilizers		650.97	650.97
Feeding stuffs	23,604.43	36,527.57	60,132.00
Library	611.35	3,602.55	4,213.90
Tools, machinery, and appliances	9,984.33	6,480.43	16,464.76
Furniture and fixtures	2,587.47	6,479.31	9,066.78
Scientific apparatus		1,352.32	1,352.32
Livestock (including hogs for hog cholera work)	3,173.00	9,953.91	13,126.91
Traveling expenses	2,928.24	26,163.27	29,091.51
Contingent expenses	5,234.23	11,972.69	17,206.92
Buildings and lands (exclusive of special appropriations)	10,125.15	21,816.98	31,942.13
Totals	\$184,991.20	\$647,366.24	\$832,357.44

GENERAL SUMMARY OF DISBURSEMENTS FOR THE FISCAL YEAR 1917-1918

	General Support	Special	Federal	Total
Agricultural Biochemistry	\$10,268.35		\$7,041.67	\$17,310.02
Agricultural Education	9,474.59		1,100.00	10,574.59
Agricultural Engineering	18,601.65		4,966.66	23,568.31
Agronomy and Farm Management	33,442.98		7,929.92	41,372.90
Bee Keeping	6,634.87			6,634.87
Dairy and Animal Husbandry	85,788.90	\$12,988.97	14,180.00	112,957.87
Entomology and Economic Zoology	10,596.37		1,827.76	12,424.13
Home Economics	28,977.22			28,977.22
Horticulture	17,618.49		5,950.00	23,568.49
Plant Pathology and Botany	24,527.55		3,350.00	27,877.55
Research in Agricultural Economics	3,922.68			3,922.68
Soils	10,974.22	4,258.65	4,000.00	19,232.87
Veterinary Medicine	13,939.31	7,746.92	2,990.65	24,676.88
Forestry Investigation	19,900.34			19,900.34
Agricultural Extension		25,761.47	56,530.88	82,292.35
Library	11,696.03			11,696.03
Repairs to buildings	34,876.02			34,876.02
General School and College	74,502.05		3,358.34	77,860.39
General Station	24,026.97		4,305.00	28,331.97
Coal	39,310.76			39,310.76
Totals	\$479,079.35	\$50,756.01	\$117,530.88	\$647,366.24



DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1917-1918

	Fund	Total	School and College	Experiment Station	Extension
Administration.....	Support.....	\$18,373.06	\$13,779.80	\$4,593.26	
	Nelson.....	125.00	93.75	31.25	
	Hatch.....	3,000.00	2,250.00	750.00	
Short Courses.....	Support.....	8,870.35	8,870.35		
	General service.....	3,063.16	2,297.39	765.77	
Farm maintenance.....	Support.....	8,230.36		8,230.36	
	Hatch.....	1,180.00		1,180.00	
Registrar.....	Support.....	6,429.08	6,429.08		
Custodial.....	Support.....	24,852.93	18,639.70	6,213.23	
General School.....	Support.....	11,212.12	11,212.12		
Physical training.....	Support.....	5,691.87	5,691.87		
Publications.....	Support.....	5,069.22	844.87	4,224.35	
Rhetoric.....	Support.....	6,736.87	6,736.87		
	Nelson.....	1,700.00	1,700.00		
	Support.....	10,268.35	5,134.18	5,134.17	
Agricultural Biochemistry.....	Nelson.....	2,000.00	1,000.00	1,000.00	
	Adams.....	2,541.67	1,270.83	1,270.84	
	Hatch.....	2,500.00	1,250.00	1,250.00	
Agricultural Education.....	Support.....	9,474.59	9,474.59		
	Nelson.....	1,100.00	1,100.00		
Agricultural Engineering.....	Support.....	18,601.65	18,601.65		
	Nelson.....	4,966.66	4,966.66		
Agronomy and Farm Management.....	Support.....	33,442.98	16,721.49	16,721.49	
	Morrill.....	1,100.00	550.00	550.00	
	Nelson.....	2,450.00	1,225.00	1,225.00	
Bee Keeping.....	Hatch.....	4,379.92	2,189.96	2,189.96	
	Support.....	6,634.87	3,317.43	3,317.44	
Dairy and Animal Husbandry.....	Support.....	85,788.90	64,341.68	21,447.22	
	Morrill.....	2,900.00	2,175.00	725.00	
	Nelson.....	5,300.00	3,975.00	1,325.00	
	Adams.....	5,200.00	3,900.00	1,300.00	
	Hatch.....	780.00	585.00	195.00	
	Dairy extension.....	12,988.97			12,988.97
Entomology and Economic Zoology.....	Support.....	10,596.37	2,119.29	8,477.08	
	Nelson.....	400.00	80.00	320.00	

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DISTRIBUTION OF EXPENDITURES AMONG COLLEGE AND SCHOOL, EXPERIMENT STATION, AND EXTENSION FOR THE FISCAL YEAR 1917-1918  
—Continued—

	Fund	Total	School and College	Experiment Station	Extension
Home Economics.....	Adams.....	1,150.00	230.00	920.00	
	Hatch.....	277.76	55.56	222.20	
	Support.....	28,977.22	28,977.22		
Horticulture.....	Nelson.....	1,658.34	1,658.34		
	Support.....	17,618.49	8,809.24	8,809.25	
	Nelson.....	2,800.00	1,400.00	1,400.00	
Plant Pathology and Botany.....	Adams.....	2,250.00	1,125.00	1,125.00	
	Hatch.....	900.00	450.00	450.00	
	Support.....	24,527.55	9,811.02	14,716.53	
Research in Agricultural Economics.....	Morrill.....	1,000.00	400.00	600.00	
	Nelson.....	1,000.00	400.00	600.00	
	Adams.....	1,350.00	540.00	810.00	
Soils.....	Support.....	3,922.68	1,961.34	1,961.34	
	Support.....	10,974.22	5,487.11	5,487.11	
	Morrill.....	1,000.00	500.00	500.00	
Veterinary Medicine.....	Nelson.....	500.00	250.00	250.00	
	Adams.....	2,200.00	1,100.00	1,100.00	
	Hatch.....	300.00	150.00	150.00	
Forestry.....	Peat investigation.....	4,258.65		4,258.65	
	Support.....	13,939.31	6,969.65	6,969.66	
	Nelson.....	1,000.00	500.00	500.00	
Agricultural Extension.....	Adams.....	308.33	154.16	154.17	
	Hatch.....	1,682.32	841.16	841.16	
	Hog cholera investigation.....	7,746.92		7,746.92	
Library.....	Support.....	19,900.34	13,266.90	6,633.44	
	Agr. Extension.....	25,761.47			25,761.47
	Smith-Lever.....	49,719.31			49,719.31
Repairs.....	Smith-Hughes.....	6,811.57			6,811.57
	Support.....	11,696.03	8,772.03	2,924.00	
	Support.....	34,876.02	26,157.02	8,719.00	
Total University Farm.....	Coal.....	39,310.76	29,483.07	9,827.69	
		\$647,366.24	\$371,972.38	\$180,112.54	\$95,281.32

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RECEIPTS AND DISBURSEMENTS OF THE DEPARTMENT OF AGRICULTURE FOR THE  
FISCAL YEAR 1917-1918

University Farm		
Allotment for General Support budget.....	\$422,237.00	
Receipts credited to Support budgets.....	7,336.08	
Balance, General Support, Aug. 1, 1917.....	40,961.85	
Transfer from Hog Cholera Serum fund.....	9,800.00	
Transfer from Farm Book Store.....	500.00	
	<hr/>	\$480,834.93
Total Receipts, General Support.....		
Appropriations for Special funds budget.....	31,000.00	
Balance Aug. 1, 1917, Special funds.....	15,335.97	
Receipts from sales credited to Special funds.....	17,911.48	
	<hr/>	64,247.45
Total receipts, Special funds.....		
Allotment for Coal.....	39,310.76	
	<hr/>	39,310.76
Total receipts, Coal.....		
Receipts from Farm sales credited to General University.....	37,365.17	
Receipts from School and College fees credited to General University.....	28,828.02	
	<hr/>	66,193.19
Total Receipts to General University.....		
Receipts from United States Government.....	117,530.88	
	<hr/>	117,530.88
Total receipts from United States Government		
Expenditures, General Support.....	\$439,768.59	
Expenditures, Special funds.....	50,756.01	
Expenditures, Coal.....	39,310.76	
Expenditures, Receipts to General University.....	66,193.19	
Expenditures, Federal funds.....	117,530.88	
	<hr/>	713,559.43
Balance Aug. 1, 1918, Gen'l Support...	41,066.34	
Balance Aug. 1, 1918, Special funds...	13,491.44	
	<hr/>	\$768,117.21

Crookston

Appropriation for Maintenance.....	\$56,000.00	
Balance Aug. 1, 1917.....	2,625.94	
Receipts from Farm sales.....	12,332.54	
Receipts from fees.....	5,159.47	
Receipts from United States Government.....	600.00	
Expenditures, Maintenance.....	\$74,031.13	
Expenditures, Federal funds.....	600.00	
Balance, Aug. 1, 1918.....	2,086.82	
	<hr/>	\$76,717.95
		\$76,717.95

Morris

Appropriation for Maintenance.....	\$50,000.00	
Balance Aug. 1, 1917.....	2,003.09	
Receipts from Farm sales.....	7,633.44	
Receipts from School fees.....	3,993.63	
Receipts from United States Government.....	1,500.00	
Expenditures, Maintenance.....	\$56,199.71	
Expenditures, Federal funds.....	1,500.00	
Balance Aug. 1, 1918.....	7,430.45	
	<hr/>	\$65,130.16
		\$65,130.16

RECEIPTS AND DISBURSEMENTS OF THE DEPARTMENT OF AGRICULTURE FOR THE  
FISCAL YEAR 1917-1918—Continued

Grand Rapids

Appropriation for Maintenance.....		\$12,000.00
Balance Aug. 1, 1917.....		4,372.48
Receipts from Farm sales.....		12,201.37
Expenditures.....	\$24,158.17	
Balance Aug. 1, 1918.....	4,415.68	
	<hr/>	\$28,573.85
		\$28,573.85

Duluth

Appropriation for Maintenance.....		\$8,000.00
Balance Aug. 1, 1917.....		5,019.63
Receipts from Farm sales.....		4,249.00
Expenditures.....	\$11,655.55	
Balance Aug. 1, 1918.....	5,613.08	
	<hr/>	\$17,268.63
		\$17,268.63

Waseca

Appropriation for Maintenance.....		\$5,000.00
Balance Aug. 1, 1917.....		3,030.70
Receipts from Farm sales.....		5,115.02
Expenditures.....	\$9,759.49	
Balance Aug. 1, 1918.....	3,386.23	
	<hr/>	\$13,145.72
		\$13,145.72

Zumbra Heights

Appropriation for Maintenance.....		5,000.00
Balance Aug. 1, 1917.....		1,741.14
Receipts for Maintenance.....		944.24
Expenditures.....	7,087.15	
Balance, Aug. 1, 1918.....	598.23	
	<hr/>	7,685.38
		7,685.38

SPECIAL APPROPRIATIONS FOR BUILDINGS AND IMPROVEMENTS FOR BIENNium  
1917-1919

University Farm

Seed Storage and Cleaning House.....	\$15,000.00	
Extraordinary repairs.....	18,750.00	
Total.....	<hr/>	\$33,750.00

Morris

Dining-Hall and Assembly Room, Gymnasium....	60,000.00	
Total.....	<hr/>	60,000.00

Grand Rapids

Extraordinary repairs.....	6,000.00	
Total.....	<hr/>	6,000.00

Duluth

Extraordinary repairs.....	3,000.00	
Total.....	<hr/>	3,000.00

Waseca

Extraordinary repairs.....	3,500.00	
Total.....	<hr/>	3,500.00

Grand total, University Farm and Substations \$106,250.00

REVOLVING FUNDS FOR UNIVERSITY FARM AND SUBSTATIONS FOR THE FISCAL YEAR 1917-1918

	Univ. Farm Dining Hall	Univ. Farm Summer Session Dining Hall	Univ. Farm Book Store	Crookston Book Store	Morris Book Store	Univ. Farm Photo Lab.	Univ. Farm Dorm.	Univ. Farm Hospital	Univ. Farm Seed Cases	Crookston Dining Hall	Morris Dining Hall	Totals
Pay rolls.....	\$7,143.67	\$600.29	\$2,754.48			\$2,728.20	\$1,719.43	\$2,092.55	\$333.33	\$2,778.58	\$4,764.45	\$24,914.98
Photo supplies.....			3,974.48	\$142.83	\$107.20	1,319.22	12.85	10.05	17.63	50.92		1,319.22
Postage and stationery.....	141.03	2.99	94.49	9.16	19.77	0.48		1.00	2.99	118.80	356.32	4,500.77
Freight and express.....	27.68	20.00	1,616.22	37.04	3.00		3,000.00	8.50	136.75	3,331.00	2,675.19	630.69
Heat, light, water, and power.....	2,649.94	53.78	2,214.00	322.98		28.58			461.33		63.54	11,676.13
Drugs and sundries.....	619.61											3,191.63
Confectionery.....												2,536.98
Feeding stuffs.....	237.87											237.87
Provisions.....	28,666.53	570.95								8,552.76	8,551.31	46,341.55
Textbooks.....	11.15		4,217.24	157.23	584.83					0.25		4,970.45
Tools and machinery.....	11.48		35.45									47.18
Furniture and furnishings.....	411.43	178.31	952.50		85.00	7.55	1,143.80	210.48	30.75	365.88	104.67	3,490.37
Traveling expenses.....						38.69	279.30			636.42	427.39	4,663.29
Laundry.....	3,320.18						570.22			31.77		808.16
Repairs.....	199.98					6.19						225.00
Land rental.....	225.00											225.00
Refunds.....	3,035.62		98.16				303.02					3,746.57
Transferred to support.....			500.00									500.00
Total.....	\$46,701.17	\$1,426.32	\$16,457.02	\$669.24	\$799.80	\$4,169.70	\$7,037.12	\$2,495.01	\$521.45	\$16,327.71	\$17,234.99	\$113,839.53

	Credits
Dining Hall, University Farm.....	\$45,844.32
Dining Hall, Summer Session, University Farm.....	2,666.19
Book Store, University Farm.....	17,526.37
Book Store, Crookston.....	647.81
Book Store, Morris.....	551.57
Photo Laboratory, University Farm.....	3,135.50
Dormitories, University Farm.....	10,259.99
Hospital, University Farm.....	1,210.99
Total.....	\$118,115.84

	Credits
Seed Cases, University Farm.....	\$1,877.16
Dining Hall, Crookston.....	18,057.29
Dining Hall, Morris.....	16,338.65
Total Credits.....	\$118,115.84
Total Expenditures.....	113,839.53
Balance, August 1, 1918.....	\$4,276.31

## REPORT OF THE DIRECTOR

### CHANGES IN ORGANIZATION

The resignation of the former Dean and Director, A. F. Woods, at the close of the preceding academic year, and the appointment of myself as Dean of the Department of Agriculture and Director of the Experiment Station on August 1, 1917, resulted in a systematic review and crystallization into definite form of the administrative organization of the Department which had been developing during Dean Woods' term of office. This reorganization affects the administration of the Experiment Station in two ways: (1) The office of vice-director of the Experiment Station has been created in place of that of assistant director. (2) There has been a distinct change in the administration of the several divisions. In previous years there had been a marked tendency toward the organization of these divisions into smaller administrative units known as sections, with some member of the staff designated as "in charge" of each section, and with some one of the section heads either elected or appointed as chairman of the division. This experiment in democratic administration resulted in a considerable increase in the number of members of the staff who had administrative duties to perform, with more or less serious interruption of their research work; and in an undesirable decentralization of administrative responsibility for the business affairs of the divisions. Hence it was determined early in the year to modify this plan of organization of the divisions so that the sections will be regarded simply as convenient units of research men, for conference purposes, which may be changed from time to time to suit changing conditions without disturbing the formal organization of the division, and the administrative responsibility for each division will be centralized in a single person who shall have a permanent appointment as chief of the division. This organization has been put into effect in all of the divisions except that of Horticulture, for which a permanent chief has not yet been selected.

### CHANGES IN THE STAFF

Because of conditions resulting from the war, with its attendant changes in industrial and commercial employment, there have been numerous changes in the personnel of the staff during the year. Aside from changes in minor appointments, in the clerical force, and in graduate student assistants, the following changes in the staff should be noted.

*Administration.*—Following the resignation of former Director A. F. Woods, E. M. Freeman was Acting Dean and Director for the month of July, 1917. On August 1, R. W. Thatcher, formerly assistant director of the Station and chief of the Division of Agricultural Biochemistry, was made Dean of the Department of Agriculture of the University and Director of the Experiment Station.

*Agricultural Biochemistry.*—Following the appointment of the chief of this division as Dean and Director, R. A. Gortner who had been associate biochemist for the last year, was made agricultural biochemist and chief of the division. R. A. Dutcher and C. A. Morrow were appointed assistant agricultural biochemists, effective September 15. C. H. Bailey, who had been on leave of absence, returned to active service as cereal technologist on August 1; later in the year his title was changed to associate agricultural biochemist, and still later he was given leave of absence for four fifths time to engage in emergency war work. Geo. E. Holm and D. O. Spriestersbach resigned as research assistants to enter war service.

*Agricultural Economics.*—E. Dana Durand resigned as chief of the division. W. W. Cumberland was appointed assistant agricultural economist and later acting chief of the division, and in October was granted leave of absence for the remainder of the year in order to serve on a commission to study economic conditions in Mexico. C. E. Robbins, of the University Department of Economics, was acting chief of the division for the remainder of the year.

*Agricultural Engineering.*—J. T. Stewart, chief of the division, was on leave of absence in war service for the year. J. L. Mowry was acting chief until December 1, and I. D. Charlton, from January 15 until the end of the year.

*Agronomy and Farm Management.*—C. P. Bull was on leave of absence after March 1, for Red Cross work in Serbia. A. S. Merrill resigned as assistant in agronomy and was succeeded by August Haedecke. Carl Kurtzweil, B. C. Helmick, and G. A. Pond served as assistants in cereal breeding, crop production, and farm management investigations, respectively, from September 15 until the end of the academic year. R. J. Garber was appointed assistant agronomist. P. J. Olson resigned as assistant agronomist, effective at the end of the year. F. L. Kennard and O. M. Kiser resigned as agronomist and assistant agronomist at Crookston, and were succeeded by R. O. Westley and A. M. Christensen, respectively.

*Bee Keeping.*—Francis Jager, chief of the division, was on leave of absence from the beginning of the year until December 1, and from March 1 until the end of the year, for Red Cross relief work in Serbia.

*Dairy Husbandry.*—Earl Weaver was appointed assistant dairy husbandman, and L. V. Wilson, assistant in dairy production; but both resigned later in the year to enter military service.

*Entomology and Economic Zoology.*—C. W. Howard resigned as Associate Entomologist, October 15. On February 6, F. L. Washburn transferred from his position as entomologist and chairman of the division to that of economic zoologist; William A. Riley was appointed parasitologist and chief of the division; A. G. Ruggles was promoted from associate entomologist to entomologist (including the duties of state entomologist). S. Marcovitch resigned as assistant on September 1, and S. A. Graham was appointed to fill the vacancy. R. N. Chapman was appointed assistant entomologist, beginning April 1.

*Horticulture.*—W. D. Valteau, research assistant, was granted leave of absence on December 1, to enter military service, and John W. Bushnell was employed as a substitute to carry on the work. A. W. Aamodt and Ferdinand Krantz, who were employed as field assistants, resigned to enter war emergency work.

*Plant Pathology and Botany.*—In the Seed Laboratory, W. L. Oswald was given leave of absence to take up war emergency work, beginning September 1, and later in the year resigned to enter commercial work; R. C. Dahlberg was made acting head of the seed laboratory for the year. R. P. Ingram resigned as seed inspector, August 1, and Mrs. E. P. Harling resigned as assistant seed analyst and was succeeded by Ruby Ure. In Plant Pathology, J. G. Leach was appointed assistant beginning September 15. E. C. Stakman was granted leave of absence to take up war emergency work in the control of cereal rusts in the Mississippi Valley for the United States Department of Agriculture, beginning March 11.

*Soils.*—J. E. Chapman, Paul M. Harmer, E. G. Roth, and W. E. Shaw were each appointed as assistant in soils early in the year, but all except Mr. Shaw resigned within a few weeks to enter military service.

*Veterinary Medicine.*—C. C. Palmer resigned as assistant veterinarian, October 1. W. A. Billings was appointed assistant veterinarian, December 1. C. B. Lord was appointed assistant in veterinary medicine, November 1, but resigned later in the year to enter military service.

#### WAR TIME ACTIVITIES

The station staff, at a meeting held April 23, 1917, adopted the following resolutions:

"Whereas, the present and prospective food shortage demands both increased production of staple food crops and scientific utilization of these and of all possible substitutes for and amendments to them, in both of which lines of endeavor German men of agricultural

science have proved of invaluable assistance to their country in a similar crisis; and

"Whereas, the experience of England has shown that in time of war skilled scientists can render their greatest assistance in promoting industrial, agricultural, and business efficiency, and

"Whereas, the results of up-to-the-minute research in the preparation of munitions and engines of warfare and in meeting emergency needs for food, clothing, medicinal treatment, etc., has been demonstrated to be one of the most necessary elements in successful modern warfare, therefore be it

"Resolved, (1) that it is the sense of the Experiment Station staff that the highest usefulness of the University, in the present crisis, will be conserved by maintaining its research organizations at their highest possible efficiency.

"(2) That the Experiment Station staff pledges its members to renewed devotion to the advancement of the science of agricultural production and distribution and offers its services to the state and to the nation as a research agency for this purpose, and

"(3) That we believe that these ends will best be attained by the uninterrupted continuation of those projects of research which have for their immediate object the increased production or better utilization of agricultural products, and by the devotion of any time and effort which may become available by the discontinuance of other projects or by decreased instructional duties to advisory and extension work having for its object the assistance of farmers in putting the best known methods into actual practice."

In accordance with the spirit of these resolutions, experimental work on minor projects and subprojects which have no immediate bearing upon war conditions was temporarily discontinued in nearly all the divisions. In the case of such projects which are organized to continue for a period of several years, such observations were made and data collected as will make it possible to continue the project at the close of the war without serious loss of time and material. All available funds and investigators have been assigned to the problems having a direct bearing upon the production and conservation of agricultural products essential for the supplying of food to the Allied nations or the carrying on of the war. The progress which has been made on these and on the regular projects of the Station is discussed in detail in the reports of the several divisions, but it seems desirable to present here the following brief summary of the special war-time investigations of the different divisions, prepared by the secretary of the staff:

*Agricultural Biochemistry.*—Special investigations on sugar and cereal substitutes have been conducted. Chief among these are:

- Production of sugar beet syrup,
- Utilization of dried sugar beet pulp,
- Continuation of special features of the sorghum investigations,

Production and utilization of soy bean products,  
Substitution of potato flour,  
Experiments with frozen-potato flour, proving its superiority over flour made from unfrozen potatoes.

Special laboratory assistance has been given to the State Dairy and Food Commission in the enforcement of the feeding-stuffs law which has assumed particular importance at this time in helping to prevent adulteration of feeding stuffs with mill by-products of little or no feeding value.

The division has cooperated with the Division of Entomology and Economic Zoology in connection with the clothes louse problem, with chemical assistance and the manufacture of special compounds for the experiment.

Many analyses have been made, and the nutritional value of various food stuffs has been investigated for the Minnesota Federal Food Administration.

The analytical service for other divisions has been greatly increased in connection with their special war projects.

*Animal Husbandry.*—This division has cooperated with the Division of Dairy Husbandry in investigating the possibilities of the utilization of barley-, rye-, oat-, and corn-flour by-products for feed.

*Dairy Husbandry.*—In cooperation with the Division of Animal Husbandry, investigations have been conducted on the utilization of new cereal flour by-products as feed substitutes.

Special feeding experiments have been conducted to determine the value of ground leguminous hays as substitutes for wheat bran.

A demonstration project was started to determine the relative value of various milking machines with respect to their efficiency, labor replaceable value, quality of milk obtained, and other points.

*Entomology and Economic Zoology.*—A new investigation on the eradication of the clothes louse was conducted distinctly as a war project for the National Research Committee of the Council of National Defense.

Experiments in raising Belgian hares for meat were started.

Special efforts of the division were directed to projects dealing with the eradication of insects of primary economic importance.

*Forestry.*—In cooperation with the United States forest service the division has conducted investigational work on spruce production for aeroplane construction.

During the summer of 1918, in conjunction with the Division of Plant Pathology and Botany, extensive experiments were started with a view to control and eradication of white pine blister rust in the infected areas of the state, as a conservation measure.

*Plant Pathology and Botany.*—Special emphasis has been laid on the diseases of the cereal crops, particularly wheat, and on diseases of potatoes.

Particular attention has been paid to the investigational work on black stem rust of wheat and other small grains and to the improved treatment of seed grain and potatoes.

In coöperation with the plant disease survey office, Bureau of Plant Industry, United States Department of Agriculture, an effort has been made to discover new and serious losses in production.

Incidental to the barberry eradication campaign, a large amount of valuable field evidence on wheat rust has been collected.

The seed inspection work, altho not altered in character, has greatly increased in volume and importance as a conservation measure.

*Poultry Husbandry.*—Experiments were conducted to determine the value of back-yard poultry keeping as a factor in decreasing the cost of feeding poultry and increasing poultry products.

*Veterinary Medicine.*—The energies of the division have centered about the diagnosis and control of infectious diseases, as a war conservation measure.

*Northwest Substation.*—Wheat has been substituted for other cereals in rotation experiments in an effort to increase the wheat production in the northwestern part of the state.

*West Central Substation.*—Special stress has been laid on the wheat investigations conducted by the station, with a view to obtaining information as to optimum conditions for wheat culture in the west central part of the state in order to stimulate the movement for an increase in wheat acreage.

#### PUBLICATIONS

During the year, 37,552 copies of the Experiment Station bulletins and 133,778 copies of the Farmers' Library and Special bulletins were mailed out in response to special requests; and approximately fifty-two thousand Experiment Station bulletins and Reports, and one hundred six thousand Farmers' Library bulletins to addresses on mailing lists. The following new bulletins have been published:

##### EXPERIMENT STATION SERIES

Bulletin 169. Report of Cloquet Forest Experiment Station, by W. H. Kenety, Superintendent. 54 pp. 5,000 edition.

Bulletin 170. Crop Rotation Investigations, Field T Experiments, by A. C. Arny, Division of Agronomy and Farm Management. 56 pp. 10,000 edition.

Bulletin 171. Coöperative Stores in Minnesota, by E. Dana Durand and Frank Robotka. 32 pp. 5,000 edition.

Bulletin 172. A Farm Management Study in Southeastern Minnesota, by Andrew Boss and A. H. Benton, Division of Agronomy and Farm Management, and W. L. Cavert, Division of Agricultural Extension. 52 pp. 12,000 edition.

Bulletin 173. The Cost of Milk Production, by F. W. Peck and Andrew Boss, Division of Agronomy and Farm Management. 36 pp. 5,000 edition.

Bulletin 174. Ear Type Selection and Yield in Corn, by P. J. Olson, C. P. Bull, and H. K. Hayes, Division of Agronomy and Farm Management. 60 pp. 3,000 edition.

##### ANNUAL REPORT SERIES

Annual Report, West Central Substation, Morris, 1917, by P. E. Miller, Superintendent. 40 pp. 2,500 edition.

Annual Report, Northeast Substation, Duluth, 1917, by M. J. Thompson, Superintendent. 16 pp. 1,500 edition.

##### AGRICULTURAL EXTENSION SERIES

##### (MINNESOTA FARMERS' LIBRARY)

63. Milk: A Cheap Food, by Flora Rose. A reprint of Lesson III, Cornell Reading Course for the Farm Home. 8 pp. 75,000 edition.

64. Conservation Recipes and Suggestions, by the Division of Home Economics. 16 pp. 75,000 edition.

The following were reprinted:

11. Dressing and Curing Meats on the Farm, by W. H. Tomhave and D. A. Gaumnitz, formerly of the Division of Animal Husbandry. 16 pp. 25,000 edition.

16. Strawberries and Bush Fruits on the Farm, by LeRoy Cady, Division of Horticulture, and K. A. Kirkpatrick, Division of Agricultural Extension. 16 pp. 25,000 edition.

47. Clover, by A. C. Arny, Division of Agronomy and Farm Management. 16 pp. 25,000 edition.

##### SPECIAL SERIES

12. Farm Dairy Cheese, by R. M. Washburn, Division of Dairy Husbandry. 8 pp. 25,000 edition.

13. Storage of Root Crops on the Farm, by Markets Division of the State Committee of Food Production and Conservation. 8 pp. 25,000 edition.

14. Preparation of Perishables for Market, by Markets Division of the State Committee of Food Production and Conservation. 8 pp. 25,000 edition.

15. Textiles: What Every Woman Should Know, by Marion Weller, Division of Home Economics. 20 pp. 15,000 edition.

16. The Prevention of Smuts, by E. C. Stakman, Division of Plant Pathology and Botany. 16 pp. 25,000 edition.
17. Boys' and Girls' Clubs: The Bread-Making Contest, 1917-1918, by T. A. Erickson and Mrs. Margaret B. Baker, Division of Agricultural Extension. 16 pp. 15,000 edition.
18. Boys' and Girls' Clubs: The Sewing Project, by Miss Annie Shelland, State Supervisor of Rural Schools, and Mrs. Margaret B. Baker, Division of Agricultural Extension. 8 pp. 30,000 edition.
19. The Cost of Milk Production, by F. W. Peck and Andrew Boss, Division of Agronomy and Farm Management (Popular edition of Agricultural Experiment Station bulletin 173). 8 pp. 25,000 edition.
20. Food Conservation Programs for Meetings of Women of Farmers' Clubs, by Lucy Cordiner, Division of Agricultural Extension. 8 pp. 10,000 edition.
21. School and Home Gardening, by R. S. Mackintosh, Division of Agricultural Extension. 8 pp. 10,000 edition.
22. Grow Better Potatoes, by A. G. Tolaas, Division of Agricultural Extension, and G. R. Bisby, Division of Plant Pathology and Botany. 4 pp. 10,000 edition.
23. Experiments with Phosphate Fertilizers in Minnesota, by F. J. Alway, Division of Soils. 8 pp. 2,000 edition.
24. Boys' and Girls' Clubs: The Pig Club Project, by R. C. Ashby, Division of Animal Husbandry, and L. H. Fudge, Division of Agricultural Extension. 4 pp. 5,000 edition.
25. Clothing Conservation for Home and Community, by Marion Weller, Division of Home Economics. 4 pp. 10,000 edition.
26. The Common Barberry—an Enemy of Wheat, by E. M. Freeman, Division of Plant Pathology and Botany. 4 pp. 40,000 edition.
27. The Story of Black Stem Rust of Grain and the Barberry, by E. M. Freeman, Division of Plant Pathology and Botany. 8 pp. 10,000 edition.
28. Contagious Abortion of Cattle, by C. P. Fitch and W. L. Boyd, Division of Veterinary Medicine. 24 pp. 2,500 edition.
29. Garden and Small-Fruit Insects and Their Control, by A. G. Ruggles and S. A. Graham, Division of Entomology and Economic Zoology. 32 pp. 10,000 edition.

## MISCELLANEOUS

That Boy on the Farm and Not in School, by W. S. Sylvester, Associate Editor, Levang's Weekly. 20 pp. 10,000 edition.

## JOURNAL SERIES

Forty-eight manuscripts have been approved for publication in the Journal series during the year. Thirty-five of these have been published and fourteen have been accepted for publication and will be published within the next few months.

The following papers were approved for publication last year, but appeared in print during the current year.

No. 58. "The Adaptation of Truog's Method for the Determination of Carbon Dioxide to Plant Respiration Studies," by A. M. Gurjar. In *Plant World*, Vol. XX, No. 9 (September, 1917), pp. 288-293.

A description of apparatus and technique for the rapid and accurate estimation of carbon dioxide respired by plant material.

No. 61. "A Neglected Factor in the Use of Nicotine Sulphate as a Spray," by William Moore and S. A. Graham. In *Journal of Agricultural Research*, Vol. X, No. 1 (July 2, 1917), pp. 47-50.

The non-volatile character of nicotine sulphate has not usually been considered in recommending its use as a contact insecticide. Owing to this character of nicotine sulphate, plants intended for human use, such as lettuce, should never be sprayed with this material, but a free nicotine extract or fumigation should be used. To obtain maximum efficiency, nicotine sulphate should be rendered alkaline before using.

No. 62. "The Handling and Storage of Spring Wheat," by C. H. Bailey. In *Journal of the American Society of Agronomy*, Vol. IX, No. 6 (1917), pp. 275-281.

A discussion of difficulties which arise when bulk grain is stored. Spring wheat should contain not more than 14.5 to 15.5 per cent of moisture, otherwise it will be almost certain to heat. The various factors involved in the heating of stored grain are discussed.

No. 64. "Summary of Observations on 1,470 Hogs, Hyperimmune to Hog Cholera," by H. C. H. Kernkamp. In *Journal of the American Veterinary Medical Association*. Vol. LI, N. S. Vol. 4, No. 4 (July, 1917), 4 pp.

The "slow intravenous" method of hyperimmunization was used in the earlier part of the work but later the "intravenous" method was practiced exclusively. In the first method an interval of from 4 to 8 days was allowed between the first and second dose of virus to effect a condition of sufficient hyperimmunity, while in the intravenous method it is effected in one operation. The average weight per hog at time of hyperimmunization was 267.14 pounds and each hog received an injection of virus into the posterior auricular vein under a pressure of from 3 to 6 pounds per square inch and at the rate of 6.18 mils per pound of body weight. The average yield of serum (defibrinated whole blood) was 4,421.09 mils per hog.

No. 66. "Toxicity of Various Benzene Derivatives to Insects," by William Moore. In *Journal of Agricultural Research*, Vol. IX, No. 11 (June 11, 1917), pp. 371-381.

Data are presented showing the toxicity of certain organic compounds, mainly from the aromatic series, to insects, particularly the house fly, and the relationship of the toxicity of the vapors of these compounds to their boiling points.

No. 67. "Biologic Forms of *Puccinia graminis* on Cereals and Grasses," by E. C. Stakman and F. J. Piemeisel. In *Journal of Agricultural Research*, Vol. X, No. 9 (August 27, 1917), pp. 429-495.

The results of an extensive and detailed study of the biological specialization of *Puccinia graminis* on cereals and grasses, including differentiation on physiological and morphological grounds. The relation between the stem rust on wild grasses and the various cereals is shown. The results of preliminary work on the over-wintering in the uredinial stage are given and the importance of wild grasses in rust epidemics is discussed, especially in connection with the barberry.

No. 68. "Studies in Greenhouse Fumigation with Hydrocyanic Acid," by William Moore. In *Sixteenth Report, Minnesota State Entomologist* (1916), pp. 93-108.

A study of the factors, particularly temperature and moisture, influencing the degree of injury to plants during fumigation with HCN gas.

No. 70. "The Influence of Salt on the Changes Taking Place in Storage Butter," by R. M. Washburn and A. C. Dahlberg. In *Journal of Dairy Science*, Vol. 1, No. 2 (July 1917), pp. 114-126.

A study of the keeping qualities of salted compared with those of unsalted butter, under both storage and kitchen ice chest temperatures. At the temperature -10 degrees F. the unsalted butter deteriorated the least, while at +58 degrees F., the salted samples kept best.

No. 71. "Enzymes of Milk and Butter," by R. W. Thatcher and A. C. Dahlberg. In *Journal of Agricultural Research*, Vol. XI, No. 9 (November 26, 1917), pp. 437-450.

"Enzymes are present in butter in such small amounts and under such unfavorable conditions for enzyme activity during cold storage that they need not be considered as a factor in the determination of butter during storage."

No. 72. "The Effect of Different Rotation Systems and of Fertilizers on the Protein Content of Oats," by R. W. Thatcher and A. C. Army. In *Journal of the American Society of Agronomy*, Vol. 9, No. 7 (October, 1917), pp. 344-348.

There is "a definite correlation between the protein content of the oat grain and the fertilizer treatment. The plots receiving fertilizers which contain nitrogen invariably produce grain having a higher protein content than that from the plots which received any other treatment."

No. 73. "The Determination of Soil Phosphorus," by Clayton O. Rost. In *Soil Science*, Vol. IV, No. 4 (October, 1917), pp. 295-311.

A comparison of six methods for the determination of the total phosphorus content of soils, five of which had previously been in use, and a sixth which is a modification of the Washington method developed by the author.

No. 77. "Insect Transmission of Infectious Anemia of Horses," by C. W. Howard. In *Journal of Parasitology*, Vol. IV (December, 1917), pp. 70-79.

Evidence was secured showing that infectious anemia can be transmitted to horses by *Stomoxys calcitrans*. The experiments with Tabanidae resulted negatively, but were incomplete owing to scarcity of material. The author is not fully convinced that insects are the usual or only carriers of the disease.

No. 78. "Hibernation of the House Fly in Minnesota," by C. W. Howard. In *Journal of Economic Entomology*, Vol. 10, No. 5 (October, 1917), pp. 464-468.

An extended series of experiments proved that in this region the house fly winters as an adult.

No. 79. "Factors Affecting the Parasitism of *Ustilago zaeae*," by F. J. Piemeisel. In *Phytopathology*, Vol. VII, No. 4 (August 1917), pp. 294-307.

A study of the factors affecting the development of *Ustilago zaeae*, the fungus causing corn smut. The effect of temperature, dessication, and various chemicals on the fungus and a study of the conditions under which the plants are most susceptible. It was shown that the corn smut fungus was killed rather quickly in the silo.

The following papers were approved for publication and appeared in print during the year.

No. 80. "Experiments in Field Technic in Rod Row Tests," by H. K. Hayes and A. C. Army. In *Journal of Agricultural Research*, Vol. XI, No. 9 (Nov. 26, 1917), pp. 399-419.

Importance of determination of field technic in plot test studies emphasized. Results reported showed that there was some effect of competition between rod rows of different varieties of small grains when grown one foot apart.

Replication studies in rod row tests showed the value of this method in overcoming the effect of soil heterogeneity.

No. 81. "Comparative Analyses of Fibrin from Different Animals," by Ross Aiken Gortner and Alexander J. Wuertz. In *Journal of the American Chemical Society*, Vol. XXXIX, No. 10 (October, 1917), pp. 2239-2242.

Analyses of fibrins prepared from cattle, sheep, and swine blood show that these fibrins may be used interchangeably in protein investigations where Van Slyke's method of analysis is used.

No. 83. "The White-Pine Weevil and Its Relation to Second-Growth White Pine," by S. A. Graham. In *Journal of Forestry* (February, 1918), pp. 192-202.

A report on the life history and habits of the white pine weevil (*Pissodes strobi*, Peck) and recommendations for its control in forest plantings.

No. 84. "On the Origin of the Humin Formed by the Acid Hydrolysis of Proteins: III. Hydrolysis in the Presence of Aldehydes. II. Hydrolysis in the Presence of Formaldehyde," by Ross Aiken



Gortner and George E. Holm. In *Journal of the American Chemical Society*; Vol. XXXIX, No. 11 (November, 1917), pp. 2477-2501.

A contribution to the study of the constitution and analysis of the proteins. The paper can not be abstracted briefly.

No. 85. "The Color Classification of Wheat," by H. K. Hayes, C. H. Bailey, A. C. Army, and P. J. Olson. In *Journal of the American Society of Agronomy*, Vol. 9, No. 6 (1917), pp. 281-284.

Pointed out that confusion which has arisen in regard to color classification is probably due to the use of a single term to describe visual effect of pigment in the bran layer and physical condition of endosperm cells. Method outlined for separate classification under the two heads, pigmentation and physical condition or density.

No. 86. "The Nitrogen Distribution in Protalbinic and Lysalbinic Acids," by Cornelia Kennedy and Ross Aiken Gortner. In *Journal of the American Chemical Society*, Vol. XXXIX, No. 12 (December, 1917), pp. 2734-2736.

These products, prepared from egg albumen, gave a nitrogen distribution very similar to that of the original egg albumen. In all probability they have a relatively high molecular weight.

No. 87. "The Effect of Prolonged Acid Hydrolysis upon the Nitrogen Distribution of Fibrin with Especial Reference to the Ammonia Fraction," by Ross Aiken Gortner and George E. Holm. In *Journal of the American Chemical Society*, Vol. XXXIX, No. 12 (December, 1917), pp. 2736-2745.

A contribution to the study of methods of protein analysis. The nitrogen distribution changes markedly with increasing length of hydrolysis, the ammonia fraction increasing at the expense of the mono-amino acids.

No. 88. "Toxicity of Volatile Organic Compounds to Insect Eggs," by William Moore and S. A. Graham. In *Journal of Agricultural Research*, Vol. XII, No. 9 (March 4, 1918), pp. 579-587.

In general, compounds with high boiling point and slight volatility are more effective in dipping and spraying insect eggs than compounds with low boiling point and high volatility. Compounds with a low boiling point kill freshly laid eggs more readily than eggs in which the embryo is partially or fully developed. Compounds of higher boiling points are more toxic to eggs with fully developed embryos than to freshly laid eggs.

No. 89. "The Duchess Apple Improved," by M. J. Dorsey. In *Journal of Heredity*, Vol. VIII, No. 12 (December, 1917), pp. 565-567.

A description of what appears to be a bud sport from the Duchess apple. Comparison is made with Duchess, which is presumed to be the parent variety. The sport differs from the parent variety primarily in deeper color.

No. 90. "The Catalase Activity of American Wheat Flours," by C. H. Bailey. In *Journal of Biological Chemistry*, Vol. XXXII, No. 3 (December, 1917), pp. 539-545.

Low-grade flours have a much greater catalase content than have high-grade flours. Measurement of this factor will assist in ascertaining the grade of an unknown sample of flour.

No. 91. "Fertilization of Queen Bees," by C. W. Howard and L. V. France. In *Journal of Economic Entomology*, Vol. XI, No. 2 (1918), pp. 265-267.

In addition to a successful experiment already reported upon (Science, Nov. 13, 1914), three partially successful artificial fertilizations were obtained out of a total of sixty-three attempts. The results do not indicate that it is practicable to control the mating of queen bees by the method used.

No. 92. "Some Studies of the Tuberculin Test," by M. H. Reynolds. In *Journal of the American Veterinary Association* (April, 1918), New Series Vol. 6, No. 1. 15 pages.

A study of tuberculin test records of herds under continuous observation and test for many years. The facts brought out were the following: That a simultaneous or combination test is more accurate than either test alone; that a recognized test should be condemned only after thoro trial; the desirability of simultaneous or some equivalent form of testing in the case of very bad herds, very valuable animals, or any conditions under which extreme accuracy is desirable; the value of carefully made clinical observations and herd history; that warnings in the form of low reactions are too frequently overlooked; that any tuberculin test should be considered as merely an aid in diagnosis and not the diagnosis; the unwisdom of generosity in diagnosis with valuable animals; that we must not condemn all cattle that show 106.0 on temperature test or pass all that stay below 103.0.

No. 93. "A Study of the Toxicity of Kerosene," by William Moore and S. A. Graham. In *Journal of Economic Entomology*, Vol. XI, No. 1 (1918), pp. 70-75.

There is great variation in toxicity of the different types of kerosene to both insects and plants. Altho an imperfect emulsion might result in injury to plants, it may be entirely due to the type of kerosene used. Since kerosenes of the same brand vary from time to time in their physical characteristics and chemical composition, the results from their use are always uncertain. Kerosenes valuable as insecticides and of comparatively slight toxicity to plants can be manufactured, but such products should be required to pass an insecticidal test.

No. 94. "Sterility in the Strawberry," by W. D. Valleau. In *Journal of Agricultural Research*, Vol. XII, No. 10 (March 11, 1918), pp. 613-670.

A study of the flower types in the strawberry shows a correlation between flower position, flower part number, and size of fruit. In the dioecious forms the pistillate plants bear staminodia and the staminate plants bear pistils which appear to be normal but rarely set fruit. This pistil condition explains nubbins. The pollen condition shows that most cultivated varieties produce large amounts of aborted pollen and that abortion takes place subsequent to liberation of the microspore from the tetrad. The interpretation is that chromosome combinations are important factors in this arrested pollen development.

No. 95. "The Preservation of Plant Juices for Analysis of Sugar Content," by D. O. Spriestersbach. In *Journal of the American Chemical Society*, Vol. XL, No. 2 (February, 1918), pp. 431-436.

The description of a method by which plant juices can be preserved for future analysis of their sugar content, thus enabling the analyst to prepare more samples in a "rush" season than can be analyzed at once and holding a part over for a "slack" season.

No. 96. "The 'Rawness' of Sub-Soils," by F. J. Alway. In *Science*, n. s., Vol. XLVII, No. 1208 (February 22, 1918), pp. 196-198.

A critical analysis of the prevailing views upon the productivity of sub-soils in comparison with the corresponding surface soils.

No. 97. "Respiration of Stored Wheat," by C. H. Bailey and A. M. Gurjar. In *Journal of Agricultural Research*, Vol. XII, No. 11 (March 18, 1918), pp. 685-713.

A study of the factors involved in the deterioration of stored grain through heating. This paper contains information of importance to everyone who stores grain for any considerable period of time. The paper does not lend itself to brief abstracting.

No. 98. "Determination of Lime and Phosphoric Acid in Peat Soils: Comparison of Jonkoping with Bremen Method," by Clayton O. Rost and Franklin C. Clapp. In *Soil Science*, Vol. V, No. 3 (March, 1918), pp. 213-218.

A comparison of the two common methods for the determination of lime and phosphoric acid in peat soils and a study of the causes of the differences in values obtained.

No. 99. "The Occurrence of *Puccinia graminis tritici-compacti* in the Southern United States," by E. C. Stakman and G. R. Hoerner. In *Phytopathology*, Vol. VIII, No. 4 (April, 1918), pp. 141-149.

The discovery that *Puccinia graminis tritici-compacti* is the common stem rust form in the southern United States and gives some hope of using wheats known to be resistant to this form in the Gulf states. The fact that the *tritici-compacti* form does not attack the varieties of wheat grown in the spring-wheat region makes it less likely that the rust blows from south to north annually. It also explains the apparent variability in resistance of certain varieties of wheat when grown in different sections of the country.

No. 100. "Normal Self-Fertilization in Corn," by H. K. Hayes. In *Journal of the American Society of Agronomy*, Vol. X, No. 3 (1918), pp. 123-126.

An experiment to determine the amount and importance of normal self-fertilization in corn. Results of tests showed that over 95 per cent was cross-pollinated. Reduction in vigor, due to use of seed artificially self-fertilized for one year, averaged about 50 per cent.

No. 101. "Natural Cross-Pollination in Wheat," by H. K. Hayes. In *Journal of the American Society of Agronomy*, Vol. X, No. 3 (1918), pp. 120-122.

The results reported indicated that conditions in 1915 and 1916 were either very favorable for natural crossing in wheat or that its occurrence is much more frequent than has been formerly considered to be the case.

No. 101a. "Case Report: Sterility," by W. L. Boyd. In *The Cornell Veterinarian*, Vol. VIII, No. 1 (January, 1918), pp. 50-51.

The proper treatment applied to a purebred Holstein cow affected with nymphomania and sterile gave good results and the animal became pregnant. This experience also showed that the milk secretion actually increased during the period of treatment.

No. 102. "The Results of an Experiment to Note the Effects of Freezing on Anti Hog Cholera Serum," by H. C. H. Kernkamp. In *The Cornell Veterinarian*, Vol. VIII, No. 1 (January, 1918), pp. 7-9.

Anti hog cholera serum often becomes frozen during the winter months in this state, especially while in transit, and the recipient doubts the potency of the serum under such conditions. Experiments were instituted along this line and serum was allowed to remain frozen for 48 and 72 hours. It was then thawed and injected into susceptible pigs. Another lot of serum was frozen then thawed and frozen intermittently and later injected into susceptible pigs. From the results obtained it would seem that the freezing of anti hog cholera serum does not destroy its immunizing properties or render it unfit for use.

No. 103. "The Nutrition of the Honey Bee," by R. Adams Dutcher. In the *American Bee Journal*, Vol. LVIII, No. 3 (March, 1918), pp. 92-93; and No. 4 (April, 1918), p. 129.

A summary of the existing knowledge of the nutrition of the honey bee and plans for future work.

No. 104. "Relation of Size of Sample to Kernel Percentage Determinations in Oats," by R. J. Garber and A. C. Army. In *Journal of the American Society of Agronomy*, Vol. X, No. 3 (March, 1918), pp. 134-142.

The importance of securing representative samples in making percentage of kernel determinations in oats is emphasized. The indications are that 200 grains taken as they come (rejecting only the broken kernels), from a thoroly mixed sample of a pound or more, gives a sufficiently accurate determination for all ordinary purposes.

No. 105. "Methods of Control of the Clothes Louse (*Pediculus humanus, vestimentis*)," by William Moore. In *The Journal of Laboratory and Clinical Medicine*, Vol. III, No. 5 (February, 1918), 8 pages.

An examination of the sachet powder and fumigation methods of controlling the clothes louse.

No. 106. "Self-Balanced Rations By Individual Pigs," by R. C. Ashby. In *Proceedings of the American Society of Animal Production*, 1916 (December, 1917), pp. 197-209.

A study of the rations of ten pigs, fed from individual self-feeders during a period of 128 days. Includes weekly records of weights and rations; composition of individual rations by three-week periods and total; quantities of

feed eaten daily; grain consumed for 100 pounds gain; the nutritive ratios by weeks and a comparison of these with established feeding standards.

No. 107. "Investigations with Growing Steers," by T. L. Haecker. In *Proceedings of the American Society of Animal Production, 1916* (December, 1917), pp. 169-173.

A report of the feeding of 196 beef-bred calves from 100 to 400 pounds in weight and the chemical analysis of 67 that were slaughtered at different weights, with the object of obtaining more definite information concerning the changes that take place in the composition of the body per 100 pounds gain in weight. The bodies were divided into their respective tissue parts and the weights of waste and of the several parts of 5 calves at the weights of 100 and 400 pounds, also the composition of the separate parts at these weights and the changes in components of steers in growing from 100 to 400 pounds normal live weight, were presented in tabulated form.

No. 108. "On the Hydration Capacity of Gluten from Strong and Weak Flours," by Ross Aiken Gortner and E. H. Doherty. In *Journal of Agricultural Research*, Vol. XIII, No. 8 (May 20, 1918), pp. 389-418.

A study of the colloidal properties of wheat gluten as related to the problem of flour strength. "There is an inherent difference in the glutens from strong and weak flours.—The difference is apparently that between a nearly perfect colloidal gel with highly pronounced physico-chemical properties, such as pertain to emulsoids, and that of a colloidal gel in which these properties are much less marked. It is suggested that such difference may be due to the size of the gluten particles and that at least a part of the particles comprising a weak gluten may lie nearer the boundary between the colloidal and crystalloidal states of matter than is the case with the stronger glutens."

No. 109. "Case Report: Parturient Paresis," by C. P. Fitch and W. L. Boyd. In *The Cornell Veterinarian*, Vol. VIII, No. 1 (January 1918), pp. 51-52.

A case of parturient paresis, or milk fever, is described which responded to air treatment but had a relapse and died. It indicated that if an animal does not remain cured after the first use of the air, a relapse is likely to be fatal.

No. 110. "Case Report: Johne's Disease," by C. P. Fitch and W. L. Boyd. In *The Cornell Veterinarian*, Vol. VIII, No. 1 (January 1918), pp. 5-54.

Johne's disease is not uncommon among the dairy breeds of cattle in this country. Three cases of this infection are described among the beef breeds i.e., in a pure Shorthorn, an Angus, and a Hereford. It is possible that Johne's disease is more common than we believe among beef cattle.

No. 111. "An Optical Method for the Determination of Malic and Tartaric Acids in the Same Solutions," by J. J. Willaman. In *Journal of the American Chemical Society*, Vol. XL, No. 4 (April, 1918), pp. 693-704.

A description of a method by which these acids can be quantitatively determined when occurring together in plant juices.

No. 112. "Physical Properties Governing the Efficacy of Contact Insecticides," by William Moore and S. A. Graham. In *Journal of*

*Agricultural Research*, Vol. XIII, No. 11 (June 10, 1918), pp. 523-538.

The general results reported in this paper indicate that the physical characteristics as well as the chemical properties have an important bearing on the efficiency of contact insecticides. Even tho the spray may contain a very active poison, it will not be effective unless it conforms to certain physical requirements—that is, the ability to vaporize and penetrate in that form or to spread over the insect and penetrate in the liquid form.

No. 122a. "Measures for Protecting Wheat Flour Substitutes from Insects," by Royal N. Chapman. In *Science*, n. s. Vol. XLVII, No. 1224 (June 14, 1918), pp. 579-581.

Outline of a simple method of heat sterilization which will destroy insect pests without injury to the cereal. A wax standardized to melt at 82 to 85 degrees C. is recommended as a heat indicator.

No. 123. "The Specific Conductivity of Water Extracts of Wheat Flour," by C. H. Bailey. In *Science*, n. s., Vol. XLVII, No. 1226 (June 28, 1918), pp. 645-647.

A preliminary study of the electrical conductivity of aqueous extracts from wheat flour. The electrical conductivity parallels the ash figures fairly closely and it is suggested that this method may be of value in determining the grade of an unknown flour.

#### NEEDS OF THE CENTRAL STATION

The Central station is still in urgent need of research laboratory space. The erection of a seed house for the Division of Agronomy and Farm Management gives storage space for seed stocks and space for field laboratory work. Additional research laboratory space would add materially to the equipment of the division. The laboratory space for the divisions of Agricultural Biochemistry and Soils is altogether inadequate and should be increased as soon as possible. Horticulture and Forestry are still housed in the same building and the work of each division is seriously limited by inadequate laboratory space. Equipment and space should be provided the Division of Animal Husbandry for feeding experiments with cattle and sheep and for demonstrating good methods of feeding. If this could be provided on a separate farm devoted to Animal Husbandry and within easy reach of University Farm it would give much better conditions for the work. Assistants are needed in many branches of the work. The loss of men through entry into army service has been large and it is difficult to secure men with adequate training for research work. The relief given by the employment of graduate students has been largely cut off, as most of these men have entered some branch of the war service.

The funds for the maintenance of experiment station work will need to be substantially increased during the next year on account of the high price of labor and increased cost of equipment and supplies.

There should be a more complete separation of men for experiment station work. In the past the demand for instructors in college and school work has drawn heavily at times on the experiment station staff. The output of research work would be greatly increased by limiting the time that workers employed in experiment station work are allowed to give for the instructional work.

The demands of the times are bringing many problems in agriculture and it is believed that investigational work should be stimulated and increased rather than curtailed.

## WORK OF THE DIVISIONS

### DIVISION OF AGRICULTURAL BIOCHEMISTRY

ROSS AIKEN GORTNER, Chief

Marked progress was made on a part of the research projects during the last year, while certain others were allowed to remain practically dormant. It is probable that this condition will persist until after the war.

Present war conditions affect the division in two ways: (1) Some of the most active research workers have left to take up various phases of war work, and it has been impossible to replace them, with the result that the research momentum of the division has slowed down. (2) The activity of those who remain is undoubtedly affected by the disturbed world conditions, so that maximum effort on research problems not directly concerned with winning the war is impossible.

Work on two projects was completed during the year and two new ones were inaugurated.

The progress on the various projects may be summarized as follows:

*Cereal and flour investigations.* Subproject: *Wheat storage investigations.*—The work reported last year has been continued. Additional data have been obtained regarding the respiration of wheat stored under different conditions. Some comparisons have also been secured with cereals other than wheat.

*Coöperative wheat investigations.* Subproject: *Influence of environment on the composition and milling quality of wheat.*—Work on this project was not actively pushed this year. Thirty-three samples of wheat receiving different fertilizer treatments were submitted to proximate analyses and the data filed for future use.

*The "strength" of wheat flour.* Subproject: *Colloidal factors which may be involved in flour strength.*—The studies of the gluten colloids have been continued during the year and one paper has been published. The results to date indicate that the physical state of the gluten is of paramount importance and that the colloidal properties of a gluten

from a "weak" flour are markedly inferior to those possessed by a "strong" flour. When gluten from a weak flour was immersed in different concentrations of certain acids, it was found to have a lower maximum imbibition capacity than had gluten from a strong flour, that is, it passed from a gel to a sol at a lower degree of imbibition. The weak gluten likewise had a much lower rate of imbibition. These facts would seem to point toward the possibility that the colloid particles comprising the weak gluten are on the average nearer the hypothetical boundary line which separates matter in the crystalloidal state from matter in the colloidal state than are the particles forming the structure of the strong gluten.

Imbibition studies have been started in which the gluten was replaced by wheat grain (or other cereals). Some extremely interesting data have been accumulated, but as yet no basis for their interpretation has been found. It would appear that the maximum imbibition capacity for a seed is reached in distilled water and that this optimum swelling persists with only minor variations throughout a range of acidity up to  $N_2HCl$ . In other words, a grain does not give an imbibition curve, while the protein isolated from the grain does.

Subproject: *Other factors which may be involved in flour strength.*—The work on the diastatic enzymes of flour was completed and it is expected that the results will be published during the coming year. The most notable result of this work is the factor of adsorption of the enzyme by the wheat proteins. The adsorption so markedly affects the analytical results that the natural question arises: *How far can we trust existing enzyme data derived from experiments in which no precautions were taken to preclude enzyme adsorption?*

A preliminary study was made of the specific electrical conductivity of aqueous extracts of flours differing in baking quality. In general it was found that the specific electrical conductivity of the flour extract gives valuable information as to the baking quality of the flour.

*The cider- and vinegar-making quality of Minnesota apples.*—Three samples of vinegar supplied by the Division of Horticulture and one sample sent in by a citizen of the state at the request of Prof. Brierley were analyzed during the year. All analytical data have been communicated to the Division of Horticulture. This completes the project in so far as this division is concerned.

*Investigation of proposed official methods of analysis.*—Determinations of organic phosphorus in samples of corn grits and wheat shorts were made by Rather's iron chloride titration method. No other samples were received this year from the Association of Official Agricultural Chemists.

*The biochemistry of resistance to disease in plants. General.*—(a) The subproject, *Investigation as to the physiological effect of hydrocyanic acid upon plants* was completed and published. The study included the mode of entrance of the gas into the plant, conditions which favored or hindered its entrance, the cause of the "burning" of the foliage, the disturbance of enzyme equilibrium in the tissues due to the presence of the poison, and the stimulus to growth and reproduction due to light fumigations with HCN. While this investigation is not directly concerned with plant diseases, it has furnished valuable information regarding certain features of cell activity.

(b) Subproject: *Fundamental nutrition of Sclerotinia spp.* A thoro study is being made of the source of carbon and of nitrogen, the mineral requirements, the optimum reaction of the medium, the effect of tannin and of inorganic and organic poisons, the possibility of the necessity for "auximones" or "vitamines," and the effect of the nutrition on the end products and on the composition of the mycelium of the fungus. Considerable progress has been made to date on the source of carbon and the reaction of the medium. Oxalic and citric acids have been proved to be frequent products of the growth of the fungus. The character of the medium determines the amount of the acids present.

(c) Quantitative methods for organic acids. Early in these investigations it was found necessary to have better methods for the determination of the organic acids found in plants and produced by fungus growth. A method for determining citric acid was reported a year ago. This year saw the completion of a method for the quantitative determination of malic and tartaric acids.

Subproject: *The enzymes of Sclerotinia cinerea.*—Work has been started on the enzymes which may equip this fungus for a parasitic life. The most pronounced one so far found is pectase, which precipitates out calcium pectate.

Subproject: *The biochemistry of resistance to cereal rust.*—Work was actively in progress on this phase of the investigation until May 1, 1918. Further attempts to grow *Puccinia graminis* in the absence of living host cells have been made but with only negative results. The hydrogen ion concentration and specific electrical conductivity of the juices from both resistant and susceptible wheats under different fertilizer treatments were determined. The hydrogen ion concentration was remarkably uniform and the results to date make it appear extremely improbable that hydrogen ion concentration *per se* is involved in the phenomena of resistance. The specific electrical conductivity of the juice paralleled rather closely the ash content.

Some experiments were made on the germination and growth of spores of *Fusarium lini* in sterile juices from resistant and non-resis-

tant flax plants. The fungus apparently germinates less readily and grows less vigorously in the juices of resistant varieties. More extensive experiments are, however, necessary before final conclusions can be drawn.

Subproject: *Photosynthesis and translocation in different parts of normal and rust-infected plants.*—No progress was made on this phase of the work this year.

*Analytical Service.*—Subproject: *Analyses and tests of flour for State Board of Control.*—Sixty samples of flour sent in by manufacturers and by the bakers at the several state institutions were tested and the results reported to the board and used by them as a basis for awarding contracts or payment for flour purchases.

Subproject: *Tests of wheat for State Board of Grain Appeals.*—Twenty-three wheat samples were tested and the results reported to the board.

Subproject: *Chemical composition of silage crops.*—Sixty samples have been submitted for analysis by the Section of Farm Crops of the Division of Agronomy and Farm Management. Owing to lack of analytical assistance, all of the analyses are not yet completed but it is expected that they will be completed before the current year's crops are ready for analysis.

Subproject: *Chemical composition of root crops.*—Sixteen samples of root crops were submitted by the Section of Farm Crops, Division of Agronomy and Farm Management. These analyses are not completed as yet.

Subproject: *Tests of quality of strains of wheat from plant-breeding nursery.*—Milling and baking tests were made on 47 samples submitted by the Section of Plant Breeding and results reported to that section.

Subproject: *Tests of quality of varieties of wheat grown by Section of Field Crops.*—Sixty-two samples of wheat were subjected to milling and baking tests for the Section of Farm Crops. In addition, 67 samples were analyzed for total protein content.

Subproject: *Tests of quality of disease-resisting hybrid wheats.*—A total of 76 determinations of the moisture content of cereals was made for the Division of Plant Pathology and Botany, and reported to that division.

Subproject: *Analyses of corn for selection of high-protein and low-protein strains.*—Protein analyses in duplicate of 300 samples of corn from individual ears were made for the Section of Plant Breeding of the Division of Agronomy and Farm Management.

Subproject: *Tests of the quality of varieties of oats grown by the Section of Field Crops, Division of Agronomy and Farm Management.*—Twenty-four samples of oats were analyzed for the Section of Field Crops.

Subproject: *Feed analyses for the Division of Animal Industry.*—A total of 126 analytical determinations has been made for the Section of Swine Husbandry, Division of Animal Husbandry.

Subproject: *Analyses and tests for the Food Administration.*—Eight or ten samples have been received from the State Food Administration requesting information regarding their composition. Such samples have included flour, bread, and canned goods. Reports have been made showing that no poisons or ground glass could be found.

Subproject: *Miscellaneous analyses.*—Miscellaneous analyses, including foods, pencils (for poisons), poisoned cereals, formaldehyde, waters, canned goods (for ground glass), and feeds, have been made, in all about two hundred. About the same number of letters have been written answering questions and giving advice and help where it was possible to do so. A considerable part of this work was made necessary by the war hysteria regarding poison, glass, and other foreign substances in food.

*Fruit storage investigations.*—The only progress made on this project relates to the utilization of frozen potatoes or potato culls in the manufacture of potato flour. Recent investigations in plant physiology have demonstrated the ease and completeness with which moisture can be expressed from frozen vegetable tissues and this method was applied to frozen potatoes. It was found that approximately twice as much moisture could be expressed from frozen potatoes as from those which were not frozen and that the quality of the potato flour prepared from the frozen potatoes was superior in every respect to that prepared from unfrozen potatoes. This information has been given to the public in the hope that some utilization may be made of the enormous quantity of potatoes which are frozen in transit.

*The biochemical reactions of the proteins.*—Rapid progress was made on this project during the earlier part of the year. As was reported last year, special attention has been paid to the interaction of the hydrolytic products of proteins and aldehydes. Substantial progress has been made on the study as to the mechanism of humin formation.

Certain of the derived proteins produced by the action of alkali on egg albumen have been prepared and studied. These substances (the protalbinic and lysalbinic acids of Paal) were found not to differ materially in amino acid content from the original egg albumen. They are recommended by German colloid chemists as being especially potent when used as "protective" colloids, but we have found that the protective action as determined by the "Gold number" is no greater than that of gum arabic and only one tenth that of gelatin.

A study as to the effect of time on the acid hydrolysis of a protein showed that deamination takes place much more readily than has

been supposed and that nearly 20 per cent of the ammonia nitrogen obtained in a 24-hour hydrolysis of fibrin results from such deamination. It was further shown that the hexone bases are not readily deaminized and that accurate figures for these amino acids may be obtained after a 6-weeks' hydrolysis, while under these same conditions the ammonia nitrogen had increased almost 150 per cent.

Inasmuch as fibrin is an excellent source of protein for comparative analyses, it was thought advisable to see whether or not the fibrins from different animals were identical in chemical composition. Fibrins from cattle, sheep, and hogs gave similar analytical figures by Van Slyke's method of analysis.

An investigation is in progress on the forms of nitrogen remaining in the so-called "Protein free milk" used by Osborne and Mendel in their nutrition studies. The work to date indicates that conjugated amino acids are present. The demonstration of such a fact would be extremely important from a nutritional standpoint.

*Chemical studies of pollen.*—The only advance in this project has been to collect several kilograms more of corn pollen and to dry and bottle it for future use. Some of this pollen has been utilized on Project 24, "A Study of the Nutrition of the Honey Bee."

*Dry sugar-beet powder and its possible utilization in Minnesota to partly replace refined sugar.*—Approximately seven hundred and fifty pounds of sugar beets were donated by the Chaska Sugar Company for the experiment. These were pared, washed, sliced, and dried, and the dried product ground to a coarse powder. Analyses of this powder showed a sucrose content of approximately sixty per cent and a raffinose content of approximately eight and one half per cent. Nearly fifty pounds of this material were turned over to the Division of Home Economics for experimentation. In addition about a gallon and a half of sugar-beet syrup was prepared by the method outlined by Townsend and Gore in Farmers' Bulletin No. 823.<sup>1</sup> This syrup had an excellent flavor and a portion was turned over to the Division of Home Economics for testing.

The sugar-beet powder was used by the Division of Home Economics in making different types of products carrying sufficiently high seasoning to veil the flavor of the beet. In no case was it possible to secure a palatable product if no other sweetening than powdered beets was used. In cases where the proportion of liquid used was small, it was impossible even to mix the product.

A small amount of work done with the sugar-beet syrup indicated that it might prove to be a very satisfactory means of sweetening. This closes the project. We believe that it has been sufficiently

<sup>1</sup>Townsend, C. O., and Gore, H. C. Sugar-beet sirup. U. S. Dept. of Agr. Farmers' Bull. 823. 1917

demonstrated that sugar-beet powder can not replace cane sugar excepting in certain limited instances, while sugar-beet syrup can be used to much better advantage.

*A study of the nutrition of the honey bee.*—Experimental colonies have been fed various mixtures of food materials. The Division of Bee Culture will report upon the condition of these colonies.

An experimental colony was fed corn pollen, under greenhouse conditions, during the winter, and samples of bee bread, larval food, and royal jelly were obtained in small quantities on which some chemical work has been done. The work will be continued during the summer.

In connection with the proposed study of the antineuritic properties of honey in the curing of polyneuritis, it has become necessary to investigate the physiological action of "vitamines." A study has therefore been made of the catalase content of the organs and tissues of normal pigeons, polyneuritic pigeons, and polyneuritic pigeons which have received vitamine (water soluble B). This work indicates that oxidative activity of the tissues is lowered in polyneuritis and that the effect of vitamine is to stimulate, in some way, the greater production of oxidizing enzymes with the probable oxidation of toxic waste materials which have accumulated in the tissues.

#### DIVISION OF AGRONOMY AND FARM MANAGEMENT SECTION OF COÖPERATIVE SEED PRODUCTION AND DISTRIBUTION

The work of the section of coöperative seed production and distribution was somewhat interrupted the latter part of the year by the granting of a leave of absence to C. P. Bull to enter upon Serbian relief work. The projects covering wild rice investigations and the sorghum investigations were laid aside for the year on this account.

The beet seed production project was maintained and coöperative relations were established with the Minnesota Sugar Company, of Chaska. Different types of mother beets selected from the fodder beets at University Farm were planted in three different fields. Some roots were stored at Chaska also, and one and one half acres of seed planted for seed production in the spring of 1918. Twenty-five pounds of sugar beet seed of analyzed mother beets were secured from South Dakota. Some of this seed was planted at Chaska for stecklings. Three plots were planted at University Farm also for stecklings. Variety tests were also undertaken at Chaska to determine the yield and sugar content. The outlook for the production of sugar beet seed this season is promising in spite of the fact that some of the beets failed to grow on account of poor winter storage. Special attention will be given when the crop is matured to harvesting desir-

able mother beets and to storing the stecklings for still further increase of seed production next year.

Coöperative work in testing and improving seeds has been continued with farmers. Work was continued at the Nickerson trial station and a survey of Victor township was made to determine as nearly as possible the varieties of grain and corn and the acreage of these crops with a view to learning the value of this method of studying the seed crop needs.

A total of 985 bushels of cereals, corn, flax, peas, and soy beans has been sold to farmers, and a small amount of seed has been distributed for experimental purposes. Seed has also been furnished for use at University Farm. The reports gathered on last year's distribution indicate that the demand for improved seeds is growing and there is considerable interest in the work. It is hoped that the work of this section can be expanded during the next year and arrangements made through coöperation with the Minnesota Crop Improvement Association for the certification of pure seeds.

#### SECTION OF FARM CROPS

*Investigations with small grains.*—In the tests of acclimated vs. imported seed oats, nothing was undertaken during the year on account of pressure of other work. Tests covering the value of different grades of seed oats were continued and a good crop secured. Data for the four-year period are ready for tabulation. In the comparison of primary, secondary, and double oat kernels for seed the results indicate that double oats are as valuable for seed purposes as primaries. No difference was found in the value of the seed crop from secondary and primary kernels. Secondary kernel oats averaged 5.9 per cent higher in value than primary kernels. Wild oats was found to be considerably lower in percentage of kernels than cultivated oats.

Studies were continued with different grades of seed wheat. Good yields were obtained from the plots used in studying the method of preparation and rate of seeding for wheat and oats. The tests indicate that 64 pounds of good seed oats per acre will give quite as satisfactory yields as any larger amount up to 112 pounds per acre. Listed winter wheat yielded three bushels more than that sown in the ordinary manner. The best yields of winter wheat were secured from seed sown September 1, with that sown on September 8 ranking next in order, and with continually decreasing yields coming from the later seedings up to October 10, which yielded only 25.6 bushels. Ninety pounds of winter wheat seed per acre gave better yields than any other amount from 75 to 105 pounds per acre.

Work was continued with the grain mixture tests and the variety trials as in previous years. Marquis wheat proved to be the highest yielder of the wheats in the plot tests. One of the new hybrids, Mindum, gave very promising yields and seems to have sufficient merit to warrant its increase and wide distribution. Victory oats introduced from Canada proved to be the best yielding oats in the variety test. Minnesota No. 184 barley, which is a selection from the Manchuria, or No. 105 type, gave the best yield of the barley variety tests. Studies made of the reliability of methods indicate that accurate yields of small field-plot tests can be secured only when at least two of the side border rows and the ends are removed, calculating the yield only from the returns from the inside portion of the plot. The results of this study have been prepared as a journal article.

A study of the size of seed as related to the yield of wheat was continued and correlation tables made.

*Forage crop investigations.*—Studies of all subprojects were continued. Comparisons were made of the distance apart to plant corn and soy beans and the stage of maturity to cut for silage purposes. Dry matter content and the determinations of the nutrients contained have not yet been made, therefore the yields for the different seeds can not be given.

The studies of alfalfa seeding were continued and three good cuttings were secured from each of the experimental plots. In tests of various seedings of grasses and legumes, medium red clover; mixtures of medium red clover and timothy; and timothy, medium red clover, and alsike clover gave the heaviest yields per acre in most of the seedings. A large tonnage was secured also from mixtures of meadow fescue and medium red and alsike clover.

*Crop rotation investigations.*—Very few changes were made in the plans for Field C and Field T rotations. All plots were cropped regularly and produced yields not greatly at variance with former yields for the systems of cropping followed. The results of the first six years of rotation work on field T have been compiled and published.<sup>2</sup>

#### SECTION OF PLANT BREEDING

*Investigations in cereal breeding.*—Two years' results of the rod-row tests show that some crosses and selections have been produced that are of considerable economic importance. An extensive test is being made of several pedigreed selections of Durum wheat both at this station and in coöperation with three of the substations. Pedit-

greed sorts produced at North Dakota and South Dakota Stations are being tested in comparison with two University Farm pure lines. In the winter wheat work, several of the nursery types are proving of considerable value. It is likely that the best of these will be increased and offered for distribution among farmers in the near future.

Studies were made of cross selections of lodging and non-lodging strains of oats, wheat, and barley. Data will be taken in the near future to determine whether there is any relation between easily determined structural characters of the stem and ability to withstand lodging in the field. A study is being made also of the relation between various physiological characters in hardness of winter wheat. Recent compilations seem to indicate that no positive results have been obtained as yet.

Studies in coöperation with the Sections of Farm Crops and Plant Breeding of the division have been continued.

The coöperative barley work with the United States Department of Agriculture has given results of promise. Several of the smooth-awned selections have given favorable results and some of these are being tested in the rod-row plots at the various substations and in the field plots at University Farm. They appear to be very promising varieties and will have considerable economic value.

Studies of individual plant data have been made of three crosses between resistant and nonresistant wheats. This work is in coöperation with the Division of Plant Pathology and Botany, the effort being to discover varieties of wheat that will be resistant to rust.

*Breeding of miscellaneous field crops.*—All of these plants that lived over the winter of 1917-1918 which had been previously selected by the correlated individual plant data, have been propagated by cuttings. Several cuttings of each of these have been made.

Owing to the severe winter of 1917-1918, a greater part of the timothy nursery was winter-killed. This project can not, therefore, be continued unless new seed is obtained.

The better millet selections have been continuously grown in the nursery and are being tested in comparison with commercial sorts in coöperation with the section of farm crops. A test is also being made of the amount of natural cross-pollination of millet.

A few of the more promising flax selections are being tested in rod rows, and plans have been made to cross a large-seeded flax with one of the better yielding selections, in an attempt to produce a high yielding large-seeded variety.

New introductions of soybeans from the forage crop investigation office of the United States Department of Agriculture were tested. None of these proved of any promise and at the present time no soybean breeding work is being done.

<sup>2</sup> Arny, A. C. Crop rotation investigations: Field T. experiments. Minn. Agr. Exp. Sta. Bull. 170. 1917.



*Corn-breeding investigations.*—The studies of the inheritance of a mosaic pericarp pattern in the color of maize have been continued through the year.

The results of the studies of high protein content in corn seem to show that a high protein strain can be immediately isolated by self-fertilization. A further investigation is being carried on to determine whether a cross between two high protein strains will give a desirable yield as well as high protein.

The season was unfavorable for corn production. Crosses did not yield very much more than the parents. A determination was made of the amount of normal self-fertilization in corn.

In spite of the unfavorable season, enough seed was saved of the Rustler White Dent corn to start the selection experiments under this project. This work is undertaken to determine the best method of selecting seed corn for farm use.

#### SECTION OF COST ACCOUNTING

*Cost of producing dairy products.*—A study of the cost of producing milk was made during the year in cooperation with eight cow-testing associations. Most of the field work has been done and the tabulations from a part of the testing associations have been compiled. The data give very good information on the factors of cost in producing milk in various sections of the state and have proved useful in arriving at a determination of a fair price for milk.

*Experience survey of northern Minnesota.*—Data were obtained from settlers during the year and the material has been tabulated and summarized. Some interesting information has been obtained regarding the development of farms in the cut-over regions of northern Minnesota. The importance of outside work and of the use of livestock in farm development under such conditions is strongly brought out.

*Cost of producing farm products.*—The statistical routes were discontinued during the year, and the rest of the year was spent in summarizing the results. The tabulations so far made indicate that the cost of production of the various farm products has materially increased during the last two years and that figures given in the earlier publications of this station will have to be revised to cover present conditions.

The five-year cooperative project with the Office of Farm Management of the United States Department of Agriculture closed on April 1, 1918. The data obtained are being summarized and tabulated in order that a comparison may be made between this form of reporting and the statistical route method in our studies of the cost of producing farm crops in Minnesota.

Considerable information has been obtained on the cost of producing apples and strawberries through a survey study in cooperation with the Division of Horticulture. This work will be continued and expanded if the field is found a profitable one for investigation.

#### SECTION OF FARM ORGANIZATION

*Farm tenancy and leases.*—A considerable amount of data has been secured concerning tenancy. Studies have been made through a farm management survey of leases and the equity of landlord and tenant in various forms of agricultural production.

*Comparison of fence posts.*—The studies of the comparative value and life of fence posts of various kinds are continued with observations taken at stated times.

*Land-clearing investigations.*—Some investigations in land clearing have been undertaken in cooperation with the North Central Experiment Station, at Grand Rapids. These investigations cover the comparative expense of removing stumps from cut-over land by blasting out, by blasting and pulling, and by pulling alone.

#### DIVISION OF ANIMAL HUSBANDRY

CARL W. GAY, Chief

The animal husbandry investigations have been confined to the projects of the Section of Swine Husbandry, which are reported somewhat in detail.

#### SECTION OF SWINE HUSBANDRY

*Investigations in swine production.*—Two definite lines of study present themselves. One deals solely with the production of pork for market, and the other includes the growth and development of breeding swine.

*Pasture and forage crops for pork production.*—Six groups of pigs were fed; two on alfalfa pasture; three on rape; and one on oats, peas, and rape. The results from four lots are summarized as follows:

Ration	Area actually pastured	Pigs per acre	Daily gain per pig	Weights per pig		Total gain per acre	Days on pasture
				Initial	Final		
	Acres		Lbs.	Lbs.	Lbs.	Lbs.	
Alfalfa 3 per cent corn.....	0.31	25.4	0.53	34.5	107.1	1,470.0	137
Alfalfa 4 per cent corn.....	0.30	33.3	0.66	32.1	123.6	2,438.4	137
Rape 4 per cent corn.....	0.50	30.0	0.74	31.1	93.4	1,868.6	84
Rape self-fed (corn tankage) ..	0.50	30.0	1.10	30.6	123.2	2,778.0	84

The grain required for 100 pounds gain was respectively 331.18 pounds, 343.05 pounds, 319.6 pounds, and 328.61 pounds. Charging corn at \$1.68 per bushel, tankage at \$100 per ton, and pasture at \$10 per acre, the *feed cost alone* of 100 pounds gain was in the same order: \$10.62, \$10.71, \$10.13, and \$10.60.

By contrast, it is interesting to note the unsatisfactory results from ten pigs on oats, peas, and rape, the pigs becoming severely rape-blistered at the start. In 98 days they gained only 821 pounds per acre of pasture, or 0.35 pound daily per pig, at a feed cost of \$11.11 for 100 pounds gain produced.

*Feeding tests with fall pigs.*—Ten lots of fall pigs were fed from weaning to market. The results from seven lots show:

Lot	Number of pigs	Days fed	Ration	Daily gain per pig	Grain for 100 lbs. gain	Pork per 56 lbs. of grain fed
1	10	105	Self-fed Shelled corn Corn mill feed Corn gluten feed Shorts Tankage	Lbs. 1.38	Lbs. 463.28	Lbs. 12.08
2	10	105	Self-fed Corn mill feed Corn gluten feed Shorts Tankage	1.14	470.11	11.91
3	10	105	Self-fed Corn mill feed Shorts Tankage	1.18	449.37	12.46
4	10	105	Self-fed Corn mill feed Shorts Tankage Condemned raisins	1.25	473.08	11.83
5	10	155	Self-fed Corn mill feed Shorts Tankage	0.90	446.73	12.53
6	10	155	Self-fed Corn mill feed Shorts Tankage Alfalfa hay	1.14	448.78	12.47
7	10	155	Hand fed Dietrich standard	0.96	434.16	12.89

*Coöperative work.*—Excellent results were secured despite the very limited time and funds available for the prosecution of this project. All but one of these tests were carried on in Renville County. The following is a summarized report of the results of the tests.

PASTURE TESTS  
(1)

Test number	Number of pigs	Days fed	Pasture	Total grain fed	Total gain	Feed cost per 100 lbs. gain
1	63	72	Rye; rape (poor)	Lbs. 4,566.0	Lbs. 738	\$14.10
2	33	86	Clover (good)	10,670.0	2,644	10.70
3	121	86	Mixed	47,711.5	8,549	12.82
4	116	76	Alfalfa (good)	17,846.0	3,949	12.53

PASTURE TESTS—Continued  
(2)

Test number	Weight per pig		Gain per pig		Grain fed daily per lb. of gain	Grain for 1 lb. gain	Per-centage corn in ration	Margin per pig*
	Initial	Final	Daily	Total				
1	Lbs. 47.16	Lbs. 58.80	Lbs. 0.154	Lbs. 11.72	Lbs. 0.84	Lbs. 5.46	..	\$0.22
2	56.21	136.33	1.00	80.12	4.03	4.03	58	4.26
3	34.27	105.8	0.82	71.53	4.59	5.58	28	2.26
4	38.3	77.0	0.47	38.7	....	4.52	52	1.25

\* Margin is difference between total feed cost and value of gains at 16 cents. Feeds charged: Corn \$1.50 per bushel; barley \$1.50; oats 50 cents; tankage \$90 per ton; buttermilk 3 cents per gallon; pasture 50 cents per pig per month, except in test No. 1, where it was \$5 per acre.

TESTS OF "HOGGING-OFF" CORN

Owner	Acres fed	Number of hogs	Gain per acre	Supplements per acre	Net return per acre of corn*
Jung	30.0	120	Lbs. 459.2	Lbs. 490.0 (bran, shorts) ...	\$64.35
Cheney	27.0	113	403.3	94.4 tankage	60.28
Hulbert	5.85	49	391.0	0.0	62.56
Pfeiffer	39.77	260†	535.3	50.3 tankage	83.38
Busian	6.8	130	611.7	4.7 bbls. buttermilk	90.82

\* Supplements at market price (\$90-tankage, 3-cent buttermilk) deducted from value of gains at 16 cents per pound.

† Included 19 old sows and 15 suckling pigs.

*Hogging-off corn.*—To secure a rotation and to combat noxious weeds, part of the ground must be planted annually to cultivated crops. Corn has been grown and hogged-off, four plots being thus used last year. The size of plots available, one acre being the largest, makes it difficult to obtain accurate results. Either very few hogs must be used or they can be fed but a short time. Last season all lots were left on the corn at least a day too long. A daily shrinkage of three pounds per head occurred frequently when hogs remained in the field after the corn was largely consumed. Results from two lots follow:

Lot	Acres	Yield per acre	Hogs per acre	Gain per acre	Grain per 100 lbs. gain	Tankage fed per acre	Pork per 56 lbs. grain fed
104*	1.0	Bu. 57.14	25	Lbs. 315.0	Lbs. 1,052.0	Lbs. 114	Lbs. 5.32
106	0.75	51.09	24	582.6	582.6	76	8.38

\* Lot 104 remained at least two days too long.

*Studies with individual pigs.*—In continuation of this project sixteen purebred pigs were fed through the summer of 1917; four litters were represented by four pigs each. Half of each litter was self-fed and half fed by hand, similar feed-stuffs used throughout. Average initial and final weights per pig were 63.61 and 147.84 pounds. For the sixteen pigs, the mean grain consumption for 100 pounds gain was 364.96 pounds.

Pig No. 10 required 461.57 pounds of grain, an excess of 96.61 pounds as compared with the mean, or 26.47 per cent. Pig No. 11

(of the same litter) required only 308.81 pounds of grain, a saving of 56.15 pounds, or 15.38 per cent, as compared with the mean. In comparison with the average grain requirements for the entire number, the litter averages are as follows:

Litter	Average grain for 100 lbs. gain	Variation from average	Per cent
	Lbs.	Lbs.	
1.....	365.826	+ 0.864	0.236
2 (pigs 10 and 11).....	371.571	+ 6.609	1.81
3.....	336.031	-28.931	7.927
4.....	385.49	+20.53	5.625

Comparing the individuals with the mean, the variations appear as follows:

Litter	Pig number	Grain for 100 lbs. gain	Variation from average	
			Lbs.	Per cent
1.....	2	332.96	-32.0	8.768
	3	396.15	+31.19	8.546
	5	394.40	+29.44	8.066
	6	327.81	-37.15	10.17
2.....	7	367.91	+ 2.95	0.808
	8	335.39	-29.57	8.102
	10	461.57	+96.61	26.471
	11	308.81	-56.15	15.385
3.....	2	309.78	-55.18	15.119
	3	394.5	+29.54	8.093
	6	321.42	-43.54	11.931
	8	315.89	-49.07	13.445
4.....	13	442.83	+77.87	21.336
	14	451.73	+86.77	23.775
	15	309.93	-55.03	15.079
	16	362.25	- 2.71	0.742
Average, 16 pigs.....	..	364.96	.....	.....

A tabulation shows the individuals grouped as follows:

Variation exceeding 20 per cent—3 pigs.

Variation between 15 and 20 per cent—3 pigs.

Variation between 10 and 15 per cent—3 pigs.

Variation between 5 and 10 per cent—5 pigs.

Variation less than 5 per cent—2 pigs.

Nine pigs fed in 1915 had average initial and final weights of 47.42 pounds and 267.33 pounds per head, and compared as follows:

Litter	Pig number	Grain for 100 lbs. gain	Variation from average	
			Lbs.*	Per cent
1.....	1	402.04	+ 7.24	0.183
	2	380.21	-14.59	3.695
	4	376.71	-18.09	4.582
	6	423.04	+28.24	7.152
	7	404.38	+ 9.58	2.426
2.....	10	430.76	+35.96	9.108
	12	397.99	+ 3.19	0.808
	13	395.6	+ 0.80	0.202
	14	355.31	-39.49	10.002
Average, 9 pigs.....	..	394.8	.....	.....

It is seen that, compared with the mean grain required per unit of gain, the variations may be grouped as follows:

1 exceeding 10 per cent.

2 exceeding 5 per cent.

6 less than 5 per cent.

While only preliminary work has as yet been done, results indicate the possibility of securing definite and practical results.

*Swine-breeding studies.*—The variations observed in tests with individual pigs have suggested the possibility of utilizing this factor to practical advantage through selective matings. Three of the females from the 1917 groups now have litters while three others have been bred.

We are interested in economical production. Is it possible to select in such a way as successfully to isolate a strain that is pure in respect to economical utilization of feed, that is homozygous for this character? The selection of breeding swine has been on a phenotypic basis. Can it be brought to a genotypic basis, with respect to this quality of maximum economy in feed utilization?

#### DIVISION OF ANIMAL NUTRITION

T. L. HAECKER, Chief

Group VIII, the dairy-bred steers that were placed in the experiment on May 22, 1916, and from which one has been slaughtered for analysis at weights of 404, 603, 810, 905, and 1,093 pounds, respectively, will be fed to 1,300 pounds, which they should attain by mid-summer, after which data on the eight groups will be compiled, tabulated, and prepared for publication.

#### DIVISION OF BEE CULTURE

FRANCIS JAGER, Chief

*Queen raising.*—Nearly five hundred queen bees were raised from pure Italian breeding queens for the improvement of the bee stock in the state. Of these, more than four hundred were sent by mail to all parts of the state, the demand as usual exceeding the supply. Instructions for requeening accompany the queens.

*Observation hives.*—One normal colony of bees was kept on scales outside all year; another was put on scales in the cellar. Three observations a day were taken and the results drawn in diagrams showing the gain of bees for the summer, recording the length and intensity of the honey flows, and the losses during the different periods and conditions of winter and spring.

*Model apiary.*—The apiary at University Farm, St. Paul, is modern throughout with best Italian bees and equipment. Best methods of management for honey production are illustrated for students of the Agricultural College and for a large number of visiting beekeepers, as

well as at beekeepers' meetings held at the apiary. A smaller model apiary has been established at the substation at Duluth.

*Artificial fertilization of queens.*—This study was closed in 1917. A paper has been published reporting the work done. The results indicate that if the mating of queen bees is to be controlled it must be done in some other way than by the method used.

*Bee and honey survey.*—Considerable information concerning bee-keeping conditions in Minnesota has been collected. This survey shows the extent and importance of bee culture in the state and also existing conditions, so that proper measures may be taken to safeguard and promote apiculture in Minnesota.

#### DIVISION OF DAIRY HUSBANDRY

H. H. KILDEE, Chief

#### SECTION OF DAIRY STOCK AND PRODUCTION

*Bran replacement value of ground leguminous hay for milk production.*—The object of this test was to ascertain the efficiency and economy of ground leguminous hays for milk and butterfat production, when substituted for bran. The present limited supply of cereals for human consumption, and the resultant high prices, make it imperative that the farm roughages be utilized to the fullest extent, in order that the dairy industry may be maintained.

The experimental period was divided into three periods of thirty days each. Each of these periods was further divided into six sub-periods of five days each. Five cows, similar in weight, lactation, and daily production were used. The quality and quantity of silage and hay remained constant during the test, while the basal grain ration consisted of: Ground oats 300 pounds, ground corn 200 pounds, cotton-seed meal 100 pounds, oilmeal 100 pounds (O. P.), bran 400 pounds. The trial grain ration was made up as follows: Oats 300 pounds, corn 200 pounds, cotton-seed meal 100 pounds, ground alfalfa hay 400 pounds.

The grain rations were fed on a basis of milk production. The amount varied with the individual cows.

Records were kept of the weights of the cows, of the water, feed, and salt consumed; and also of the production in terms of milk, butterfat, and total milk solids.

The results of this preliminary trial seem to indicate that ground alfalfa hay may be quite satisfactorily substituted for bran in the grain ration. It seems to be as efficient as bran in maintaining the body weight and in milk and butterfat production.

*Concentrate replacement value of ground leguminous hay for growing dairy heifers.*—The object of this preliminary trial was to determine the efficiency and economy of ground leguminous hay when substi-

tuted in the ration for growing dairy heifers. The experiment was divided into two feeding periods of twenty days each. The first period was preceded by a five-day residual period, a five-day transition period separating the two. Nineteen yearling heifers—6 Guernseys, 7 Holsteins, and 6 Jerseys—were used. The animals were divided into two groups, numbered 1 and 2.

The feeds used were fed in two rations; a check ration and a trial ration.

The check ration consisted of: Prairie hay at will, silage at will, and 3 pounds of a grain mixture, as follows: oilmeal 100 pounds, middlings 100 pounds, bran 100 pounds, cornmeal 100 pounds. The trial ration consisted of: Prairie hay at will, silage at will, and 3 pounds of a grain mixture, as follows: oil meal 100 pounds, middlings 100 pounds, ground clover hay 200 pounds.

Group 1 was fed the check ration and group 2 the trial ration during the first twenty-day feeding period. During a five-day transitional period between the first and second twenty-day feeding periods, the reverse method for feeding was employed. The same feeds were fed during the second twenty-day feeding period as during the transitional period.

Records were kept of the weight of the animals, the feed and salt consumed, and the condition and health of the animals at the beginning and end of each feeding period.

The results of this preliminary trial are of value in indicating the possibilities for further work along this line, but the data secured thus far are insufficient to be considered as final and conclusive.

#### SECTION OF DAIRY MANUFACTURE

*Influence of salt on changes taking place in storage butter.*—The object of this series of tests was to determine, with greater accuracy, the role played by common salt in the preservation of butter.

The work was done in the Station creamery from unpasteurized cream, each churning being divided before working, so that both the salted and unsalted portions had an equal amount of working. Initial scoring and tests were made. All samples were then placed in commercial refrigerating temperatures and scored and tested later at intervals of about three months. At the end of 284 days in storage, the samples were subjected to a temperature of about 58° F. for 20 days, to learn the effect of such temperature upon germ growth and upon scoring. The results and conclusions from this work have been published.

*The accuracy of the Babcock test and the butterfat losses in creameries.*—The objects of this investigation were: To determine the butterfat losses occurring in the average, well-conducted whole-milk

and hand-separator creameries; and to furnish additional information as to the accuracy of the Babcock test in commercial practice.

The work was done in the state creamery under every-day working conditions, but with sufficient additional help furnished to make possible the accurate determination of the various losses occurring in the process of buttermaking. Several tests were also made to verify the accuracy of various methods of operating the Babcock test. The results of the investigation are being prepared for publication.

*Keeping quality of butter as affected by prompt vs. delayed refrigeration.*—Considerable work has been done on this problem and interesting, and probably valuable, data obtained; but since the test was conducted under what might be considered non-commercial conditions, it is deemed advisable to repeat them on a larger scale before publishing results.

#### DIVISION OF ENTOMOLOGY AND ECONOMIC ZOOLOGY

W. A. RILEY, Chief

Prior to February 1, 1918, the Division of Entomology and Economic Zoology was organized on the committee basis. The writer began his term of service as chief of the division on that date, but was granted a leave of absence from March 1 to June 15, for the purpose of completing his teaching work at Cornell University. The following report was in large part prepared by F. L. Washburn, who served as acting chief in the interim.

#### SECTION OF VERTEBRATE ZOOLOGY

*Nursery and Orchard Inspection.*—Before February 1, 98 nurseries were inspected and granted certificates. Certificates were also issued to 8 dealers, and permits were issued to several persons for shipping ornamentals locally. Three hundred thirteen cases of foreign stock, including 433,397 plants were also inspected.

Since February 1, 21 nurseries have been inspected, 15 nursery inspection certificates and 2 dealer's certificates issued, 22 shipments of foreign stock—94 cases—inspected, and 124 permits given to make small shipments from the woods or from one farmer to another.

*White pine blister rust.*—Work on white pine blister rust continues to occupy a large part of the state entomologist's time. During the summer and fall of 1917, nurseries received two and frequently three special inspections for the disease and "leads" from infected nurseries were followed and reinspected, diseased trees being destroyed. Plantations and private plantings of pine were given rigorous examinations. An extensive survey was made of the counties bordering on the St. Croix affected area. One hundred and forty-six towns were visited and 284 pine plantings inspected, representing approximately ten thousand pines. Sixty-five hundred pines were destroyed. This

work was done in cooperation with the United States Bureau of Plant Industry and reported in a "Special Report to the Governor of Minnesota," Circular 45, December 1, 1917.

Systematic cataloging of all leads and plantings concerning which information is available has been completed. The records of the express companies and of nurserymen are being carefully examined for further information on shipments from suspicious sources. One infection on a lead at Chicago City was found and destroyed with the rest of that shipment. Nurseries and all plantings from suspicious sources are being inspected as rapidly as possible.

On March 19, 1918, the Minnesota Commission of Public Safety made the state entomologist responsible for the eradication of the common barberry, and 823 official notices have been sent to owners to eradicate these plants. Probably 85 per cent have been eradicated in the country districts, and 70 per cent in the larger cities.

*Field mice and other rodents.*—No work was done on this project.

*The Belgian hare and allied breeds of rabbits as a source of food.*—Efforts are being made to determine the best of the three strains: Belgian, Flemish Giant, and New Zealand Red; their comparative productiveness, freedom from disease, rapidity of growth, and the cost of meat production.

*Hymenoptera of Minnesota.*—This project is nearly completed, notes are being compiled, and drawings and cuts secured to accompany the colored plates. The collection has been thoroly revised.

#### DISTRIBUTION OF LIVE FISH TO FARMERS

This work has been continued and 22 applications from Minnesota farmers have been forwarded to the United States Bureau of Fisheries, at Washington.

#### SECTION OF ECONOMIC ENTOMOLOGY

Fifty breeding-cage experiments were undertaken in the Insectary. Experiments were conducted on the use of kerosene for leaf hoppers on potatoes; control of the raspberry *Byturus*; dust spraying; effect of orchard spraying upon bees; the use of tree tangle-foot and its effect on the bark of young trees; wheat stem maggot; corn ear-worm; and the effect of spraying the eggs of plum aphid with lime-sulphur solution.

Studies of measures for protecting wheat flour substitutes from insect attack were undertaken by Mr. Chapman early in February, and have yielded results of great importance in view of the requirements of the Food Administration. It has been found that the fatal temperature for the common insects infesting cereals is about 45 degrees C. at 24 per cent relative humidity. A simple method of

heating cereals to kill insects in any stage of development and at the same time to avoid any injury to the cereals, has been recommended. A wax indicator to melt at the appropriate temperature, 85 degrees C., has been devised and is being distributed through wholesale grocers. Altho only a brief note relative to this work has been published, inquiries from officials in ten different states have been received, and the testing wax and full directions for the protection of the flour substitutes are being distributed.

Investigations on ant injury to cedar poles were conducted as well as on insect injury to pulp wood.

A nicotine sulphate spray was used effectively against the winter eggs of lice on snowball.

#### SECTION OF INSECTICIDAL INVESTIGATIONS

*Specific toxicity of various chemicals to insects and their hosts.*—Extensive work has been accomplished and some striking results obtained in this project. The toxicity of kerosene to both insects and plants has been studied, as well as the efficiency of other oils. Various compounds of nicotine were also experimented with.

Much emphasis has been placed on work with lice, war conditions calling for research in this direction. Different louse powders were studied and new ones compounded. In this connection, fumigation of clothing was experimented with and an efficient fumigant found. The effectiveness of impregnating underwear with some repellent was also studied.

#### SECTION OF PARASITOLOGY

C. W. Howard, in charge of this section, resigned October 10, 1917. Previous to his departure he prepared for publication a series of papers covering important investigations in his field. In addition many data bearing on his projects were made available to his successor.

#### DIVISION OF FORESTRY

E. G. CHEYNEY, Chief

The experimental work of the Division of Forestry has followed three general lines: silviculture, forest management, and wood preservation.

Most of the silvicultural work was carried on at the Cloquet Station and included nursery practice, planting, seed studies, and plant introduction. Work has been completed on the collection and extraction of white, Norway, and jack pine, and white spruce seed. Some interesting relations have been found between the source of seed, and hardiness and immunity from insects and disease.

In the nursery practice with the pines, only a little work remains to be done in the use of fertilizers, spacing, and damping off. Other-

wise the study is complete and the results were published in the report of the station.

The work on planting and sowing and the determination of site, covered by about six hundred half-acre plots, is almost completed. Some of the experiments must be repeated to determine the effect of different seasonal conditions, and observations must be continued for several years to check results.

Forest management work covers cuttings at different times in reference to seed years, to secure reproduction; brush burning; thinnings; growth studies; volume studies; and working plans. Interesting data have been collected on thinnings. Graded volume tables of white and Norway pine have also been made.

The working plans of Itasca Park and of the water works tract at Lake Vadnais, now nearing completion, will be of great interest as the first thing of the kind worked out in this state. They should be completed the coming season. The study of the pine plantations at Grand Rapids, the oldest forest plantations in the state, are of especial interest in this connection.

The post-treating work consisted in checking fences constructed some years ago. The record will not, of course, be completed until all the posts have decayed, some years hence, but some interesting results have appeared.

A survey was made of the windbreaks and prairie plantations in the western part of the state. The results are now being prepared for publication.

A comprehensive study of damping-off disease was undertaken in coöperation with the Division of Plant Pathology and Botany, including the nursery practice and the fungi involved. The nursery practice is about complete and has brought out some valuable results. These will be checked next year for seasonal differences. It is hoped to complete the pathological work also.

Some experiments in blueberry culture have been started in coöperation with the Division of Horticulture to determine the possibilities here, under cultivation, of the strains developed in the east, and also of our native plants.

#### DIVISION OF HORTICULTURE

W. G. BRIERLEY, Chairman

#### SECTION OF FRUIT HANDLING AND UTILIZATION

*Cider and vinegar-making quality of Minnesota apples.*—Work on this project was completed in the season of 1916-1917 and the material is now being prepared for publication.

*Pruning the apple.*—No further winter pruning has been done, the work on the project consisting largely in the collection of data on the growth during the season of 1917 and the effects of the winter of 1917-1918 on this growth. Some time has been spent in collecting data on the healing of pruning wounds.

*Blueberry culture.*—Work has been continued with the native species at Cloquet. Indications are that wild plants can be readily transplanted and will grow well if set in common jack pine soil, mulched with peat, and given attention, such as watering and weeding. The twenty seedlings of *Vaccinium corymbosum*, the highbush species, furnished by the United States Department of Agriculture in 1916, appear to be too tender to stand the northern winters without considerable injury to the shoots. Owing to lack of suitable facilities at University Farm, the plants from the New Hampshire cuttings were all lost. It is expected that the work will soon be put on a basis of coöperation with the United States Department of Agriculture and that several hundred highbush and lowbush-highbush hybrids will be planted at Cloquet for trial for a period of ten years.

*Cost of fruit production.*—Work on this project has been started in coöperation with the Section of Cost Accounting, Division of Agronomy and Farm Management. Records were collected from several orchards and small-fruit tracts. This work will be continued in the effort to obtain a larger number of records for tabulation.

*Nut culture in Minnesota.*—Information has been gathered from all available sources as to the distribution of the several native nut species in the state and the extent to which these have been planted. Seedlings of butternut, black walnut, and shagbark hickory have been sent to the several substations for trial. More extensive plantings of these nuts, together with trial plantings of named varieties of black walnut, hickory, sweet chestnut, filbert, pecan, and English walnut, have been established at University Farm and at two other localities in the Mississippi River Valley.

#### SECTION OF FRUIT BREEDING

*Inheritance of fruit characters.*—The studies on the plum hybrids which have been under way for the last two years were continued. This has been made necessary by the fact that only a part come into fruiting each year. With these hybrids, particular attention has been given to the inheritance of fruiting types, head-shape, leaf-form, and freeness, color, size, and quality of fruit. Observations of these characters have as far as possible been completed, but the final records on fruit characters have been delayed by the crop failure. Studies on other fruits, particularly the apple and raspberry, are under way.

*Sterility in fruits.*—The work on this project has been confined for the most part to the plum and the apple. Careful records of the percentage of setting in controlled crosses in the greenhouse in each of these fruits show that certain variety combinations are sterile and others fertile. All of the plums which have been self-pollinated have been found to be self-sterile. Primary attention has been given to the phase of sterility shown by dropping after blooming time. This investigation has shown that there are three distinct periods of dropping, in the plum. The first flowers to drop have aborted pistils. The next in point of size drop three or four weeks after bloom. These are not fertilized. The next drop comes about three weeks later (the so-called "June drop") and these fall as a result of embryo abortion. Since dropping occurred to such a large percentage in the hybrids as well as in the standard varieties, an attempt was made to determine the causes. Final data on self-sterility in the plum have been taken during the spring of 1918.

*Breeding fruits for hardiness.*—Records of winter injury to bud, twig, wood, and bark in the plum hybrids have been taken again this year for the third time in order to check up the injury from season to season. Approximately 150 different parent combinations are included in these studies. During the winter of 1917-1918 the injury was more severe than in either of the two winters preceding. Considerable attention has been given to devising a method of determining the relative hardiness of seedlings. The results of these studies show that the winter injury to the tenderest tissues of the plant serves as an accurate index of hardiness.

Self-fertilized seedlings of some of the hardiest varieties of raspberry have been obtained as a basis for studying the range of hardiness in the species mostly grown in the Northwest. The results of the tests of the trial plots at Deerwood, Grand Rapids, and Cloquet show that in the raspberry only a very few of the varieties available in the nursery trade are sufficiently hardy to stand the winter of the northern section of the state uncovered, and only a few of them are hardy when covered. A large number of seedlings are now growing in the trial plots from the seed obtained from Canada during the summer of 1916.

#### SECTION OF FRUIT AND VEGETABLE INVESTIGATIONS

*Breeding and selection of vegetables.*—Distinctive strains of beans, varying in size and shape, productiveness, color, and brittleness of pod, have been isolated from the Refugee bean "1000 to 1." The most promising are being propagated to obtain sufficient seed for trial by canning factories.

The isolation of strains in the canning pea, Alaska, has also been productive of results. Many of the low-yielding yellow types have been discarded and the better ones are being propagated for commercial test.

A second generation of several cucumber crosses has been grown in the greenhouse and various types, varying from White Spine to English types, with many intermediates, have been produced. A few of the intermediates appear to be desirable types and will be fixed if possible.

The progress of the onion selection work has been checked by the loss of W. T. Tapley, who is now in military service. However, the strains already isolated are being continued.

The selection of types within the Hubbard squash has given definite results. Types varying from roundish to long oval, from thin- to thick-fleshed, from "blue" or grayish to green, have been isolated. The productiveness and commercial value of these types are being tested. As in the past, the first generation tomato crosses have proved generally more productive than their parental mean and often more productive than the higher yielding parent. The first generation crosses gave a much larger number of fruits in every case than the parental mean and consequently the fruits averaged slightly smaller. In the 1917 test, the cross between John Baer and Earliana proved to be exceptionally promising, for the fruit was not only very early, but smooth and abundant. A severe attack of the mosaic disease in the greenhouse for the last two seasons has interfered greatly with the production of seed for distribution and experimental work.

The most prominent crosses will be sent out for trial on a commercial basis as soon as ample seed can be obtained.

*Potato investigations.*—The work in 1917 was modified to some extent to meet war emergencies, that is, experiments were planned so as to produce the maximum amount of food. Consequently new experiments were started and the old ones limited as far as possible. Advantage was taken of the fact that new seed produces good crops at University Farm. A comparison was made between whole tubers weighing 2, 3, and 4 ounces, respectively, and 1-ounce cut pieces. The respective computed yields were 306, 322, 350, and 266 bushels per acre and the stalks per hill 3, 3.82, 4.73, and 1.5. Seed pieces one ounce in weight from the stem, middle, and seed ends were compared and gave the respective computed yields per acre 258, 276, and 294 bushels. The value of thinning stalks to one per hill, hills 18 inches apart and rows 3 feet apart, was tested, the variety used in all these experiments being Green Mountain. An average of 1.646 stalks and 266 bushels per acre was produced in the rows planted with 1-ounce

seed pieces, while the same sized seed pieces with stalks thinned to one per hill produced 240 bushels per acre. The Green Mountain seed planted two weeks later, owing to wet weather produced about 100 bushels less tubers to the acre. In the later planting, 1-, 2-, and 3-ounce cut pieces gave a computed yield of 183, 228, and 214 bushels per acre. The results corroborate the well-known fact that the size of seed piece that can be profitably used depends directly upon the fertility and condition of soil, together with the price of the seed.

Early Ohio potatoes from various types of soil and various regions in Minnesota were divided into four lots and grown at the Northeast Experiment Farm, Duluth; the North Central Experiment Station, Grand Rapids; the Northwest Experiment Station, Crookston, and University Farm. Very noticeable differences were found in the tubers produced at these places. The tubers averaged larger at University Farm than at the other places and had large papillae, small knobs, and numerous scab injuries. The Duluth tubers had very indistinct papillae and an exceptionally smooth skin. The Crookston tubers were more immature than the others, had a redder skin, and a strong tendency to be elongated and tapering towards proximal end. The Grand Rapids tubers had a more flaky skin than the others and were infected to a small degree with *Rhizoctonia*. In every case the Duluth and Grand Rapids tubers retained the shape of their parental stock much better than the tubers grown at Crookston and University Farm.

The degeneracy studies have been continued as in the past. The straw mulch and shading had no material effect on tubers already running out, and consequently this part of the experiment had to be started with new stock. Varieties exchanged with the stations mentioned have shown a marked degree of rejuvenation, altho certain varieties were not entirely rejuvenated in one season and will have to be grown north for a longer period. Bordeaux mixture produced a very marked effect on the tubers, for seed from the sprayed plants gave a substantial increase in yield the following season. If this fact is supported by further investigations, it will be of great importance to potato growers. In the past the value of Bordeaux mixture has been noted simply for its immediate effect, and not for its effect on the following crop.

*Variety tests of fruit.*—The testing of numerous varieties of fruits has been continued as in the past. Many of the unhardy and inferior kinds fell by the wayside during the last winter, which was especially severe, owing to the dry condition of the soil and light snowfall. Trees of Duchess, Wealthy, McIntosh, and Jonathan on French crab roots purchased from nurseries in Minnesota and from the east,



south and west, have behaved very similarly. All of the Jonathan were severely injured during the hard freeze last fall before the foliage dropped. At the base of the trunks the bark became cracked and loose and the cambium was discolored for about a foot above the ground. This injury was probably aggravated by a heavy wind which switched the trees about while the wood and the ground were frozen. Many large apple trees 18 to 20 years old were also more or less injured. The roots in certain cases were partially killed and this caused the upper portion of the tree, altho hardy, to show injury. Numerous plum and cherry varieties also suffered considerable winter injury.

The currant, gooseberry, and raspberry varieties, even tho unprotected, came through the winter very satisfactorily. Grape varieties, especially the semi-hardy kinds, and nearly all the black-berry varieties, even tho protected with soil, were badly injured and in many cases killed. Numerous strawberry varieties also suffered severely from injury. A few of the promising strawberry varieties were sent, in the spring of 1918, to the Southeast Demonstration Farm and Substation, Waseca, for trial. Stock of new varieties which are recommended in other states was obtained for trial.

*Coöperative orchard management.*—The orchard at the Northeast Experiment Farm, Duluth, is gradually becoming established by replacing the trees killed during the winter. Many of the trees have made satisfactory growth, and within a year or two the orchard should be in shape to begin tillage-versus-sod methods of management. The orchard at the State Hospital for Inebriates, Willmar, lost a few trees during the winter, but as a whole is progressing finely. The half of the orchard which has been in sod only one season shows less vigor and growth, and as time goes on this difference will probably become more marked. J. P. West's orchard, at Rockford, is now fairly well established and the trees have recovered from the rabbit injury. All of the Hibernial trees that were to be topworked to Wealthy have been either budded or whip-grafted. In J. C. Bailey's orchard, 300 Virginia crabs were budded to Wealthy and other varieties and 900 trees were left on their own roots for checks. About 95 per cent of the buds lived through the winter, but many were destroyed by the bud moth and worms in the spring.

#### SECTION OF LANDSCAPE GARDENING AND FLORICULTURE

The winter of 1917-1918 was very hard on herbaceous perennials and shrubs. About half of the iris died out, all of the phlox, about half of the herbs, and a considerable proportion of miscellaneous perennials which are ordinarily considered very hardy. Peonies were

injured to some extent by late spring frosts and perhaps more by the drouth of last season and the lack of snow during the winter. In spite of this, nearly all of them bloomed heavily and in many cases fully as good flowers were produced as in ordinary seasons. The blooming period of several shrubs and perennials was set forward from a week to ten days over ordinary seasons. An interesting thing noted in the iris was that late varieties in some cases bloomed earlier than the early sorts and many of the early sorts bloomed very late. This was also noticed to some extent among the peonies.

About 600 varieties of dahlias were grown. Nearly all produced flowers, but comparatively few flowered freely on account of the hot, dry weather in August.

Practically all of the hedge plots came through the winter in good shape, with the exception of California privet and Thunberg's barberry, both of which were cut back to the snow line.

About seventy-five varieties of annuals were tested last season, but owing to hot dry weather they were not a success except in a few instances. Several United States Department of Agriculture importations were tried and a few are proving worthy additions to our list of shrubs.

A fairly creditable showing of chrysanthemums was made in the greenhouse last autumn, altho most of the stock was held over from the preceding year. A few of these varieties demonstrated their usefulness as plants for home growing and were distributed through the State Horticultural Society this spring. A further test of these varieties and about a hundred additional varieties will be made this fall.

Flowering bulbs were not a success in the greenhouse, owing, perhaps, to their not being planted early enough and possibly to their being of inferior quality.

A quantity of seed of ornamentals was collected in 1917 and planted this spring. A large quantity of *Cotoneaster acutifolia* seed collected two years ago was planted, and the plants are now growing nicely. They will be distributed eventually to be used as hedge plants. *Ulmus pumila*, one of the Chinese elms imported into this country a few years ago, has proved a splendid addition to our list of small shade trees. It has finer foliage and seems to stand drouth better than many of the common elms. The habit of the tree is more dwarf.

## DIVISION OF PLANT PATHOLOGY AND BOTANY

E. M. FREEMAN, Chief

## SECTION OF PLANT PATHOLOGY

*Plant disease survey.*—More careful records than were heretofore possible were kept on plant diseases. Several new diseases were found, and data were obtained as to the seriousness of most of the important diseases. Cereals largely escaped rust and scab, but suffered the average loss from smut. Potatoes escaped late blight, but considerable losses occurred from other troubles. Frost and winter injury were more than ordinarily serious.

*Rusts of cereals.*—Further progress was made on the development of the resistant hybrids. This work was done in coöperation with the Bureau of Plant Industry of the United States Department of Agriculture and the Section of Plant Breeding of the Division of Agronomy of Farm Management.

Studies on biologic forms were continued vigorously and papers published covering findings over a considerable portion of the United States. Strains of rust in various regions were found to have an important bearing upon the development of varietal and hybridizing work.

The work on the relation of soil conditions to rusts was largely completed.

The genetics of rust resistance was studied, and the study is being continued.

*Cereal and forage crop diseases.*—No new phases of corn smut studies were begun and no opportunity was afforded for work on flax rust.

Studies of wilt-resistant flax were made in coöperation with the Section of Plant Breeding of the Division of Agronomy and Farm Management.

The work of isolation, identification, and testing of pathogenicity of imperfect fungi affecting cereals was carried toward completion.

The work on loose smuts of cereals was continued, considering particularly treatments for control.

*Potato and garden truck diseases.*—Cucumber nubbin was studied as to the method of spread of the disease. Bean bacteriosis was studied to some extent and further work done with tomato mosaic. Potato diseases were studied and progress was made on seed plot work. Wilt, dry rot, and dry stem rot were particularly studied experimentally. Seed plot work was carried on in coöperation with the Division of Agricultural Extension.

*Fruit diseases.*—There was no occasion to work on the Wealthy fruit spot or the varietal resistance to brown rot.

In experimental apple and plum spraying rather definite results were obtained, particularly in regard to plum pocket and brown rot.

Raspberry diseases were studied, particularly the gray bark disease. The fungi were isolated and laboratory and field studies on infection and control begun.

*Dendropathology.*—The sub-project on oak canker was at least temporarily concluded.

Work on blister rust of white pine was continued in coöperation with the United States Department of Agriculture. Accurate information was obtained as to the prevalence and seriousness of this disease.

*The microflora of peat lands.*—It has been impossible to do any work on the project this year.

## SECTION OF SEED LABORATORY

*Seed studies.*—Revised methods for germinating flower seeds have been worked out. A formaldehyde treatment has been developed to improve the germination of onion seed.

The experiment on lawn-grass mixtures has been quite largely completed with the additional finding that red fescue makes a good base for lawns.

*Weed seed cases.*—About 350 weed seed cases were distributed in Minnesota and surrounding states. These cases are being used quite extensively in high school and college laboratories. A new weed seed case has been manufactured to contain seeds of the so-called five inseparable weeds mentioned in the federal grain grades for wheat.

*Seed testing.*—In continuation of this work, 13,200 samples of seed were voluntarily sent in for germination or purity tests or both. This is about 20 per cent increase over last year.

Inspection work was carried on, on a larger scale. One hundred and eighty samples were collected and three prosecutions for violation of the Minnesota seed law were carried to successful completion. Beneficial results were obtained in testing of corn seed.

*Weeds.*—The weed survey project has been developed considerably and special work is being done in Clay County. An endeavor is being made to bring about complete eradication of Canada and sow thistles in this county.

## DIVISION OF POULTRY HUSBANDRY

A. C. SMITH, Chief

The results of a trial with three lots of six breeds and eight different varieties during the summer of 1917, showed very little difference in weight of the chicks of the different varieties at broiler age. The maximum variation in the first lot was 0.33 pound, in an average

weight of 1.34 pounds. This is a variation of approximately twenty-five per cent and would be material if it were not controverted by the fact that the average variation was only 0.14 pound and further by the fact that the average variation of the second and third lots was only 0.15 and 0.11 pound, respectively. In the first lot, three of the seven varieties averaged within 0.1 pound of maximum weight. In the second lot, four of the eight varieties averaged within 0.12 pound of maximum weight and two more within 0.2 pound. In the third lot, the average deviation from maximum weight was only 0.11 pound. It is evident that the difference in weight of the different breeds and varieties at broiling age will not affect the proceeds sufficiently to become a determining or even an influential factor in selecting breeds and varieties for egg production.

In a study of the palatability of the different ingredients used in laying mashes, a constant supply of each ingredient was maintained in a separate hopper before a flock of laying hens. They chose the different ingredients of this mash in the following order: (1) Beef-scrap, (2) Hominy, (3) Wheat bran, (4) Ground oats, (5) Wheat middlings, (6) Bone meal, (7) Alfalfa.

A comparison of bran fed to one lot of young chicks in brooders and freshly cut green alfalfa to another, as a laxative and nutrient, showed bran the better for both purposes, that is, better results were obtained both in the health and the growth of the chicks.

#### DIVISION OF RESEARCH IN AGRICULTURAL ECONOMICS

C. E. ROBBINS, Acting Chief

The work of the division from June 30, 1917 to June 30, 1918, has followed plans outlined in previous years, dealing with problems of land settlement, rural credit, coöperation, and marketing. Owing to the inroads made upon the division staff by war demands, it has not been possible consistently to pursue projects in all these fields.

*Collection of statistics of coöperative organizations in Minnesota.*—In compliance with the state law, information and statistics have been obtained from coöperative organizations engaged in marketing farm products and buying supplies for farmers. Data have been secured specifically from elevators, creameries and cheese factories, livestock shipping associations, potato warehouses, and coöperative stores. The information is for the year 1917.

*Market business practice.*—Under arrangements entered into in September, 1916, the division coöperates with the Office of Markets of the United States Department of Agriculture for the investigation of methods of accounting and management of marketing organizations, especially coöperative organizations and particularly for the promotion of the installation by such organizations of a system of accounts devised by the Office of Markets.

*Marketing of farm products.*—The division has coöperated with the State Committee of Food Production and Conservation and with the Minnesota Public Safety Commission to facilitate marketing of farm products and to conduct investigations and give advice relative to just prices to be set by the Commission on specified products.

#### DIVISION OF SOILS

F. J. ALWAY, Chief

Field studies and field experiments, the urgency of which was mentioned in the last report, have continued to occupy the most prominent place in the work of the division, altho fair progress has been made with part of the laboratory investigations. Since the end of last summer great difficulty has been experienced in properly caring for either field or laboratory work, on account of the entry into military service of nearly all the younger members of the staff, and also of those graduate students who had received training in the division and who otherwise would have been available.

*Peat land investigations.*—The legislature of 1917 appropriated \$6,000 a year for three experimental tracts on peat soil—one in Beltrami County, or some county west of it; the second in Koochiching, Itasca, Aitkin, or some county east of these; and the third in the southern half of the state. The amount, while much smaller than needed properly to start the work on three tracts, will permit the field experimental work on peat soils to be begun on a permanent basis. The three tracts have been selected, one at Golden Valley in Marshall County, another at Dibbell, in St. Louis County, and the third a short distance from Anoka. The areas of the three tracts are respectively 35, 38, and 40 acres.

Five other experimental fields of from 10 to 40 acres each are urgently needed. One of these should be located on the lime-deficient upland loams in the southeastern counties and another on the sandy soils of the central counties adjacent to the Mississippi River. The need of these two is especially urgent. In addition there should be a field on the Late Red Drift and another on the Late Gray Drift, both located as close as possible to the Experiment Station Farm, the soil on which, unfortunately, is representative neither of these nor of any extensive soil type in this state. Finally one should be located on the heavy lake-washed clay in Koochiching, St. Louis, or Beltrami County.

*Fertilizer experiments.*—The experiments outlined in the last report as already under way or about to be inaugurated, have been carried out and a summary of the results so far secured has been published.<sup>3</sup>

<sup>3</sup> Alway, F. J. Experiments with phosphate fertilizers in Minnesota. Minn. Agr. Exp. Sta. Special Bull. 23. 1918.

The results of the experiments so far conducted in Minnesota on the use of phosphate fertilizers on ordinary or mineral soils, and with the ordinary farm crops, do not justify any recommendations for their general use, even under the prevailing high prices; but the highly profitable results shown at the Morris farm, when acid phosphate is used alone, suggest that on a large proportion of those soils in the west central part of the state upon which grain has long been grown without the application of manure, the use of acid phosphate may be found highly profitable with wheat and clover, especially on the fields which do not receive an application of manure once every three to five years.

Arrangements have been completed with nineteen farmers in Stevens County for cooperative experiments in the use of acid phosphate on land to be sown to spring wheat this season, the farmers purchasing the fertilizer and with the assistance of an experiment station representative applying it to fields that have received no stable manure within recent years. Somewhat similar arrangements have been made with fifteen other farmers in the same county for the application of the same fertilizer to fields to be seeded with clover when sown to a small grain, the main object being to determine the influence of the phosphate upon the yield of hay the following year. All of this work with the farmers in Stevens County is being carried on in cooperation with the Extension division and the West Central substation.

*Peat soils.*—The laboratory study of the peat soils of Anoka County has been completed and greenhouse experiments have been conducted with peat soils from various parts of the state, including those from two of the new peat experimental farms.

The fertilizer experiments on the Dibbell tract and on the Oak Leaf farm, in Anoka County, were discontinued except for the determination of the yields of hay on various plots on both farms. The experiments on the Grand Rapids bog were continued in cooperation with the North Central substation.

*Soils of the different drift sheets.*—The chemical study of the soils collected in the southern counties has been completed, and the results are being prepared for publication.

The field experiments with lime, using alfalfa as an indicator crop, have been continued. The fields will be kept under observation during the coming summer, and at the end of this season it is intended to publish the results of the four years' work.

The laboratory investigation of soils with an acid reaction has had to be left in abeyance during the greater portion of the year.

A soil survey of Stevens County in cooperation with the United States Bureau of Soils and the West Central substation has been

partly completed. A study of the most significant chemical factors and physical constants of the prominent soil types encountered is accompanying the survey.

*Glacial soils of the Gray Drifts.*—The laboratory investigation of the series of samples taken in Rice County for a comparison of the soils of the Old Gray Drift with those of the Young Gray Drift has been nearly completed. A similar study of the series taken from widely separated points on the Young Gray Drift in Minnesota has made much progress, but has now been interrupted for several months.

*Movement of water in soils.*—Both laboratory and field studies have been continued, the unusually severe drouth in the northern part of the state in the season of 1917 being especially favorable to the latter.

#### DIVISION OF VETERINARY MEDICINE.

C. P. FITCH, Chief

Because of changes in personnel, the projects of this division were entirely revised, beginning January 1, 1918, and special emphasis was placed on work to be done with contagious abortion of cattle and mares. These diseases are of the greatest economic importance.

#### SECTION OF ANIMAL PATHOLOGY AND BACTERIOLOGY

*Contagious abortion of cattle.*—An experimental herd of twelve female calves from 5 to 8 months old has been secured. It is planned to increase this to twenty-four animals August 1, 1918. These animals will be used in general work in investigations of abortion, but in particular to study the problem of artificial immunity by the use of living and dead cultures of *Bact. abortus*, Bang. The work of controlling abortion by the use of bacterins has been continued in a few herds belonging to private individuals and in the dairy herd at University Farm. The results are very encouraging, but much further information must be obtained before an opinion as to the value of this method should be expressed. Many blood samples have been taken from different cattle of various ages and tested by the agglutination method. A preliminary report on the value of this test in the control and eradication of abortion disease will soon be ready for publication. So far our work has shown that it has very little practical use if any.

*Contagious abortion of mares.*—A partial survey of the extent of this disease has been taken by means of the agglutination test. The principal work has been done on the biology of *B. abortivo equinus*, the cause of abortion in mares. We have found that certain errors have occurred in the description of this organism as regards its action on the carbohydrates. These were due to the fact that hydrolysis took place during the process of sterilization of the sugars and the results of the fermentive action were misleading. This work is nearly

completed. We have isolated several organisms from cases of navel ill and pyaemic arthritis of foals. These are being studied critically. Several workers have reported that *B. abortivo equinus* can easily be isolated from infected individuals. We have not been so fortunate as to isolate the causative organism with the facility reported, and question whether it is as easily isolated as previously stated.

*Obscure infectious diseases.*—A total of thirty-eight specimens have been examined since January 1, 1918. Among the more important diseases found are: hook worm disease (*Uncinaria polaris*) among the foxes kept on a large fox ranch, leukemia in poultry, and Johne's disease among beef cattle. Tuberculosis among poultry is very common in this state and strict hygienic and sanitary precautions should be taken to prevent it from becoming a veritable scourge. A report of some of the more important cases will be published.

#### SECTION OF VETERINARY PHYSIOLOGY

The work of this section has been temporarily discontinued because of the resignation of Dr. Palmer.

#### SECTION OF VETERINARY MEDICINE

*The pathology of sterility in contagious abortion of cattle.*—The study of sterility, or failure to breed, which is one of the vital phenomena of abortion disease, has been steadily and vigorously pursued. An inventory of the reproductive organs of several hundred cows has been obtained. The chief pathological lesions observed during the last year are metritis, metropéritonitis, endometritis, pyometra, hydrosalpinx, pyosalpinx, chronic salpingitis, cystic and fibroid degenerations of the ovaries and ovarian hematomata. Cervicitis and cystic degeneration of the vagina have frequently been found. Three cows which came under our observation suffering with diseased condition of the genital organs suffered also from fracture of the pelvis. This was in each instance undoubtedly brought about by mounting other cows in oestrus or being themselves mounted by other animals. The organs from these cows revealed cystic changes of the ovaries and in one double hydrosalpinx was also found. Three freemartin heifers were studied and the organs of each are being examined microscopically. One interesting case in the University herd was a three-year-old heifer that had persistently refused to conceive even after a series of treatments. This animal was slaughtered and upon examination was found to be affected with oedema and mucoid degeneration of the uterine mucosa and submucosa.

The records of the various animals treated, together with the microscopical findings of the genital organs of cows destroyed on account of permanent sterility, are being carefully tabulated. A preliminary report on the pathology of sterility is in preparation.

*White scours and calf pneumonia.*—This highly fatal disease is quite common among calves and in many instances coexists in herds affected with abortion disease. Several outbreaks during the year have been investigated, aid given in the control of the infection, and bacteriological and pathological investigations made on animals dead of this infection. The use of white scours serum has proved of considerable value as a preventive agent and is quite helpful in cases not too far advanced with this infection. On account of the similarity of the lesions existing in calf pneumonia and hemorrhagic septicaemia, it is probable that these diseases are often confused. Bacteriological examinations, unless carefully conducted, may prove misleading also on account of the morphological similarity in stained preparations of the colon bacillus and the organism of hemorrhagic septicaemia.

*Farm practice, cattle and sheep.*—Eighty-six cases, most of which were of sporadic, non-infectious variety, have been cared for since January 1, 1918. The treatment of sterility has restored many good animals to a healthy breeding condition. An attempt has been made to examine the genital organs of all cows within sixty days following parturition hoping in this way to prevent the development of chronic and permanent sterility. Diseases of the digestive system have been the most frequent in occurrence, with diseases of the reproductive organs next. Careful records of all cases are kept and the most interesting ones are published.

*Laboratory specimens.*—Two hundred and twelve specimens have been received for laboratory examination since January 1, 1918. Some of these arrived too badly decomposed to be examined. The records of the diagnoses are so kept that they are easily available for publication.

In connection with the State Live Stock Sanitary Board frequent trips have been made for the purpose of aiding in the diagnosis and control of infectious and obscure diseases. Numerous autopsies have been conducted and specimens carried back to the laboratory for further examination.

#### SECTION OF VETERINARY BIOLOGICAL PRODUCTS

*Production and distribution of anti hog cholera serum.*—The production of serum has been very limited because of the decreased prevalence of cholera and consequent reduction in demand for serum, the increased price of pigs and materials, and the large amount of serum on hand.

*To determine the possibility of producing an active immunity following a passive immunity.*—Experiments were undertaken to ascertain whether a pig with a passive immunity can be made actively immune. Results thus far indicate that an active immunity can be produced

in a passively immunized pig at least 15 days after being injected with serum.

*To determine the effect of freezing on anti hog cholera serum.*—Serum was frozen under various conditions and then tested. From the results obtained it appears that freezing does not destroy the immunizing properties of the serum or render it unfit for use. A complete report has been published.

*To attempt the isolation and cultivation of the etiological organism of hog cholera.*—Smears made from the blood of cholera-infected pigs did not reveal the diplococci, which according to Proescher are the etiological factor of hog cholera. No cultivation experiments have been attempted.

*Special biological products.*—During the latter part of the year a considerable amount of hemorrhagic septicaemia bacterin was prepared, in coöperation with the State Live Stock Sanitary Board. Six strains of *Bact. bovissepticus* were used in the preparation of this bacterin. The production of tuberculin has been started for use in the station and substation herds.

*Obscure infectious diseases.*—Sixty-three specimens have been received for examination and diagnosis since January 1, 1918. Notable among these is necrobacillosis of swine. Apparently this disease has become quite widespread. We have observed that in young pigs the disease most often affects the mucous membranes of the mouth and nose and the skin about the head. In older pigs, the lungs and intestinal tract are more often involved. In many instances necrobacillosis and hog cholera have been diagnosed in the same animal and it is very important to recognize these co-existing cases, since hog cholera serum may aggravate the condition, rather than improve it. Brine poisoning was identified in a herd of garbage-fed hogs. Poisoning from *Chenopodium* (American wormseed oil) was observed in a herd of pigs that were being treated for internal parasites.

#### SECTION OF LIVESTOCK SANITATION

Three hundred and eighty-three purebred herds have been tested during the year. Diplomas have been issued to 110 Minnesota herds of purebred cattle, recognizing them as state accredited tuberculosis free herds, an increase of 30 herds during the year. Seventy per cent. of the limited amount of tuberculosis found in Minnesota purebred cattle during the year has been in cattle recently imported. There has been no unusual prevalence of infectious diseases of animals.

Research work in connection with the tuberculin test problem has continued as heretofore. Studies have been made of the following: Relative accuracy of the thermal, intradermal, and ophthalmic tests singly and combined; practical desirability of various combinations

of these tests; relative accuracy of primary and sensitized tests by these methods; origin and significance of atypical reactions, differential diagnosis between the pus of true ophthalmic reactions in cases of tuberculous cattle, and pus that may appear in the eyes of healthy cattle, independently of test; effect of repeated intradermal tests in the same caudal fold; whether some non-tuberculous cattle are naturally sensitive to tuberculin.

During the fall and winter of 1917 about five hundred animals were given either a simultaneous thermal and ophthalmic test or a simultaneous thermal, ophthalmic, and intradermal test. In this work it has been possible to check on a fairly large scale the accuracy of these several tests where no reactions should be obtained on presumably healthy cattle in clean or practically clean herds and the relative accuracy in a smaller number of positive reactions in cases of tuberculous animals.

A considerable amount of valuable data has been collected in the assembling of complete tuberculin test records of individual animals and herds that have been under test and observation for many years. It is hoped that this will serve a useful purpose by giving information upon which to interpret more intelligently, doubtful and uncertain reactions and thus aid in more accurate diagnosis, which in turn should result in a more complete removal of diseased animals, and in condemning fewer healthy animals.

#### THE SUBSTATIONS

Investigational work at the substations has progressed satisfactorily. Additional attention has been given to organizing projects and systematizing methods of conducting investigational work. Fertilizer and rotation experiments have been conducted in coöperation with the Central station. During the year the variety testing and crop culture investigations have also been formulated into coöperative projects.

#### NORTHWEST EXPERIMENT STATION, CROOKSTON

C. G. SELVIG, Superintendent

#### GENERAL CONDITIONS

The rainfall during the season of 1917 was the lowest recorded during the 37 years that observations have been taken at Crookston, 9.44 inches being the record for the year. The average is more than 22 inches. The snowfall during the winter of 1916-1917 was light and practically all the water ran off before the frost left the ground. There was no flow in the tile lines at any time during the season. The season was also one of the shortest on record, being 35 days less than the average.

## WORK WITH FARMERS

The further extension of pure seed distribution was made possible in 1918 from the seed stocks grown at the station in 1917. Two hundred and eighteen farmers purchased seed in small lots under an agreement to keep it pure and free from weeds. In addition coöperative work in tree planting was carried on with school districts and individuals. Distribution of selected seed potatoes, testing of grass mixtures for pastures, and hemp tests were new projects. Requests for reports, special information, and interviews relative to farming practices in northwestern Minnesota, as well as increased correspondence, have been features of the year.

## AGRONOMY SECTION

*Varietal tests of farm crops.*—The work with varieties of farm crops was greatly extended in 1917.

*Wheat, barley, and oats varieties.*—Pentad wheat yielded the highest, 27.7 bushels per acre, while the average yield of the check plots of Minnesota No. 169 was 18.3 bushels. Hannchen barley yielded the highest, 33.3 bushels per acre, while Oderbrucker used as a check yielded 24.4 bushels. Minnesota No. 533 oats yielded the highest, 66.4 bushels per acre, while Minnesota No. 281 used as a check yielded 27.3 bushels.

*Rye, peas, and flax varieties.*—Minnesota No. 2 rye yielded 19.1 bushels per acre while the average of other varieties was 13.8 bushels. Canadian White field peas No. 95 yielded the highest, 12 bushels per acre, in the variety test. North Dakota No. 155 wilt resistant flax yielded 10.8 bushels per acre, the highest of the varieties in the test.

*Forage crops and corn varieties.*—Among the forage crops, Kursk millet yielded the highest, 4,840 pounds per acre; Amber cane yielded 4,500 pounds; Sudan grass, 3,400 pounds; Manchu soybeans, 2,800 pounds; and a black yellow soybean, 2,480 pounds. The corn varieties did not mature for seed on account of the early frosts, altho the larger number of them produced good silage.

*Nursery varieties.*—In the nursery increase tests, Victory oats yielded 57.3 bushels per acre and No. 923 barley 38.2 bushels. In the alfalfa nursery the characteristics of several well-known varieties were studied with regard to their adaptation to Red River Valley conditions. Disco No. 32 C produced 2,625 pounds per acre in one cutting and Disco No. 78, 1,925 pounds.

*Grasses and grass mixtures.*—The work with grasses is an important part of the varietal testing at the Northwest station. Tall meadow oats grass yielded 3,940 pounds per acre; slender wheat grass, 3,760 pounds; orchard grass, 3,380 pounds; timothy, 3,360 pounds; and Kentucky bluegrass, 3,160 pounds. These yields were made in a single cutting. The following combinations of grasses yielded the

highest in 1917: (a) brome grass, 10 pounds; tall meadow oat grass, 6 pounds; white clover, 2 pounds; and alfalfa, 4 pounds; yield: 6,160 pounds per acre. (b) Timothy, 6 pounds; orchard grass, 6 pounds; and alfalfa, 4 pounds; yield: 5,200 pounds per acre. (c) Brome grass, 10 pounds; alfalfa, 8 pounds; and meadow fescue, 6 pounds; yield: 4,160 pounds per acre.

*Cultural methods with farm crops.*—Subproject: *Rate of seeding wheat, oats, and barley.*—In the rate of seeding tests the stand was thin on account of the dry season with increased yields from the heavier rates. The thin seeding did not tiller as when the rainfall was greater. In the work with oats, 8 pounds per acre gave the greatest yield.

Subproject: *Methods of winter wheat protection.*—Winter wheat seeded on stubble and on plowing succumbed to winter conditions. Seeded on corn land with every sixth row standing the yield was 12.5 bushels per acre; and with all the corn standing, 30.7 bushels. Straw did not furnish the protection necessary. Results at the Crookston station seem to indicate that growing winter wheat is not profitable.

Subproject: *Date of seeding winter wheat.*—In the tests of the date of seeding winter wheat, the seedings of August 15 and September 1 resulted in better yields than the later seedings.

Subproject: *Date of plowing.*—Contradictory results were again secured in the tractor vs. horse plowing and disking. The value of early plowing was shown in the date-of-plowing tests. The effects of disking stubble after harvesting were beneficial. In comparing early August vs. spring plowing for corn the yield in fodder was 2,925 pounds per acre for the former as against 1,100 pounds for the latter.

*Crop rotations.*—The work with crop rotations was continued. The yields of wheat in the different rotations are: In the 7-year rotation, 20.9 bushels per acre; in the 5-year rotation, 25.5 bushels; in the 4-year rotation, 23.7 bushels; in the 3-year rotation, 25.8 bushels; in the continuous cropping with clover, 16.6 bushels; and in the continuous cropping, 15.9 bushels.

Oats yielded 71.9 bushels in the 7-year rotation; 65.2 bushels in the 5-year rotation; and 73.8 bushels in the 4-year rotation. Barley yielded 39.6 bushels in the 7-year rotation and 39.5 bushels in the 3-year rotation. Detailed results are given in the Crookston station report.

*Fertilizer tests.*—The use of commercial fertilizers resulted in very slight increases in yields or none during 1917, confirming earlier results.

Results in the 3-year rotation.—The following figures give the principal differences. In the 3-year rotation the check plots yielded

2,600 pounds of fodder corn per acre, the average for three years being 2,649 pounds. The potassium sulphate and acid phosphate plots yielded 2,840 pounds, the 3-year average being 3,178 pounds. The acid phosphate treatment yielded 3,560 pounds, the 3-year average being 2,466 pounds. Barley in the 3-year rotation check plot yielded 39.5 bushels, the 3-year average being 41.0 bushels. The potassium sulphate and acid phosphate treatment yielded 44.6 bushels, the 3-year average being 43.0 bushels. The acid phosphate treatment yielded 45.4 bushels, the 3-year average being 42.5 bushels. Clover in the 3-year rotation check plot yielded 2,096 pounds per acre, the 2-year average being 2,113 pounds. The acid phosphate treatment yielded 1,850 pounds, the 2-year average being 1,983 pounds.

In the 4-year rotation, the following table gives results to date of four treatments:

4-Year rotation	Corn Lbs. per acre		Oats Bu. per acre		Wheat Bu. per acre		Clover Lbs. per acre	
	1917	3-Yr. Av.	1917	3-Yr. Av.	1917	3-Yr. Av.	1917	2-Yr. Av.
	No treatment.....	2,446	2,394	77.8	46.8	20.6	.....	1,786
Manure only.....	3,260	2,128	73.8	45.0	23.7	.....	2,563	3,165
Acid phosphate.....	4,173	1,993	75.8	46.1	24.3	.....	2,800	3,412
Acid phosphate and manure.....	3,306	2,472	79.5	40.8	26.2	.....	2,766	3,407

*Fertility study.*—The study to determine the proper rate of application of manure and of straw and of the place of a fallow in a 4-year rotation, which was begun in 1917, is being continued.

#### WEED ERADICATION

Net returns from the different methods employed in eradicating quack grass are given. All except the rye plot grew barley in 1917.

Treatment in 1916	Net return per acre
Summer fallow.....	\$19.25
Buckwheat plowed under in full bloom, reseeded, and plowed under after frost.....	2.00
Buckwheat matured.....	36.90
Hemp.....	84.00
Millet followed by winter rye.....	38.48
Corn.....	34.00

#### WORK WITH PEAT

New work was taken up in cooperation with the Division of Soils in investigating the crop-producing requirements of Northwestern Minnesota peat land, of which there is a large acreage about fifty miles north and northeast of the Crookston station. A tract near

Golden Valley in eastern Marshall County was secured in the fall of 1917 and put into crop the following spring.

#### HORTICULTURAL SECTION

*Fruit investigations.*—The gooseberries, currants, and strawberries yielded fair crops in 1917. Of the raspberries, the Sunbeam and Turner came through in the best condition.

Late summer growth on the apple and crab trees was induced by the light showers of August, and the killing frost of early September caught all of the immature new growth on the clean cultivated plots. All of the trees on the plots given clean cultivation except the Alaska crab suffered severe winter injury. Virginia crab and Hibernial apple in the sweet-clover-sod plot shed their leaves normally in the fall and Virginia crab came through the winter perfectly. Hibernial, however, showed some winter injury.

*Tree and shrub investigations.*—The open severe winter following the dry season of 1917 proved a test for many trees and shrubs. Three- and four-year-old seedlings of white elm and green ash winter-killed in the more exposed portions of the nursery rows, while the trees in the lower portions of the row wintered perfectly. The laurel leaf willows in the garden hedge row suffered greatly from alkali injury and most of them are dead, while the adjoining hedge row of *Caragana arborescens*, or pea tree, has made good growth and shows no alkali injury whatever. The laurel leaf willow elsewhere on the grounds made good growth. The best stand of willow cuttings in 1918, as in 1917, was obtained by fall planting.

*Garden crop investigations.*—In 1917 the growth of all crops was retarded by lack of moisture, the best growing conditions for the season not coming until late in August. Tender crops, as cucumbers, beans, and tomatoes were killed by the early September frosts and gave light yields. Navy beans were a total failure for the first time in six years. Cucumbers, in a test of nine varieties, yielded from 6 to 22 bushels per acre with the Long Green and Pickling varieties best. Earliana tomato yielded more than twice as much as any of the other fifteen varieties in the test, yielding three and one half tons per acre.

*Field root crop investigations.*—Mangels, rutabagas, stock carrots, and sugar beets were benefited greatly by the late August and September showers and made fair to good yields. Rutabagas, in a trial of seven varieties, averaged 259.8 bushels per acre. Stock carrots averaged 142.5 bushels per acre; sugar beets, 9 tons per acre; and mangels, in a test of eight varieties, gave an average yield of 13.4 tons per acre.



## POTATO INVESTIGATIONS

*Variety testing.*—The season of 1917 was unfavorable for potatoes. The drought of early and midsummer retarded the growth and the killing frost of early September caught the late varieties before the tubers were half grown. Early Ohio ranked first in yield of the early sorts, followed in order by Irish Cobbler and Triumph.

*Potato diseases and insect control.*—Of the six treatments tried for the control of tuber diseases, the whole seed treated with formalin gave the highest total yield, 154 bushels per acre. The formalin treatment did not, however, control *Rhizoctonia*, or scab, for 65 per cent of the tubers were scab specked and 1.5 per cent were unmarketable because of scab and black scurf. The plots treated with corrosive sublimate yielded 128 bushels per acre and showed only a trace of scab and black scurf.

The 5-5-50 bordeaux mixture used twice gave a yield of 101 bushels as compared to 89 bushels on the check plot. Bordeaux mixture applied three times in comparison with self-boiled lime-sulphur and commercial lime-sulphur mixture gave the best results, the yields, given in the order named, were 117.1, 110.1, and 106.6 bushels per acre, as compared to 100.3 bushels per acre on the check plot.

Of the many insecticides used in the control of the potato beetle, paris green proved most effective. It was applied both as liquid and as a dust spray. Home-made lead arsenate proved to be the most economical spray used.

*Methods of planting.*—In testing the sizes of potato seed pieces, the results of former years were verified, namely, that when the price of seed is a factor in potato production there is no advantage to be gained by planting whole potatoes or extra large seed pieces. In the "Amount of seed per acre" test with the Early Ohio, seed pieces of the same size were used in all plots. The larger amounts were obtained by dropping the seed pieces closer in the row. The plot in which 16 bushels of seed were planted per acre yielded 203.5 bushels per acre as compared with 184 bushels on the 18-bushel plot. The 16-bushel plot yielded 12.69 bushels for every bushel of seed planted. In this plot the seed pieces were dropped from 11 to 13 inches apart, which is apparently the correct spacing for Early Ohio.

*Fertilizer tests.*—The fertilizer tests on potatoes are conducted in cooperation with the Division of Soils at University Farm. Commercial fertilizing elements applied singly and in combination in standard amounts have not in the past shown marked results. In the 3-year rotation in the fertilizer series, the highest average yield in four years has come from the plots treated with potassium sulphate and acid phosphate in combination. They have produced an average

of 142.9 bushels per acre as compared with 128.1 bushels on the check plot. The plots treated with potassium sulphate alone have averaged 121.8 bushels. On the phosphate-treatment plots no appreciable effect could be noted in using manure in combination with either rock or acid phosphate. Phosphate test plots are cropped in 4-year rotation, and in this cropping system barnyard manure has given the most economical gains with potatoes. In a 3-year average the single treatments have yielded: Check, 81.53 bushels per acre; rock phosphate, 91.2 bushels; manure, 99.5 bushels; acid phosphate, 104.18 bushels.

*Potato seed selection.*—Considerable variation is noted in the pure-line selection work started from high-yielding hills of Early Ohio. A large number of tuber units are still in test but it will require several years of trial to ascertain the type and reproductive qualities of each lot.

*Rotation tests.*—The 3-year rotation in the fertilizer series yielded 144 bushels of potatoes per acre as compared with 107.4 bushels on the 4-year rotation given the same culture. On the Agronomy series the 7-year rotation yielded best, 98.6 bushels per acre, while the 3-year rotation yielded only 71.0 bushels. The drought of early summer and the poor physical condition of the 3-year rotation plot probably account for the difference in yield.

## DAIRY AND ANIMAL HUSBANDRY SECTION

The work of this section was continued as in the past, the only experimental work being with swine. Two projects dealing with swine feeding are under investigation: *The use of the self-feeder* and *To determine the influence of over-feeding with protein*. The first phase of these investigations is completed but the projects require considerable additional time and equipment which are not now available.

*Livestock management.*—The station stock was maintained as in the past. The tuberculin test showed the herds to be free from disease. The state accredited herd certificate was issued the station by the Live Stock Sanitary Board. The natural increase in the sheep flock was 180 per cent. Many breeding animals were sold to farmers.

## POULTRY SECTION

Very satisfactory results were obtained in the poultry section in spite of the fact that we were compelled to resort to war rations. Egg yields were quite up to former years. Several experiments were completed but no new projects were undertaken. The demands for lectures at farmers' clubs and boys' and girls' clubs and for judging at fairs were frequent.

*Artificial vs. natural incubation of chickens.*—This project, covering a period of six years, was completed. The conclusions arrived at were:

1. That white diarrhea can be controlled by reversion to natural incubation.
2. That white diarrhea disappears after the second generation of natural incubation.
3. That it is not necessary to discard infected breeding stock in order to control the disease.

#### HENS VS. PULLETS AS PROFITABLE EGG PRODUCERS

The results of the first year show that 25 hens out-layed 25 pullets by 222 eggs, making \$4.22 greater profit than the pullets.

*Cockerel fattening experiment.*—This experiment was conducted to try to prove the value of fattening market poultry. The results were as follows: 12 cockerels weighing 48.10 pounds made a net gain of 14.9 pounds in two weeks and a net profit of \$4.83.

*Hatching and rearing chicks.*—Results in hatching and rearing were above normal. This was especially true in regard to Leghorns. A smaller percentage of eggs than usual was required to produce a given number of chicks. A large number of excellent specimens for breeding purposes were raised.

#### WEST CENTRAL EXPERIMENT STATION, MORRIS

P. E. MILLER, Superintendent

Because of war conditions, no new projects were inaugurated but all established projects were continued. Most of the experiments have now been established from three to five years and the results are each year becoming more interesting. They are valuable, also, in their application to the farms of western Minnesota. The problems being worked on at the West Central station are practically all regional problems, that is, problems that must be considered under the soil and climatic conditions of western Minnesota. These include the big questions of soils, their fertility and cultivation; crops, their improvement and adaptation; fruit, tree, and garden crops; and livestock management.

The results of the phosphate fertilizer tests again showed a decided advantage for the use of these fertilizers, and it was decided to begin a series of cooperative tests with farmers in 1918.

#### WEATHER

Weather conditions during the season of 1917 were generally favorable for all crops except corn. The growing season was featured by a late spring and an early fall, with an absence of the hot weather which characterized the growing season of 1916. There were scarcely

ninety days between killing frosts. Rainfall was below normal in the spring and summer, resulting in short meadows and pastures. The season was not favorable for setting out trees and fruits because of the dry weather. Clover and timothy seedings were generally poor for the same reason, and old meadows will largely be relied on for the hay crop of 1918.

April was a very backward month, being characterized by uniformly low temperatures and snow throughout. May was a month of low temperatures and subnormal rainfall. The weather was excellent for small grain but too cold for corn. The mean temperature for June was 4.5 degrees below normal and the rainfall 2.45 inches below normal. July was favorable for crop growth, with a mean temperature of 1.5 degrees above normal. August opened with all crops except corn at about normal growth. Hot dry winds in the early part of the month affected the development of small grain and the yield was in many instances reduced. The month was one of the driest on record and harvest came on rapidly, being completed by the end of the second week in August.

In September a cold wave the 9th and 10th killed practically all corn and all vine crops. Rainfall was again below normal. October closed with the lowest temperatures on record for this month. An early freeze damaged potatoes extensively. November was ideal for farm work.

#### AGRONOMY

*Fertilizer projects.*—Four years' results are now available from these fertilizer tests and the increases secured in past seasons were again obtained in 1917. Because of abnormal conditions in 1914, due to late seeding, the results of the first year have been discarded. During the last three years corn has given an average increase of 4.5 bushels per acre, wheat, 4.1 bushels, oats, 5.9 bushels, clover, 0.72 ton, with acid phosphate applied at the rate of 480 pounds per acre once during the period of the rotation. For all four crops in the rotation rock phosphate has given an average increase of 42 cents above the cost of fertilizers, rock phosphate and manure \$2.92, manure alone \$8.98, acid phosphate and manure \$7.28, acid phosphate alone \$10.12. These figures are obtained by figuring corn 60 cents per bushel, wheat \$1, oats 40 cents, and clover eight dollars per ton. Where there is sufficient manure to cover the farm once in four years it is evident that the use of phosphate fertilizers is not urgently necessary. This condition, however, exists on very few western Minnesota farms at the present time.

Manure has produced almost as high yields as the combination of manure with either of the two phosphates, and at the cost prices assumed has proved the cheapest fertilizer. Acid phosphate, when

used alone, has given almost the same yields as manure alone, except in the case of wheat, where it has given a higher yield. The combination of acid phosphate with manure has produced the same amount of corn, less oats, and more wheat than the manure alone. The value of all four crops together has been only a trifle higher than where the same amount of acid phosphate was used without manure. It is evident that on such soil acid phosphate can not profitably be used where there is sufficient manure to give the land a dressing of eight tons per acre once in four years. However, where this amount of manure is not available, it would appear decidedly profitable to apply acid phosphate to wheat and clover on the fields which receive no manure. The rock phosphate, both alone and in combination with manure, has failed to cause enough increase in yield during the first rotation to pay for its cost; but as no more is to be added during the second rotation, the large amount still remaining in the soil may cause sufficient increase during the eight years to make the application profitable. On account of the large amount of organic matter characteristic of the prairie soils of western Minnesota it appears unnecessary to add manure in order to make the rock phosphate effective. Like the acid phosphate, its beneficial effect is more marked when it is applied to land not receiving manure.

*Commercial fertilizers with alfalfa.*—Phosphate, manure, and potash fertilizers were applied to each plot in the alfalfa series in the spring of 1915, 1916, and 1917, with the exception of rock phosphate, which plots received only the initial application. As described in the 1916 report, the north half of each plot was treated in 1916 with ground limestone at the rate of 3 tons per acre. As in 1916, no increase was secured from the limestone treatment. Acid phosphate is the only fertilizer that gives any distinct increase. Thus far alfalfa has failed to respond to rock phosphate, while clover on the adjoining series gives substantial increases with the same treatment. Because of an imperfect stand on the manure plots, no increase was obtained. The practice of top-dressing the alfalfa meadows with manure has proved very beneficial. Thus far fertilizers have not increased the yield of alfalfa sufficiently to warrant the use of any of these materials on a commercial scale.

*Crop rotation experiments.* Subproject: *Rotation experiments with manure.*—The rotation used in the experiment with manure is corn, wheat, barley, and clover. The fertilizers are applied to the plots in corn at varying rates, from 0 to 32 tons per acre. The first series of plots was planted in 1916, and the second series in 1917.

Thus far results are slight, owing to the high state of fertility of these plots at the beginning of the experiment.

Subproject: *The use of crop residues.*—In 1916 a test was begun to demonstrate the fertility value of wheat straw and of corn stover. A 2-year rotation of corn and wheat is followed. Corn stover is plowed under in the fall at the rate of 0, 1, and 2 tons per acre, and wheat straw is plowed under at the same rate. The results for 1916-1917 do not show anything conclusive, altho thus far the heavy applications of stover have had a depressing effect on the wheat crop which follows.

Subproject: *Clover utilization rotation.*—The purpose of the clover utilization rotation is to compare the various methods of utilizing red clover in a four-year rotation of corn, wheat, barley, and clover. The work was begun in 1916 and the first crop of corn was grown in 1917 on the clover plots of the previous year. As with all fertility projects on these soils, at least the period of one rotation will be needed before results can be relied on.

Subproject: *Alfalfa rotation.*—An 8-year rotation including 4 years of alfalfa and 4 of grain and corn was begun in 1916. The 1916 yields were among the highest produced at the station. The plots were on old alfalfa sod broken the previous fall. The 1917 yields on alfalfa sod broken the previous fall were not so satisfactory, owing to the very dry condition of the soil. Corn was not so much affected by dry weather as were wheat and barley, because small grains need their supply of moisture early in the season. About three inches of rain, which came too late to benefit the small grains, fell just when the corn was most in need of moisture. In 1917, wheat averaged 30.1 bushel per acre, barley 35.6 bushels, and corn 44 bushels on this rotation.

*Varietal tests of farm crops.*—Nineteen varieties of oats were tested in 1917. All varieties did well, ranging in yield from 49 to 85 bushels per acre. Medium and late varieties were superior to early ones, altho this order was reversed in 1915 and 1916. Dry weather seriously affected the growth of straw, and to some extent the yield of grain. Early varieties experienced very unfavorable weather while the grain was filling, and consequently the yield was affected. There was little lodging, no appreciable damage from rust, and the quality of the grain was excellent in all cases. Of the varieties that have been in test for three years or longer, Minnesota Nos. 281 and 295, and Excelsior head the list. In the hands of farmers, Minnesota No. 281 has done remarkably well. In 1917, No. 281 yielded 74.1 bushels per acre; No. 295, 61.8 bushels; and Excelsior, 67.3 bushels.

Five of the leading types and varieties of spring wheat were in test in 1917. The range in yield was from 21.5 for Marquis to 23.8 for Bluestem. The season was generally favorable and under such

conditions Bluestem is hard to excel in both yield and quality. Marquis has proved a better yielder under unfavorable weather conditions. The so-called humpback varieties are consistent yielders but can not be recommended because of the market discrimination against them. Durum has consistently yielded well and has the highest 3-year average. The quality has been uniformly good and it has a resistance to lodging and stem rust that makes it admirably adapted to Western Minnesota conditions.

Thirty-three strains and selections of spring wheat were grown in 400 nursery rows.

In addition to the spring wheat varieties, 10 selections of winter wheat were seeded September 16. All varieties made fair growth and were well stooled before winter weather set in. Being located on exposed ground, there was little snow protection and the severe winter of 1916-1917 caused all varieties to winter-kill from 60 to 100 per cent. Nine varieties matured enough plants to obtain seed for the following year. These yielded from 6 to 14 bushels per acre.

Both spring and winter rye have done well in the variety tests. Minnesota No. 2 winter rye has shown itself to be of superior yielding ability and extremely hardy. In 1917, Minnesota No. 2 rye yielded 30.9 bushels.

Minnesota No. 105 barley has averaged 38.1 bushels per acre over a 3-year period, and Minnesota No. 230 an average yield of 33.5 bushels. All the work carried on at this station has tended to show that the Manchuria and Oderbrucker six-rowed barleys are superior to all other types for this section, both in quality and in yield per acre. In 1917, Minnesota No. 105 barley yielded 49.1 bushels per acre.

Seven varieties of flax yielded from 13.1 to 17.8 bushels per acre.

Fourteen varieties of corn were tested in 1917. A selection of Minnesota No. 13 which has been carefully selected for four years at this station made a yield of 44.7 bushels per acre and matured very well. Minnesota No. 455 also made a very good record, 62.7 bushels per acre. Minnesota No. 23, Northwestern Dent, was thoroly matured at husking-time. Murdock, Silver King, and Calico again failed to mature.

White spring speltz again made a very good yield, 47.4 bushels per acre. In 1916 the yield was 42.5 bushels per acre.

*Clover and alfalfa investigations.*—Six of the leading varieties grown in the Northwest have now yielded four seasons' crops in the varietal test plots. Grimm and Baltic have consistently out-yielded the other strains. Winter-killing has been so severe on the Kansas, Nebraska, and Dakota plots that the stand is no longer profitable. Turkestan

is perfectly hardy but the yield is generally so poor for the second and third cuttings that it can not be recommended.

Twenty-five strains and varieties are now in the nursery, where the plant characteristics are studied and data in regard to hardiness and yield are taken. Various strains of Grimm received from different sources do not show the similarity in plant characteristics and hardiness to be expected. True Grimm has thus far proved superior in yield and hardiness to any other strain.

Extensive seeding tests with alfalfa, begun in 1915, were continued in 1917. Bare seeding has given uniformly better results than seeding with a nurse crop. Early spring seeding without a nurse crop has exceeded all other methods, giving an excellent stand and yielding a crop the first season. No results have been secured from either soil or culture inoculation tests. Because of the ease with which inoculation may be done, it should be recommended, as general observation throughout the section seems to indicate that the stand is improved where inoculation is practiced. Seeding in corn at the last cultivation has not been a success. Results thus far seem to indicate that on a clean well-prepared seedbed, 8 pounds of seed will give a perfect stand. If the soil is not free from weed seeds or in the best condition, more seed is recommended.

*Selecting corn for yield and early maturity.*—Corn breeding work is now confined to Minnesota No. 13. An early-maturing selection of this variety was obtained in 1913 as the foundation stock and has been grown continuously since that time. For three years the work was entirely bulk plot selection. Good yields have been secured each year and the percentage of mature corn has been increased each season. Gradually the type has been improved, altho yield and maturity are the two factors which have been emphasized. In 1917, 35 ears were grown in centgener rows and this practice will be continued as long as practicable.

#### HORTICULTURE

*Potato varieties.*—Eight varieties of potatoes were grown in 1917. Early Ohio yielded 108 bushels per acre, Burbank 154 bushels, and Rural New Yorker 243 bushels. The late varieties out-yielded all of the early varieties, owing largely to more favorable weather conditions.

*Garden crops.*—About seventy-five varieties of garden crops were in test during 1917.

The short growing season was unfavorable to late-maturing garden crops. Only the early varieties of tomatoes matured. Navy beans grown on a commercial scale were in most cases severely damaged by frost. The earliest varieties of watermelons and muskmelons, the seeds of which were planted in the open ground, failed to ripen.

Experience has shown that all vine crops grown on the prairies, where excessive winds prevail, should be given the protection of an effective windbreak for best results. This is not necessary for root crops. Cabbages produced a heavy yield. All root crops yielded well.

*Tree and shrub investigations.*—The season of 1917 was not favorable for tree planting. Little new growth was made on stock newly set and in many cases none. Plantings of the previous year made good growth. A few varieties were unable to withstand the strong winds that prevailed throughout the season, the foliage being destroyed and the plants making no growth. All ornamentals are heavily mulched in the fall with stable manure, which is spaded in, in the spring and the ground cultivated throughout the season.

*Fruit investigations.*—The new plantings made in 1917 include the following varieties:

Strawberry.—Progressive Everbearing, and Minnesota No. 935.

Currant.—Red Dutch, White Grape, and Perfection.

Gooseberry.—Pearl, Downing, Houghton, Industry, and Carrie.

Raspberry.—Sunbeam, Turner, King, Gregg, Kansas, Cumberland, and Minnesota No. 4.

Grape.—Minnesota Nos. 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, and 26.

#### DAIRY AND ANIMAL HUSBANDRY

The work in animal husbandry in 1917 was largely a continuation of the work of 1916, namely, the founding of purebred herds, the eradication of contagious abortion, and the laying of the foundation for future experimental and demonstrational work. The breeding herds of beef and dairy cattle have not been materially changed. Two Holstein cows were purchased, bringing the number of Holsteins of breeding age up to nine. The sheep purchased in the fall of 1916 made a very creditable record. The 13 ewes dropped 22 lambs, 21 of which were raised, making an increase of 161 per cent. The ewes were wintered on alfalfa hay, most of which was discarded by the cows. No grain was fed with the exception of half a pound per day for three weeks at lambing-time. The flock averaged a ten-pound wool clip.

*Contagious abortion.*—In 1917 the same method of procedure in handling contagious abortion was followed as was reported in detail last year. There were only two cases and both of these were heifers with first calf. It is hoped that by another year this disease will have been entirely eliminated from the herd.

*Swine feeding.*—This project, conducted in 1916 and reported in the annual report of that year, was repeated in 1917, the details of the project being the same. Spring pigs were taken at

weaning time, ranging in age from nine to twelve weeks, and were divided into four groups of fifteen each. The pigs were put in various lots for a period of 103 days, from June 15 to September 25. Lots 1 and 2 were put in dry yards without pasture of any kind, while lots 3 and 4 were given an acre of alfalfa each. The pigs in lot 1 were fed twice a day in a trough in the usual manner, the feed consisting of 70 per cent ground barley, 20 per cent flour middlings, and 10 per cent tankage. They were fed all of this mixture they would clean up, twice daily. The pigs in lot 2 had free access to a self-feeder where they could help themselves to ground barley, flour middlings, and tankage. The pigs in lot 3 were fed similarly to those in lot 2 except that they had alfalfa pasture in addition. The pigs in lot 4 were fed the same as those in lot 1 except that they had alfalfa pasture in addition. All had free access to water in a trough. All feeds were fed dry. The profit per pig above cost of feed in lot 1 was \$6.78; in lot 2, \$6.72; in lot 3, \$8.08, in lot 4, \$7.19.

The alfalfa was cut twice and about half of a cutting stood on the ground when the pigs were removed, September 25. The pigs trampled some of the alfalfa, not in any way injuring the hay but making it impossible to get quite all of it. About half the amount of hay was obtained as from the same amount of land not pastured. The pigs did some rooting during June and July but the stand did not seem to be seriously injured. To prevent further damage, the pigs were ringed on July 6. At no time during the season were the pigs able to use all of the alfalfa and apparently one acre would have easily supported two or three times as many pigs.

#### NORTH CENTRAL EXPERIMENT STATION, GRAND RAPIDS

OTTO I. BERGH, Superintendent

*Weather records.*—The rainfall for 1917 was 14.71 inches, only about half the normal. Besides being unusually dry, the summer was abnormally cold. Frequent frosts occurred on the uplands every month except July. Frost occurred on the peat lands (muskeg) on the following dates: June 1, 2, 5, 15, 20, and 22; July 4, August 6, 25, and 29. The latest killing spring frost on the upland occurred June 20, and the earliest fall frost August 29. September was exceptionally cold as was also October. In September the thermometer registered 32 or less on eight different dates as follows: 31 degrees on the 2d, 32 degrees on the 4th, 6th, 9th, and 10th, 27 degrees on the 11th, 30 degrees on the 21st and the 27th. On the muskeg the mercury dropped to 16 degrees September 10 and to 1 degree below zero on October 23. In October 12.6 inches of snow fell and seriously interfered with the harvesting of potatoes and other late crops after October 9.

## CROPS

The crops were planted under very favorable conditions. The weather was dry with much sunshine. The precipitation for May was only 0.12 inch, giving full opportunity for the preparation of seedbeds and planting. Lack of moisture, however, retarded the growth of grasses and clovers, resulting in poor pastures and very low yields of hay from the meadows. June frosts destroyed beans and other tender vegetables and also set back the corn, which continued very backward throughout the season. Corn was severely damaged by frosts in August and early September so that many fields were unfit for silage. Practically no seed corn was saved except from fields protected from frosts by adjacent bodies of water.

With the exception of potatoes, all crops were much below the average. Field oats yielded from 20.1 to 30.6 bushels; spring wheat 6.8 to 11.9 bushels; barley 19.12 bushels; winter rye, 21.3 to 32.1 bushels; winter wheat 6.6 to 12.1 bushels. In the case of both winter rye and winter wheat the fields seeded in August gave much larger yields than did those seeded later in the fall. Potatoes yielded from 211.82 to 303.2 bushels per acre; rutabagas 13.8 to 15.6 tons. All hay crops except oats and peas were very discouraging. Clover and timothy meadows yielded from 0.94 to 1.20 tons; alfalfa averaged 1.14 tons in two cuttings, yielding 0.59 ton the first cutting and 0.56 ton the second; oats and peas hay 2.12 tons; millet 1.02 tons; *Bromus inermis* 1.20 tons. All hardy garden crops, such as cabbage, peas, onions, and the root crops did well, giving about normal yields. The fruit crop was practically a failure owing to the drought and late spring frost.

## EXPERIMENTAL WORK

Experimental work was continued as outlined in the 1916 report with but few additions.

*Land clearing.*—A project on land clearing was completed. The object of the project was to determine the cost of clearing similar tracts of land by different methods, that is, by the use of the stump puller alone, with dynamite alone, and by the use of both in combination.

*Field crops.*—Variety testing, study of cultural methods and time and rate of seeding were continued.

*Orchard crops.*—There was much evidence of winter-killing among the apples, grapes, and blackberries. Plums, raspberries, currants, gooseberries, and strawberries set out in 1915 and 1916 were seriously affected by drought.

*Garden crops.*—Variety testing of garden crops is being continued.

*Soils and fertilizers.*—Fertilizer work on both the upland and muskeg continues to give very interesting results. Barnyard manure

on the upland and barnyard manure with lime on the muskeg seem to be the most practical treatments in maintaining fertility. An application of 10 tons of manure per acre gave an increase of 57.2 bushels of potatoes over the untreated plots, bearing out the results of 1915 and 1916 when the same applications gave an increase of 49.1 and 95.9 bushels, respectively. A comparison of raw peat with barnyard manure as a fertilizer is being continued.

*Peat for barn litter.*—Peat is being used as barn litter and four years' experience justifies us in recommending it as an absorbent in barns. The cheapest method of preparing peat for barn litter is to disk the surface of a drain bog and haul it under cover while dry.

*Forestry.*—No further forestry planting has been done, owing to shortage in labor and lack of funds.

## ANIMAL HUSBANDRY

*Management of dairy herd.*—The project of breeding up a herd of grade Guernsey cows is being continued, and improvement from year to year is shown by the average annual production per cow in milk and butterfat for the last four years; 1914: milk 5,518.7, butterfat 259.0; 1915: milk 5,721.2, butterfat 279.8; 1916: milk 6,281.0, butterfat 300.7; 1917: milk 7,184.1, butterfat 358.1.

No change has been made in the swine department except that a larger number of breeding sows are being carried over. The station has been unable to meet the demand for breeding stock. Only the large white improved Yorkshire are being raised. The station is in need of a new swine barn.

*Poultry breeds.*—The project of comparing different breeds of poultry kept for profit under the same feed, care, and housing is being continued. Approximately five hundred hens are kept. The annual production per hen, by breeds, was as follows: Rhode Island Red, 121.45 eggs; White Leghorn, 118.64; Plymouth Rock, 87.09; Orpington, 79.23.

## IMPROVEMENTS

Improvements in 1917 include a barn 32 x 80 feet with a wing 30 x 36. This affords quarters for the horses and a small flock of sheep, with ample room for the hay crop. An electric power line was constructed and a portable 15-horse-power motor purchased which gives us cheap and convenient power for threshing, grinding, cutting ensilage, and sawing wood.

NORTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION, DULUTH

M. J. THOMPSON, Superintendent

Field crop tests made in cooperation with the Division of Agronomy and Farm Management at University Farm gave best results with

early peas, barley, and oats. Miscellaneous crops of flax, buckwheat, and millets were grown. The potato and orchard work are coöperative with the Division of Horticulture. In the study of the effect of place on yield of potatoes, the crop from northern-grown seed exceeded all others. Of the six varieties of apples, Hiberna stood the winter best and Okabena the poorest, with respective losses of 10 and 30 per cent.

Hay yields varied from 1.13 tons on an old pasture to 1.94 tons on new seedings. Fertilizer experiments were carried on in coöperation with the Division of Soils. Manure and acid phosphate gave best yields of potatoes, manure alone produced the most rutabagas, and acid phosphate plots yielded most oats.

Some feeding work was done. A group of heifers was wintered on a daily ration of mixed hay, five pounds of roots, and two pounds of grain. They made gains ranging from 46 to 152 pounds. On pasture, however, owing to the dry season, they gained only 0.57 pound per day as compared to 1.6 pounds per day the season before. With milk cows the gross returns from stump-land pasture were \$16.29 per acre. Horses on high pasture did a little better than maintain weight, and feed was thus saved. Some feeding work was carried on with swine. The cost of feeding young pigs from weaning time to sale was 41 cents, a self-feeder having been used. Brood sows bearing two litters per year gained flesh on a ration of grass and 1 per cent of grain.

A successful year was experienced with poultry. Production rose from 107 to 135 eggs per hen per year, but altho the gross receipts per hen increased 29.2 per cent, the increase in cost of feed and supplies was 47.6 per cent.

Some reforestation and land clearing was done. A tract of two acres of park land was planted with pine and spruce. Twenty and 30 per cent dynamite was used in land clearing. The cost of removal per stump was 13.91 cents and 10.03 cents, respectively. Four acres of new land were put into crop and twelve additional acres were cleared for 1918. Twenty-five acres were brushed for pasture.

SOUTHEAST DEMONSTRATION FARM AND EXPERIMENT  
STATION, WASECA

ANDREW BOSS, In Charge

THE FARM

The farm at Waseca has been operated in the last year as a diversified farm, specializing in the production of milk, beef, and hogs. No building of consequence has been done through the year, altho some improvements were made in the roads and grounds and some additional planting has been done.

The drainage system at the south end of the farm has been completed and some drainage lines have been supplied for the experimental unit. On the whole the farm is now well drained except that portion that is in permanent pasture. It is planned that as soon as funds accrue from the operation of the farm this part of the land also will be drained, and the pasture broken and reseeded so as to make it more productive.

Good grain crops of all kinds were obtained. The corn crop did not mature owing to the early frost but it was all converted into silage and used to good advantage.

The dairy herd has been maintained at from 20 to 24 head of milking cows. Products sold amounted to \$1,552.96. In addition, seven head of cattle have been sold at slightly more than \$100 per head. Excellent calves have been raised, some of which will be kept in the herd to replace the older cows. The cows are still hand milked and given good feed and care with a view to developing them as milkers.

The purebred herd of Poland China hogs has been developed and several were grown for sale as breeding stock. In all, 47 hogs were sold during the year for \$1,641.66. A good foundation has been kept for future breeding operations and a number of hogs on hand will be ready for sale at an early date.

Sheep, also, have done well, giving a good increase and a good crop of wool.

Total receipts from the sale of farm products for the year have been \$4,896.70.

The five-year major rotation which was organized when the farm was first secured is still in effect and giving very good results so far as production of grain and the supply of feed for the livestock is concerned.

The entire farm has been fenced during the year and all farm food supplies are now utilized to the best advantage and with a minimum of labor.

THE EXPERIMENTAL UNIT

Coöperative work in crop investigations has been established with the section of farm crops of the Central station. Numerous variety and cultural tests have been made. Row tests of winter and spring wheats and of flax have been conducted in coöperation with the section of plant breeding. Some selections of flax from wilt-infested soil have also been made with a view to securing wilt resistant strains. The field results this year were very striking. The fertilizer plots conducted in coöperation with the Division of Soils again yielded good crops and satisfactory data were secured. The

purchase of a small-plot thresher has greatly improved conditions for plot work, and investigations of this kind will be expanded in the future. Additional seedings of alfalfa have been made and tests of soybeans in combination with corn as a silage crop were made. Coöperative relations have been established with the Division of Horticulture and trials were made this year of raspberries and strawberries. Tests were also made of varieties of potatoes, cabbages, and other garden vegetables. All of these crops are maturing well and give promise of satisfactory yields.

#### COMMUNITY WORK

The Waseca farm continues to be a center for community work. Many farmers' club meetings are held at Institute Hall and it is in demand for meetings of various kinds. The superintendent of the farm has been active in organizing a county good seed association and has been especially useful in promoting county farm exhibits and community activities of various kinds which are calculated to stimulate an interest in the production of better crops and livestock.

#### FRUIT BREEDING FARM, ZUMBRA HEIGHTS

CHARLES HARALSON, Superintendent

The crop season of 1918, like that of 1917, has been a very successful one at the Fruit Breeding Farm. A number of new seedlings have fruited, so that it has been possible this season to make additional selections of promising seedlings, as well as to discard those which are unpromising. During late fall and early spring considerable discarding of undesirable types and older plantings was done, so that these plots will be available another year for new plants. The limited space, however, has made it necessary to discard too closely in some cases.

The winter of 1917-1918 was unusually severe on the tender varieties and seedlings. A line has been drawn quite sharply between the tender and hardy seedling plums, and selections are being made almost entirely from those plum seedlings which withstood the winter. Apples were winter-killed to a greater extent than in any other season since the Fruit Breeding Farm was established. Frost on the night of May 12 did some damage to plums and apples and the earlier strawberries. There was some winter-killing in the seedling strawberries owing to the fact that wind blew the straw cover off in the higher, exposed locations. Even in these cases, none of the new seedlings were completely killed.

#### THE CROP

The season has been favorable as far as fruit production is concerned. This is very fortunate because it has made possible the elimination of varieties which hitherto have been promising on

account of their hardiness. The fruit yield has been particularly heavy in the plum, strawberry, and raspberry.

#### NEW FRUITS

In addition to the further test of promising seedlings, some new selections have been sent to trial stations and also distributed as premiums by the State Horticultural Society. In the strawberry the new numbers which have been sent out for trial are 935, 842, 482, and 339. In the plum, Shiro x Wyant, on account of its hardiness as well as its fruit characteristics, promises to be one of the best of the seedling plums yet developed. This new seedling has been hardy at the Fruit Breeding Farm in both bud and wood during the last three seasons it has been under observation. The block of Malinda apples fruited lightly this year, being injured the last two seasons, in spite of spraying, by the cankerworm. A sufficient number of these, however, have fruited so that in addition to former selections, numbers 300, 237, 207, and 90 have been sent out to the trial stations.

#### CROSSES

Cutworm injury has been severe during the last two seasons on the young plants of new crosses in the seed bed. Some provision will have to be made another year to reduce this injury to a minimum either by growing the seedlings in flats in the greenhouse or by sterilizing the soil. Additional crosses have been made in the plum, raspberry, strawberry, apple, blackberry, and dewberry. These seeds are stratified ready for planting next spring.

#### PLUMS

Plans have also been made for making controlled hand crosses on a larger scale than has hitherto been possible. In addition to new standard parent varieties, it is now possible to continue the crossing with a number of the new seedlings, particularly in the raspberry, strawberry, and plum. Limited storage and greenhouse space are materially affecting the making of the controlled crosses to the extent to which they should be made. The greenhouses will be used to better advantage by making them bee-proof so that they can be used later in the spring, after the bees are in flight outside.

#### REPORT OF COMMITTEE EXAMINING MINNESOTA STATE FRUIT BREEDING FARM

*To the Regents of the University of Minnesota and the Minnesota State Horticultural Society*

GENTLEMEN:

August 27 last your committee visited the State Fruit Breeding Farm at Zumbra Heights on the south shore of Lake Minnetonka. We were given an opportunity by Charles Haralson, the Superintendent, to make a thoro inspection.



The farm consists of 78 acres, 65 of which are under intense cultivation, and the remaining 13 acres are in meadow and timber, which it is thought advisable and necessary to leave in its present condition. The buildings are well cared for, but because of lack of funds for the employment of sufficient help the fields and orchards showed some neglect. Trees were not pruned and weeds were much in evidence. We found also that Mr. Haralson has to devote a considerable portion of his time to common labor, taking him from his more important scientific work.

There is now available for the farm annually \$5,000 state appropriation and about \$800 receipts from the sale of fruit, making a total of \$5,800 available annually.

Its necessities are: superintendent's salary \$2,250, two men to be employed by the year at a salary of \$1,000, or \$2,000; four men at seven months at \$80 per month, \$2,240; four men for four months at \$80, or \$640; farm utensils and farm supplies \$1,000, making a total of \$8,130. The foregoing items are figured at a minimum. It would be advantageous to the state if sufficiently attractive salaries could be paid to employ most of these men by the year, as the experience and knowledge thus gained would be of far greater value to the state than the services rendered by employees who are employed from day to day or from month to month, or for a single season. There should be available for the exclusive use of this farm to pay salaries and general expenses under the direction of the regents of the University a sum of from \$8,000 to \$10,000 annually.

Nor has this station adequate buildings to accomplish desired results or to fulfil its purpose. It is greatly in need of an additional root cellar, which is as essential to fruit breeding as chemicals are to a chemical laboratory, or books to a library. A suitable root cellar can be erected at a cost of \$2,500, and should be erected at the earliest possible date.

The farm is far too small for present use, to say nothing of its future growth. There is now available 40 acres which can be secured for about \$12,000. With the rapid growth and development of this territory, no one can say how long there will be available land in this locality. We earnestly urge the acquisition of this land as soon as possible.

The great problem of to-day, recognized by all, is "Back to the Farm." Make the farm more enjoyable; combine comfort with toil, pleasure with labor, and the problem "Back to the Farm" is in part solved. Those of you who are pioneers of Minnesota, or who have read Proctor Knott's speech on Duluth, know how dreary and desolate originally were Minnesota farms. Pin cherries were its most abundant and staple fruit crop, a provision intended by nature

more for birds than man. Through the untiring energy of men of vision, Minnesota has developed the Wealthy and Duchess apples. While very acceptable, they are far short of the goal to be reached. You all know that the Wealthy, while an apple of excellent quality, is a poor keeper, borne of a tree that does not possess the hardiness we desire. Mr. Haralson has produced an apple, for the time being known as No. 300, which we hope will soon be shorn of this present name and given the name of some splendid pioneer in horticulture.

Apple No. 300 is a larger apple than the Wealthy, of a hardier tree, equal in quality, and an excellent keeper. This apple alone is worth all the money put into this station by the state.

But this is not all of Mr. Haralson's achievements. He has given to the state and to the world strawberry No. 3, one of the very best strawberries to be found in the markets of the Northwest, and so recognized and credited. He has taken our small thick-skinned large-stone puckering wild plum and given in its place Plums Nos. 12, 17, and 21, as large and meaty as the California plum with a more delicious flavor.

His latest achievement is raspberry No. 4, a large fine-flavored red raspberry, possessed with good market qualities, that needs no protection from the climate and does not winter-kill. It seems to be as hardy as our northern pines. Mr. Haralson is now working on a grape that he hopes will have fair size and good flavor and be as hardy as our native wild grapes. He hopes to develop a hardy currant with good cluster and large berry; a gooseberry more adapted to our local environments; and he is also developing a pear that it is hoped will be hardy in this locality. He is about to begin experiments with our native black walnut, hoping to cross-fertilize it with the English walnut and produce a thin-shelled walnut which will be of great commercial value.

Those of you who are familiar with present conditions know what great labor is required and what almost insurmountable difficulties are encountered by the farmer when he has each fall to lay down his raspberries and cover them with earth and dig them out in the spring; when his apple trees are of such tender variety that after a few year's growth they succumb to the climate, and what is true of the raspberry and apple is true of all kinds of fruits in this locality. When the Minnesota farm has its apple and plum orchards equal to those of the most favored climates, and has its small fruits surpassed by no locality, there will be an attractiveness to the farm that can not be measured in dollars and cents. When Minnesota has developed an apple, and we believe it can, that is equal to the Spitzenberg, which has made the state of Washington famous and prosperous, or a Jonathan, which has made Colorado likewise prosperous

and famous, all the money invested by this state in the development of such an apple will be at a trifling expense.

The development of fruit may be considered from two standpoints: (1) that of the general farmer, who will as a rule only produce sufficient fruit for his immediate needs, and when he does this, as before stated, it will add an attractiveness to the farm that is easily recognizable; (2) that of the horticulturist, and when you consider that the climate of the Dakotas and Montana is such that it will take at least a century to develop fruits that can be produced in those states and that for a long time to come they will be dependent on Minnesota to supply them with their fruits, it is readily seen what a great opportunity there is to add to the wealth of this state by the immediate development of choice fruits. The State Fruit Breeding Farm at Zumbra Heights is worthy of immediate and abundant financial support. We believe that if its necessities are presented to the legislature that intelligent and patriotic body will respond to these necessities, and we feel confident that the regents of the University of Minnesota will be more than pleased to see that such funds are wisely expended for the fullest development of this institution.

We regard Mr. Haralson as earnest, enthusiastic, and thoroly competent. He is doing good work and is achieving worth-while results. He will accomplish greater results if given the additional acreage and maintenance fund herein recommended.

Respectfully submitted,

E. W. RANDALL

C. L. SMITH

Committee.